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Analysis of the Short Sea Container Ships Market. Support for Investment Decisions.

by

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Acknowledgments

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Abstract

As container ships get ever larger, the container shipping market is increasingly developing 'Hub and Spoke' networks, thus increasing the importance of smaller vessels to conduct the final short sea carriage to destination port. The main objectives of this thesis is to analyse the short sea fleet (Feeders, Handysize and Sub-Panamax) dynamics with regards to fleet deployment and development, and prices of new built and second-hand vessels.

The analysis of the fleet dynamics shows the fleet deployment of larger short sea ships, Handysize and Sub-Panamax, is changing at a rather high pace for the years 2011-2016. These fleets are constantly increasing their activity in the short sea market, thus operating less in the North-South trade. This is presumed to be caused by a cascading effect created by 'Mega size' vessels.

We conduct a time series analysis that captures the most important factors determining ship prices, based on methods identified in the literature review of previous studies in this field. The time series data is tested for stationarity with the Augmented Dickey Fuller test and all series showed to be stationary in their first differences. Further, cointegration testing was conducted with the Johansen Cointegration test, which concluded that all models had at least one cointegration relationship.

The models chosen to estimate the ship prices were the Ordinary Least Squares, ARIMA, GARCH(1,1) and VECM. The results indicate that the steel price and LIBOR are the most important factors when estimating the newbuilding prices of short sea container ships, while time charter rates are most significant for second-hand prices. This is in line with previous empirical research on ships prices. The VECM is found to be the most appropriate model to identify the factors affecting the price for all categories, except Feeder newbuilding, where the GARCH(1,1) is best suited. Further, for all second-hand models, the time charter rates have a short run causality running to the second-hand prices, while LIBOR and second-hand prices are both identified to have a short run causality effect on the newbuilding prices in two categories.

The analysis in this thesis can be of use for investors in short sea container ships, to evaluate different factors before making a decision whether to invest in a vessel, or deciding weather it should be newbuilding or second-hand, based on economic and maritime related indicators.

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List of Abbreviations

TEU	Twenty-foot Equivalent Unit
OLS	Ordinary Least Squares
ARIMA	Autoregressive Integrated Moving Average
GARCH	Generalized Autoregressive Conditional Heteroscedasticity
VECM	Vector Error Correction Model
Ro-Ro	Roll On-Roll Off
DWT	Dead Weight Tonnage
DSS	Deep Sea Shipping
SSS	Short Sea Shipping
EU	European Union
MPP	Multi Purpose
S&P	Sale and Purchase
LCS	Large Container Ships
VLCS	Very Large Container Ships
ARCH	Autoregressive Conditional Heteroscedasticity
VLCC	Very Large Crude Carriers
MDE	Multivariate Density Estimator
TC	Time Charter
LIBOR	London Interbank Offered Rate
CGT	Compensated Gross Tonnage
VAR	Vector Autoregressive
MLE	Maximum Likelihood Estimator
3SLS	Three Stage Least Square
NBP	Newbuilding Price
SHP	Second-Hand Price
OECD	Organization for Economic Cooperation and Development
G20	Group of Twenty (20 Major Economies)
ADF	Augmented Dickey Fuller
JC	Johansen Cointegration
AIC	Akaike Information Criterion

Chapter 1 Introduction

1.1 Introduction

The shipping business is a mature industry with first known activity traced back 5,000 years when trading networks developed in the Arabian Gulf (Stopford 2009). Shipping has been important to the economic development of countries and regions. The well-known economist Adam Smith pointed out in 1776 that the key to success in capitalist society was the 'division of labour'. With increased labour productivity and skills, a business can supply more goods than needed for a local market. For this increased productivity a larger market is needed and to supply that market while staying economical, the transportation needs to be affordable. This is why shipping is so important as it is the cheapest way of transport and is, therefore, the driver for global trade, carrying more than 80% of the volume traded in 2014 (UNCTAD 2015).

Since the mid-19th century, seaborne trade has grown a great deal thanks to free trade agreements and technological developments. This growth in trade is in correlation with world merchant fleet growth, from 84.6 million tons in 1950 to 654.4 million tons in 2005 (Stopford 2009). One of the important technological developments was the containerization in the 1960's making transportation of general cargo more efficient. Since 1990, the container ship fleet as grown from 4,772 ships carrying 3.2 million TEUs (twenty foot equivalent units) to 8,337 ships carrying 18.9 million TEUs in 2014 (Khoi & Haasis 2014). This is equivalent to a 74.7% increase in the number of container ships and 596% increase in TEUs carried, which further points out the great development in the average carrying capacity of each vessel.

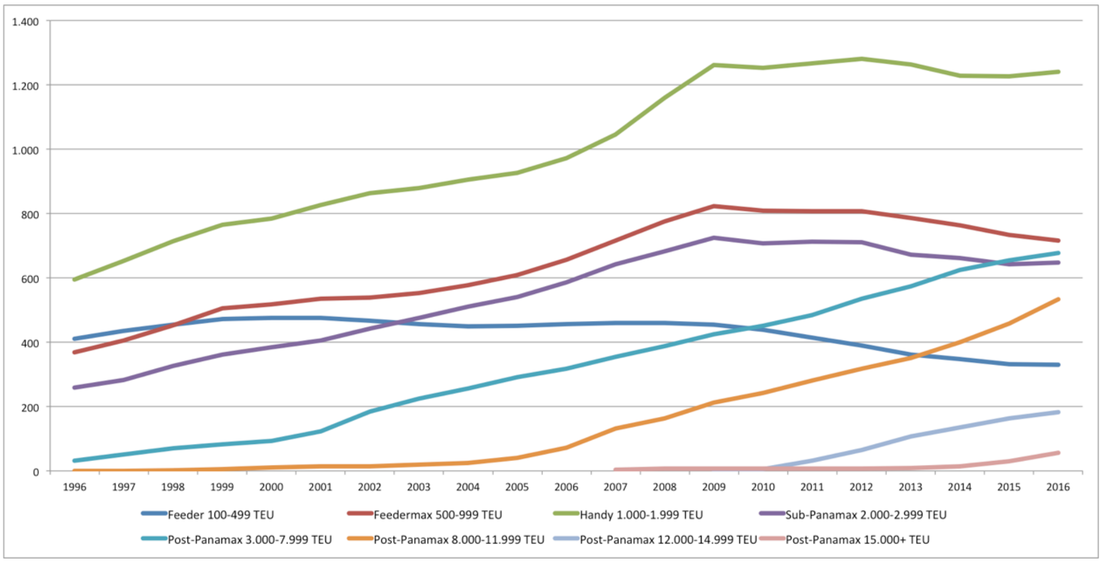


Figure 1: Number of Container Ships by Size from 1996 to 2016
Source: Compiled by Author from Clarkson Research Services Ltd (2016b)

Figure 1 shows the development of the container fleet since 1996. The increase in carrying capacity of the containership fleet can be traced largely to the trend of ever larger container vessels (8,000+ TEU fleet). The Post-Panamax fleets have been growing constantly since 1996 while other fleet sizes, Feeder, Feedermax, Handysize and Sub-Panamax have not sustained steady growth since the economic crisis hit in

2009. However, the Handysize fleet is still by far the largest fleet of them all and the Feedermax still the second largest in 2016.

Stopford (2009) states that no business is more exciting than shipping. By that he is referring to the great volatility of the shipping market. The shipping market is subject to the world economy's ups and downs, and a long-term balance of the supply and demand of available tonnage in the market is rare. This typically has to do with the time lag between when orders are placed for a new vessel and the time of the delivery of the vessel. New orders are based on the current market situation (and the investors' expectations of future developments) which might have changed by the time the vessel arrives, contributing to overcapacity in the market (Scarsi 2007). Due to this great volatility, shipping investors have to be very careful in assessing the market before making a decision to buy a vessel, taking all relevant factors into consideration. Further, the decision investors face is not only whether to buy a vessel but also whether it should be a second-hand or newbuilt vessel.

Research shows that good business decisions are made after careful consideration of related factors and use of good market intelligence (Stopford 2009). The aim of this thesis is to contribute to that very important market intelligence research regarding investments in short sea (<3,000 TEU) container vessels.

1.2 Research Question and Objectives

After a decision has been made to buy a certain type and size of a vessel, the next step is to analyse whether it should be newbuilt or second-hand. As described above, there are a lot of determinants that influence the value of a ship and help with the investment decision. Owners need to know how and to what extent these determinants influence the value and future developments in the market. There is, to some extent, literature available for analysing and modelling the value of a ship when choosing between a newbuilt or a second-hand vessel (e.g. Tsolakis, Cridland, & Haralambides (2003), Merikas, Merika, & Koutroubousis (2008), Luo & Fan (2011)), but they focus mainly on larger container vessel, bulkers, and tankers.

With ever larger container vessels constantly being introduced, the market is acting increasingly as a hub and spoke network. Cascading effects have been observed as Handysize and Sub-Panamax vessels are increasingly being deployed to serve the short sea market, that is, to handle the final regional ocean carriage. This study will look into the determinants that can affect the investment decision made in the short sea shipping segment with regard to purchase and sales of Feeders, Handysize, and Sub-Panamax container vessels.

Due to the major role these kinds of vessels play in the hub and spoke network and the size of these fleets worldwide, an analysis of investment decisions in this sector is highly relevant.

To elaborate further we propose the following research question:

"How is the short sea container fleet developing and which are the main determinants affecting the sale and purchase of new building and second-hand short sea container ships?"

To be able to answer the main research question the following sub questions need to be answered.

1. *“What are the dynamics of the short sea container fleet?”*

2. *“What analytical approaches are of use to analyse the factors that influence the price of newbuilt and second-hand ships?”*

3. *“Which of these approaches are best suited to support the investment decisions made in short sea container ships markets?”*

The main research question is aimed at giving a clear picture of what factors affect new-order and second-hand prices and transactions made in Feeder, Handysize, and Sub-Panamax container ships and future developments of this fleet. In other words, this is what shipping investors should look out for when estimating the value of a ship, both in terms of price and future trading activity in the market.

To answer the first sub research question, we will look at data concerning fleet development and analyse the fleet dynamics, how different sizes of container ships are being deployed as well as data concerning real transactions made in the markets.

A comprehensive literature review will answer the second sub research question, firstly, with regards to econometric modelling and, secondly, to new-order and second-hand ship sales and purchase markets.

To answer the third sub research question, a selection of models will be run for each size category, Feeder, Handysize and Sub-Panamax. If valid models are found, they could be of use as a tool for investors when making decisions about whether to buy newbuilt or second-hand, by defining opportunities in time or making a forecast based on economic outlooks.

1.3 Thesis Structure

For the remaining chapters of this thesis, the following will be covered:

Chapter 2 will firstly introduce the reader to container shipping and short sea shipping. Secondly, maritime economics will be introduced by describing the shipping cycles and their associated risks. Lastly, the four shipping markets typically referred to in maritime economics will be covered.

In Chapter 3, we will analyse container fleet dynamics to see, for example, how the short sea fleet is responding to the delivery of mega-size ships with regard to route deployment and development of the fleet in general.

Chapter 4 will cover the existing literature related to our research and elaborate on different econometric models used to determine the price of a ship as well as identify important variables.

Chapter 5 is methodology and data. The methodology identified in the literature review and chosen for this study will be explained in more detail. The data we use in the models will be presented and it will be explained why we think this data is relevant in the models.

The results from the econometric models for newbuilding prices will be presented and discussed in Chapter 6 and the same for second-hand prices in Chapter 7. In these chapters, models will be assessed and diagnostic testing results introduced to examine if the models are a good fit to our data and viable. The models estimated are the Ordinary Least Squares (OLS), ARIMA (Autoregressive Integrated Moving Average), GARCH (Generalised Auto-regressive Conditional Heteroscedasticity), and VECM (Vector Error Correction Model).

Finally, Chapter 8 concludes the research and identifies recommendations for further research.

Chapter 2 Introduction to Container Shipping and Shipping Economics

2.1 Introduction

Shipping is a way of transporting goods from one place to another, satisfying the demand and supply of any given market. Martin Stopford categorizes cargo shipping into the three following segments.

- Bulk shipping: carrying homogeneous bulk cargoes.
- Container/general cargo shipping: carrying containerized general cargo.
- Specialized shipping: transporting chemicals, liquefied gases, forest products, vehicles, and refrigerated cargo (Stopford 2009).

Figures 2 and 3 show that bulk shipping is by far the largest fleet by gross tonnage (GT), but general cargo is however the largest by number of ships.

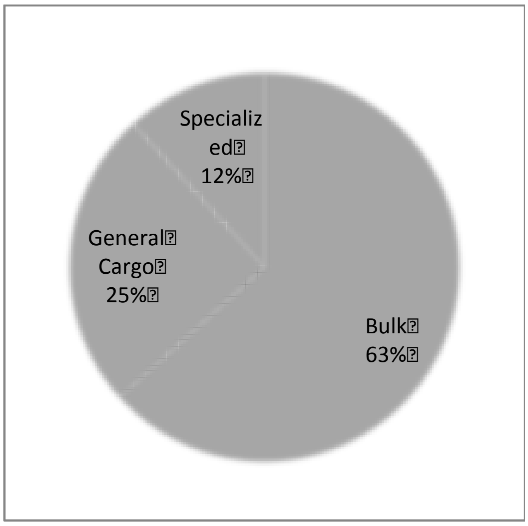


Figure 2: World Cargo Fleet by Type (% of GT)

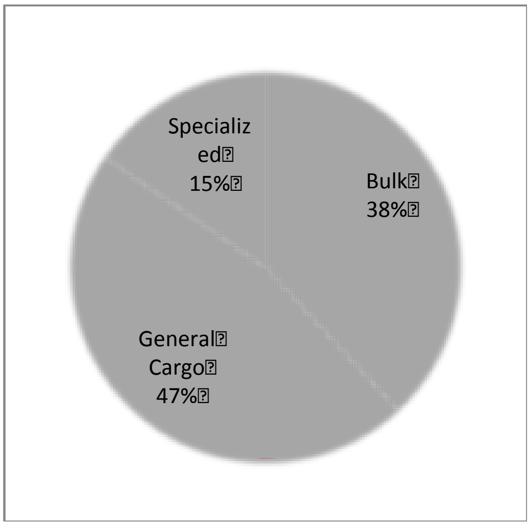


Figure 3: World Cargo Fleet by Type (% of number)

Source: Compiled by author from Clarkson Research Services Ltd. (2016b)

The shipping transportation system transformed greatly after the Second World War. As labour became more expensive, technological developments in machinery gradually replaced it. The three shipping segments mentioned above replaced cargo liners and tramps, which resulted in better use of economies of scale, standardization, automation, and better designed ships to optimize stowage and handling (Stopford 2009).

The first half of this chapter concentrates on container shipping and, more specifically, on the evolution of containerization, short sea shipping, and getting to know the different types of container ships and their characteristics. The second half of the chapter is devoted to maritime economics. Firstly, the business cycles in shipping and the consequent risk and, secondly, the four shipping markets and how they relate to the shipping cycles.

2.2 Containerization

The invention of the metal box called a container is the fundamental trigger to innovation in container shipping, making the shipping of goods cheap and contributing heavily to economic development. These boxes date back to the 18th century when companies began operating with containers and, after the First World War, the first roll-on/roll off (Ro-Ro) ship was built. Although the container dates back to the 18th century, real containerization did not start until the 1960s (Wijnolst & Wergeland 2009).

The complexity of handling conventional cargo in ports was a trigger to containerization. Depending on customs category, destination, consignee, and other things, the cargo had to be categorized on the dock itself which was very time-consuming and created bottlenecks. Ongoing improvement and innovation in port infrastructure to handle conventional cargo and vessels designs were not enough to exploit the economies of scale with growing vessel sizes. The ships had a very long turnaround time in ports, spending of average 30% of their voyage in port (or waiting for docking) with up to 50% in some areas (Vigarie 1999). These delays forced manufacturers, wholesalers, and retailers to keep large stocks on hand, which meant tying up expensive capital. These facts and the high cost of labour meant that the supply chain was becoming too expensive, thereby preventing international trade and economic development (Haralambides 2007).

This disability in the handling conventional cargo in an efficient way also put a 15,000 DWT cap on vessels capacity (Wijnolst & Wergeland 2009). The first years after the introduction of the container, growth in the size of ships was comparatively high. The first generation of container ships were converted cargo ships, merchant vessels, and conventional vessels. The second generation were purpose-built container vessels with cell guides to enable more efficient loading. The third generation of container vessels were the Panamax vessels introduced in the early 1970s with the carrying capacity of 3,000 TEU. In a six-year span, the deadweight had increased from 15,000 DWT to 55,000 DWT (Wijnolst & Wergeland 2009). After this rapid growth, there was a plateau phase and the 4,000 TEU vessel was not introduced until 1988. That is when the trend of ever-larger container vessels started for real and the development was fast, as shown in Chapter 1.

2.3 Short Sea Shipping

Depending on the length of the haulage, shipping can be categorized as deep sea shipping (DSS), short sea shipping (SSS) and inland shipping.

Deep sea shipping is the long haulage between continents, connecting major industrial areas such as, for example, Asia and Europe. These trades are most commonly operated by larger vessels taking advantage of economies of scale for either low-cost bulk transport or more expensive container liner service (Stopford 2009). Short sea shipping is the transport of goods within regions (short haul). The vessels used for this trade are smaller than the deep sea vessels and often referred to as feeders. They are more flexible than the deep sea vessels and make a lot more port calls, thus needing good organisational skills (Stopford 2009). Inland shipping is mainly covered by barges working on waterways, either intra-port between terminals or between inland ports.

Deep sea vessels and short sea vessels often interact in a so called ‘hub and spoke system’, where deep sea vessels ship containers between hubs (large ports such as Rotterdam and Singapore) and then the feeders—the spokes—deliver containers to their final destination port.

The most significant short sea markets worldwide are the Asian and the European markets. In 2003, 10,000 ships (500-10,000 GT) made 457,000 port calls between European ports out of 20,000 ships and 1,070,000 port calls worldwide, thus making European short sea shipping (both container and bulk) 45% of the world total short sea activity that year (Wijnolst & Wergeland 2009, based on Lloyd's Marine Intelligence). Looking at the fleet deployed to the short sea container market at the beginning of 2016, Clarkson Research Services found that 26% of the world container fleet operated intra-Asia and 13% intra-Europe. Then, 4% operate in other short sea markets, making a total of 42% operating intra-regional (short sea). Further analysis of the fleet deployment will be carried out in Chapter 3.

As short sea ships operate in a regional market, they act both as a supplement and competition to road and rail transport. Many nations rely heavily on the highway system to carry cargo which is known to be the most expensive and polluting way of transport, as well as creating traffic congestions (Medda & Trujillo 2010). To clamp down on these negative effects of road transport, policy makers, such as the European Union (EU), promote SSS to achieve a more sustainable transport network by moving transportation of cargo from the roads to SSS (Musso et al. 2002). Musso et al. (2002) mention that this will have environmental benefits as SSS is less polluting and safer than road transport. Surface transport congestion reduces economic benefits. Reducing surface transport reduces capital expenditure on road infrastructure. Turning more to SSS will increase the competitiveness of ports.Similar to Musso et al., Baird (2007) points out three advantages of sea transport compared to land transport: The sea is free and does not need any kind of maintenance, it is very spacious and not congested like narrow roads and railways, and the capacity of sea transport can easily be increased compared to land transportation, as roads and railways have complex infrastructure and need large capital to expand.

2.4 Types of Container Ships

Stopford (2009) describes a container ship as “*in principle, an open-top box in which containers can be stacked”*. This description is, however, more relevant to the characteristics of larger container ships (deep sea vessels) as they are rather homogeneous compared to short sea ships (Feeders, Handysize, and Sub-Panamax). As this study covers only the short sea container vessels, a further analysis of the characteristics of these kinds of ships is needed.

Firstly, the ship can either be geared or gearless, meaning that some ships are geared with cargo handling equipment to load and discharge containers/cargo. Secondly, the ship can either be cellular or multi purpose (MPP).

Cellular container ships have cell guides under deck (in the hold) in which containers can be fitted and stacked on top of each other without further lashing. Then hatches are used to close the hold, making it possible to stack more containers on top of the hatches, which, then in absence of cell guides, require lashing (twist-locks and chains) to secure the cargo. There are also fully cellular container ships which are not equipped with hatches and therefore resemble more the description by Stopford of the 'open-top box'.

Multipurpose vessels are capable of carrying both break bulk cargo (non-containerized) as well as containers. They usually do not have cell guides so all container must be lashed and secured. Further, this kind of vessel often has tween decks (one extra deck) to optimize the intake of different types of cargo, containers as well as break bulk. Figure 4 shows an example of a geared MPP vessel with tween decks in the holds.

Figure 4: Example of a Multipurpose Vessel
Source: Kable Intelligence Limited 2016

Deep-sea container vessels (Panamax and larger) are more standardized compared to the short sea container vessels as they are hardly ever geared, with no tween decks, nor hatches and sail mostly on main routes without entering cold waters (needing reinforced hull).

When it comes to classifying different sizes of container ships, sources differ. For the remain of this study, we use the classification found in various documents from Clarkson Research Services:

Feeders – Feeders can further be broken down to 'Feeders' which can carry 100-499 TEUs and 'Feedermax' which can carry 500-999 TEUs. These vessels are used for short haulage, distributing containers within regions, from 'hubs' such as Rotterdam as well as coastal carriage (Stopford 2009). In June 2016, 39% of this fleet was geared.

Handysize – These vessels can carry 1.000-1.999 TEUs. Like the Feeders they are mainly used for regional trade but are also capable of serving the long North-South trades (Stopford 2009). In June 2016, 52% of this fleet was geared.

Sub-Panamax – These vessels can carry 2.000-2.999 TEUs and mainly serve the same trade as Handysize. In June 2016, 54% of this fleet was geared.

Summary of all the ships sizes can be seen in Table 1.

Table 1: Types of Container Ships

Type	Ship size TEU	Average Length Overall (LOA) in meters	Average Draft in meters	Average Beam in meters
Feeders	100 - 999	122	7,0	19.6
Handysize	1,000 - 1,999	166	9,3	25.5
Sub-Panamax	2,000 - 2,999	208	11,4	30.5
Panamax	3,000 - 4,999	255	12,2	32.2
Post-Panamax	5,000 - 7,999	280	13,7	39.7
Post-Panamax	8,000 - 11,999	329	14,5	45.2
Post-Panamax	12.000 +	374	15,4	51.4

Source: Compiled by Author from Clarkson Research Services Ltd (2016b)

Figure 5 shows the share of each fleet by ship types. We see that the Handysize fleet is the largest with a 24% share and together with the short sea ships (<3,000 TEU) account for 56% of the world total container fleet.

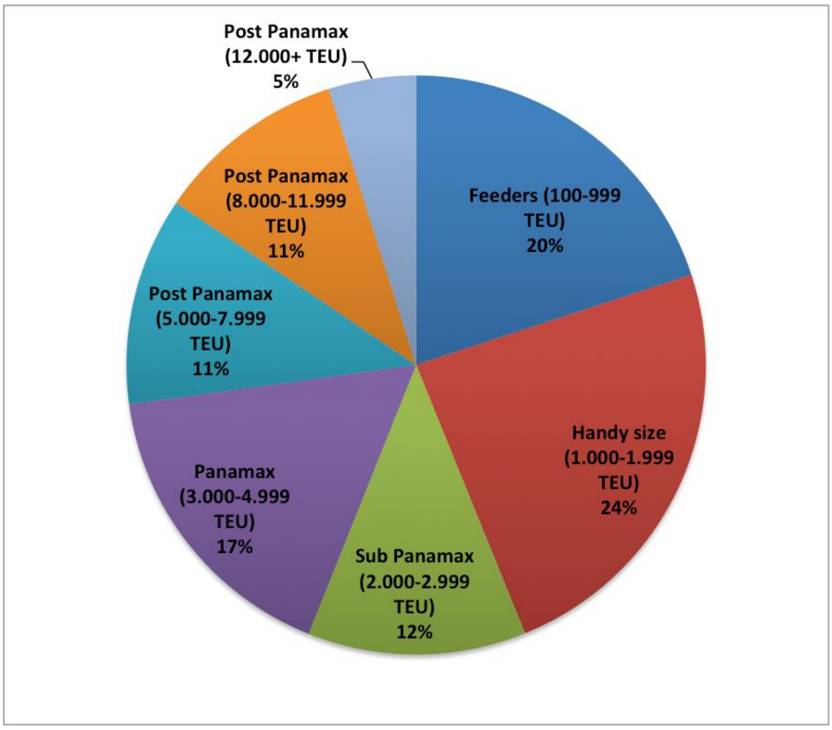


Figure 5: Container Fleet July 2016
Source: Compiled by author from Clarkson Research Services Ltd.

2.5 Shipping Cycles and Risk

As mentioned in Chapter 1, the shipping business is very cyclical and exciting to operate in. Economic cycles exist in many industries and are often categorized as long, short, or seasonal cycles. One long-term cycle—which lasts, for example, 60 years—consists of multiple short-term cycles, also referred to as business cycles, which typically last 5-10 years. These short-term cycles are mostly what is referred to as a shipping cycle in maritime economics (Stopford 2009). Martin Stopford puts the challenges of a ship owner nicely in a metaphorical way.

These shipping cycles roll out like waves hitting a beach. From a distance they look harmless, but once you are in the surf it's a different story. No sooner has one finished than another starts and, like surfers waiting for a wave, ship owners cluster in the trough, paddling to keep afloat and anxiously scanning the horizon for the next big roller. Sometimes it is a long wait.

This explains well how volatile the business of shipping is for ship owners. Never should they doze off enjoying the ride of a big wave because history has shown that one cycle in the shipping business is a short-term one and the owners should be fit enough to paddle in the trough at some point in time. Some courageous investors will try to gain profits from one wave with an 'asset play', buying low and selling high.

Figure 6 shows the four typical market stages of the shipping cycle: Trough, Recovery, Peak, and Collapse, followed by explanations based on Stopford (2009).

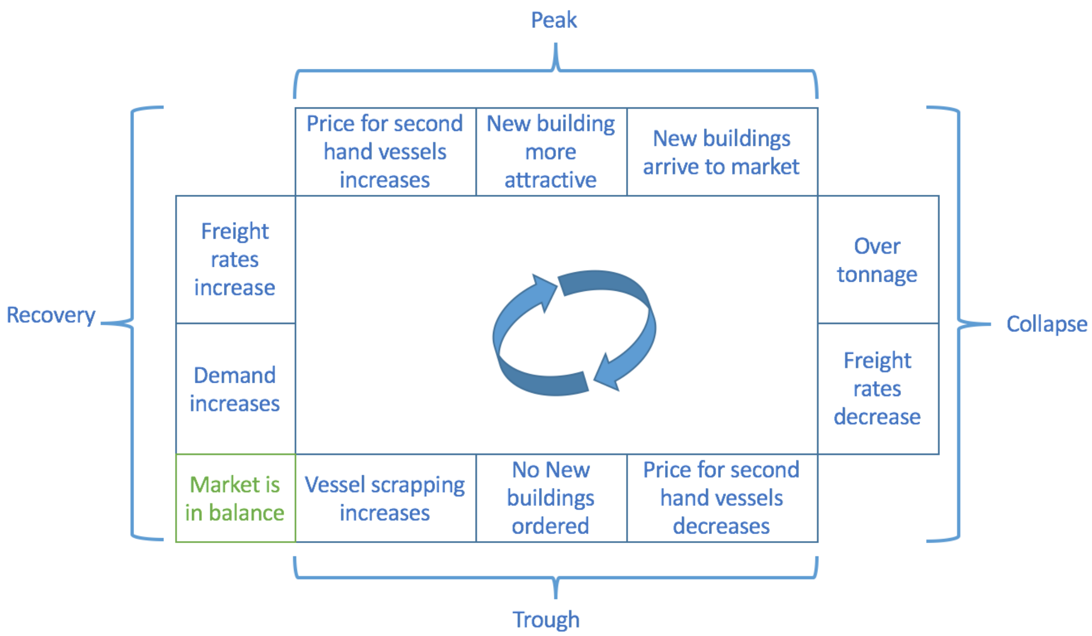


Figure 6: Typical Market Stages in a Shipping Cycle
Source: Author based on Stopford (2009)

Trough—The market has an over-supply of available ships and freight rates are low. Due to low freight rates, the price for a second-hand vessel is low which makes investment in newbuildings not so attractive. As freight rates fall below the operating cost of the least efficient vessels, ship owners see no alternative but first to lay them up and further, many are scrapped in the end. Eventually the market will reach recovery stage as supply and demand for ships balances.

Recovery—As demand increases, freight rates start to pick up and go beyond the operating cost of the least efficient vessels (the ones that survived the trough and were not scrapped). Second-hand prices increase with increased liquidity and banks become more keen to lend capital to buyers.

Peak—Second-hand prices go beyond their replacement cost as many buyers are impatient and do not want to wait for newbuildings. Others, not as impatient, place an order for new vessel which, after some time, will result in oversupply.

Collapse—When supply then overtakes demand, the freight rates start to fall again. Inefficient vessels are idle, waiting for cargo, or laid up. Ship owners are hesitant to sell ships at a discount because they refuse to believe that the peak is over while liquidity remains high.

Koopmans pointed out in 1939 that the main reason for the cyclicality of the shipping market was the lag between the ordering of a newbuilt vessel and the time it arrived at the market. Owners would order new vessels according to an expected future freight rate in the peak of the cycle which might, at the time the vessels arrive at the market, not be as profitable. In these situations, it would further depress a depressed market by increasing its oversupply (Tsolakis 2005).

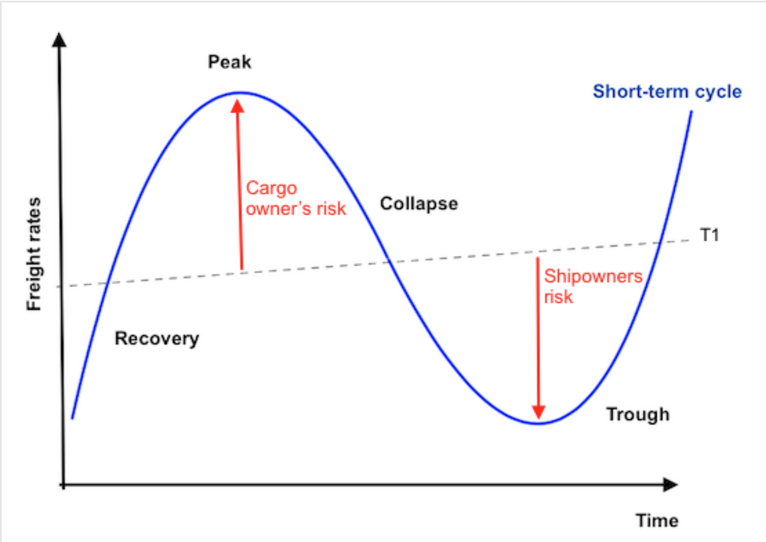


Figure 7: Risks of the Shipping Sycle
Source: Stopford (2009)

This highly cyclical shipping market, makes it a risky market in which to operate. Risk can be explained as '*measurable liability for any financial loss arising from unforeseen imbalances of supply and demand'* (Stopford 2009). The risk takers are the cargo owners (shippers) and the ship owners, which in the long run balance the supply and demand between them. Figure 7 explains in one short-term cycle how the risk is allocated between the two risk takers. The break-even cost of transport is the line T1 which is what long-run freight rates would be in a perfect market. When freight rates are high, in the peak of the cycle, cash is transferred to the ship owners and cargo owners bear the financial risk. On the other hand, when freight rates are low, in the trough of the cycle, the cargo owners ship their goods cheap and the cash transfers to them, thus with ship-owners bearing the risk and losing money (Stopford 2009).

Shipping investors can, however, adjust their exposure to risk by 'playing the cycle' and varying their individual risk profile (Stopford 2009). Ship owners can minimize their risk by having a certain number of ships on time-charter contract and others on voyage-charter contracts (contracts further explained in 2.7.1). They would then use time-chartering as a hedging instrument by fixing the freight rate for a period, thus also limiting their chance of increased cash during peaks. Opposite to this, they can also place their vessels on the spot-market (voyage-charter). This is riskier because freight rates might suddenly decrease, thus reducing the owners cash flow. The same goes if the market suddenly starts to rise, thus increasing the cash flow (Scarsi 2007).

A successful ship owner and investor in shipping is the one who understands these cycles and risk and times his investments well in line with the peaks and troughs of the market. By rationale, he should buy low, sell high, and—when the market is rising—he should spot-charter and—when the market is at a peak—he should time-charter (Scarsi 2007). Further, he survives the troughs by not having overwhelming debt and allocates his profits wisely during peaks so he can survive the next (somewhat unavoidable) trough. Of course, all these aforementioned rational choices sound good in theory but are very hard to apply in practice.

2.6 Decisions Facing Ship Owners

It has now been very well established how cyclical and risky the shipping business is as ship investors base their actions on future expected freight rates which are very volatile. Not only does this volatility make the investment decision hard, but the high capital needed to buy a ship also plays a big role, as shipping is one of the most capital intensive industries in the world (Luo & Fan 2011). When buying new ships, ship owners pay high capital cost which is often almost half of the cost of running the new ship. However when ship owners buy second-hand ships, they pay less capital cost due to the lower price of the vessel but instead they pay a higher operational cost as older ships are less efficient (Luo & Fan 2011).

As the competition in shipping is fierce, shipping companies look to make their fleet more efficient by buying new vessels, thus increasing their market share and gaining more profits. However, when the ships are delivered, the market may have declined and might be oversupplied with new ships as many shipping companies think alike. When the ships are delivered, the freight rates might be much lower than was expected when the newbuilding order was made and the capital cost of running a new ship may be catastrophic for the shipping company (Luo & Fan 2011).

This future uncertainty that ship investors have to deal with when deciding to buy a ship makes a second-hand purchase slightly less risky. The ship is delivered into a current known market situation, and profits can be established right away. However, higher operational cost and possible unexpected maintenance can reduce the competitiveness of the company (Luo & Fan 2011).

2.7 Four Shipping Markets

As the previous section showed, ship owners have to take many critical and difficult decisions in a cyclical and risky shipping market. This shipping market can be broken down to four markets, the Freight market, the Demolition Market, the Shipbuilding market and the Sale and Purchase (S&P) market. These are the markets that ship owners take action in, and they can all be linked together as cash flows between them (Stopford 2009).

2.7.1 Freight Market

The freight market is the main source of cash and practically the driving force of ship investments. If freight rates are high and ship owners or investors are optimistic that the rates will stay high for some time, they tend to buy a second-hand vessel in the S&P market or place an order for newbuilt vessel in the shipbuilding market. On the contrary, if freight rates are low and the ship owners are pessimistic, they might decide to sell the ship in the S&P market or, if times are really bad, sell it in the demolition market.

As mentioned earlier, a ship owner can ‘play the cycle’ by choosing his risk profile. According to Stopford (2009), there are four types of charter contracts he can choose to enter his ship in to:

Voyage charter—Also called freight contract, it is the riskiest market in which the ship owner can operate. A charterer (cargo owner) hires the ship for one voyage only, bringing his goods from port A to port B. The rate is fixed per tonne shipped, with all operation cost included (even port cost and bunkers) and the master is instructed by the ship owners. A voyage charter is mainly used for the bulk sector and not container business, which this study focuses on.

Contract of affreightment (COA)—A more complicated version of a voyage charter. Here the charterer hires a vessel to ship a series of cargo from A to B over a certain period and pays a fixed fee per tonne. This way, the ship owner can plan other use of the ship in accordance with the charterer’s needs to optimize the utilization of the ship.

Time-charter—A contract where the charterer hires the vessel for a specific time period. The rate is fixed per day and the charterer instruct the master where to load and discharge cargo, but the owner gives the instructions for the ship. Charterer pays for port cost and bunkers.

Bare boat charter—The charterer also hires the vessel for a specific time period, but unlike the time-charter he is fully in charge of the operation of the vessel and pays all operation costs, leaving only the capital cost with the owner.

2.7.2 Sale and Purchase Market

Shipping is an intriguing market and one of few industrial markets where its main capital assets, the ships, are traded like any other commodity. Ship owners and investors come together in the S&P market to sell and buy ships, usually via broker, thus establishing easy entry and exit to the freight market. These characteristics make the market very competitive (Tsolakis et al. 2003a).

The extreme price volatility in the S&P market make it attractive to investors who see the opportunity in making profit from‘asset play’ by timing their activities well, thus buying low and selling high (Tsolakis et al. 2003b & Stopford 2009). Stopford (2009) indicates four factors that influence the price of the ship. Freight rate is the most important factor when valuing a ship as it has shown to be closely correlated with the price. The other three factors are the age of the ship, inflation, and ship owner’s expectations.

2.7.3 Newbuilding Market

Similar to the S&P market, the prices in the newbuilding market are highly volatile. The price of newbuilding is dependent on market expectations, shipbuilding cost, and the shipyard capacity. The shipbuilding prices and second-hand prices are also closely correlated, and some even argue that they are substitute commodities (Haralambides et al. 2004).

However, the newbuilding market is a little more complex than the S&P market. Firstly, as the ship is not yet built, negotiations about ship design must take place. If the buyer settles for a standardized design from the shipyard, he can save both time and money compared to when modifications to the standard design are required. Secondly, as this is a major industrial undertaking, a contract between the buyer and the yard is much more complex than in an S&P market. Thirdly, when you buy a second-hand ship in the S&P market, the ship is delivered to you promptly, while a newbuilding will not be available for 2-3 years, which after that time, market circumstances might have changed (Stopford 2009).

2.7.4 Demolition Market

When the value of the vessel in the S & P market has reached below the scrapping value of the ship, a ship owner should consider selling it to a demolition yard. Although this is the rational thing to do, many ship owners hold on to the vessel hoping that the competitive shipping market will improve, and that others will scrap their vessels before them (Adland & Strandenes 2004). The price a ship owner gets for his vessel is based on the number of ships already available for scrapping as well as the demand for scrap metals. These demolition yards are situated mostly in Asia (e.g. China, Bangladesh, India, and Pakistan).

2.8 Summary

The shipping transportation system went through a sweeping transformation in the 19^{th} century, mainly technological development of handling equipment in ports, vessel design, and the introduction of the container. Short sea shipping is an important part of the transportation system, both in connecting larger hubs with final destination ports and as an alternative to the more polluting and congested land transport. The shipping market is very volatile as the shipping cycle is often identified as a short one. One cycle has four phases: peak, where demand is high and prices are high; collapse, where demand falls and overcapacity starts to affect the market; trough, where prices are very low and vessels are sold for scrap or laid up; recovery, where prices start to increase and the market comes to a balance for a while. This volatile cyclicality makes the shipping business a risky one and owners need to evaluate carefully the risks to all decisions made in different markets, whether in regard to freight contracts, buying a second-hand or newbuilt vessel, or deciding between scrapping a vessel or waiting out the trough.

Chapter 3 Container Fleet Dynamics

This chapter will cover the fleet dynamics of short sea ships. First will be an analysis of the fleet and route deployments, second, an analysis of the development of the fleet and orderbook, and, last, an analysis of activity in the sale and purchase market. The objective of this chapter is to answer the first sub research question.

3.1 Multipurpose Container Fleet

The MPP fleet has not sustained growth over the last years and is facing competition with the container fleet and bulk fleet which have, in recent years, had surplus capacity. Container ships are expected to keep gaining market share as cargo handling infrastructure in ports keeps improving and more cargo is containerized (Clarkson Research Services Ltd 2016c).

Due to how heterogeneous the fleet of MPP vessels is and the limited availability of data compared to container vessels, no further analysis will be done.

3.2 Effect of Deliveries of Mega Size Ships on Short Sea Fleet

As we saw in Chapter 1, the trend of ever larger vessels since the 1990s has not yet come to a stop. According to the Clarkson Shipping Intelligence Network Database (2016), the largest container ships sailing the seas in July 2016 have a capacity of 19,224 TEU, and the first 21,100 TEU vessel is expected to be delivered by the end of 2016. Lately, when new record-breaking mega size ships are delivered to the market, they start off by trading in the main lane between the Far-East and North-Europe (OECD/ITF 2015). Then, when the next generation of even bigger ships are delivered, a cascading effect takes place, deploying very large vessels to other trade lanes with less demand, where smaller vessels currently operate. This delivery of a new generation of mega size ships has, therefore, an effect on the whole maritime transport chain, including the short sea sector (OECD/ITF 2015).

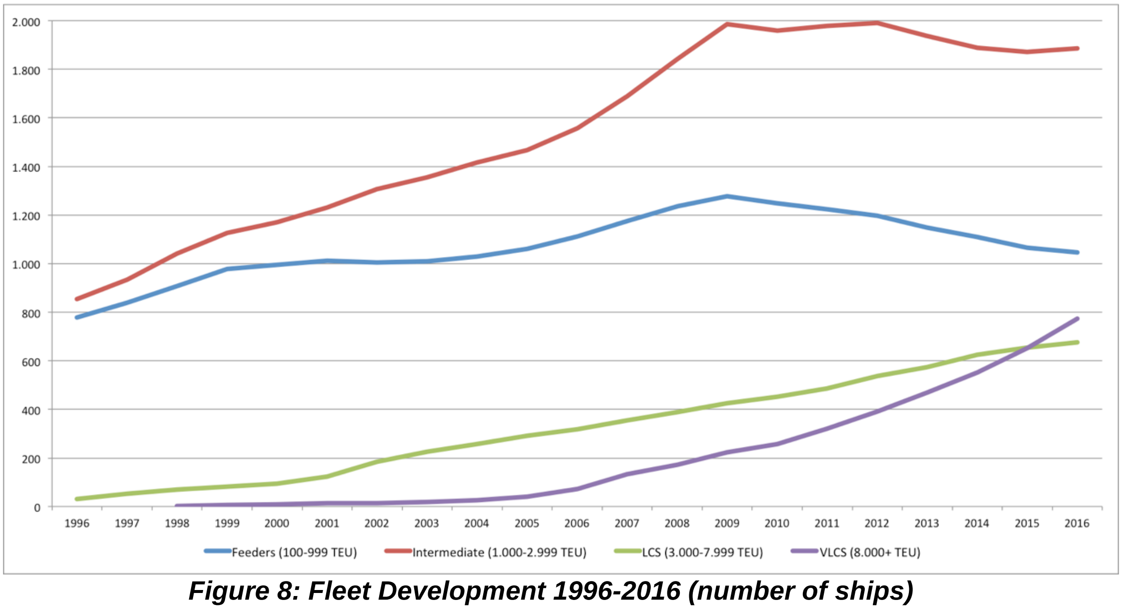


Figure 8: Fleet Development 1996-2016 (number of ships)
Source: Compiled by author from Clarkson Research Services Ltd (2016b)

If we now categorize the ship sizes to four groups: Feeders (100-999 TEU), Intermediate (1,000-2,999 TEU), Large Container Ships (LCS, 3,000-7,999 TEU), and Very Large Container Ships (VLCS, 8,000+ TEU), we see in Figure 8 that the VLCSs are constantly growing while the short sea vessel fleet (Feeder and Intermediate) has declined since 2009. However, the cascading effect on the intermediate size seems to have slowed down since 2014.

3.3 Fleet and Route Deployment

Clarkson Research Services publishes a quarterly review and outlook for the container shipping market called Container Intelligence Quarterly. An assembly of their review for the first quarter of every year since 2011 was made to show the development of the fleet deployment (unfortunately this estimate of deployment was not in the reviews before 2011).

3.3.1 Ship Deployment by Route

Starting by looking at the development of ship deployment by route to capture the cascading effect on the short sea market, we begin with the VLCSs.

3.3.1.1 Very Large Containers Ships

Figures 9 and 10 show an estimate of how the VLCS fleet is being deployed among routes. It is interesting to see that almost all the fleet was deployed to the main East-West route in 2011. However, in 2016, their deployment in the North-South and Non-Main East-West routes has grown rapidly, bringing the share of deployment in the Main East-West route down to 71%. The changes in the deployment as a percentage of TEU is not as dramatic, as lower capacity vessels within the VLCS's are deployed instead in the North-South and Non-Main E-W trades. As shown below, the VLCSs are starting a cascading effect by entering the North-South route and Non-Main E-W route.

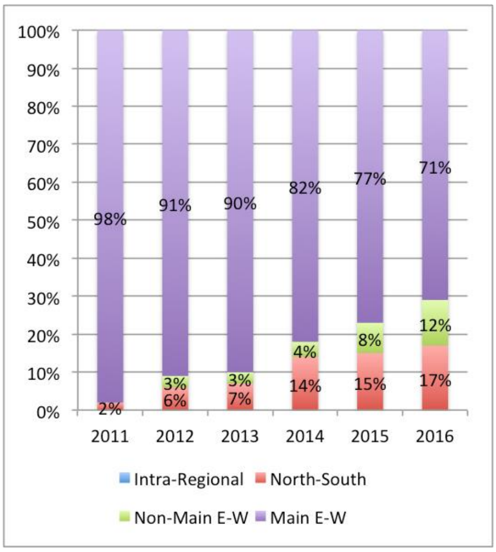


Figure 9: Estimated VLCS Deployment by Route (% of No.)

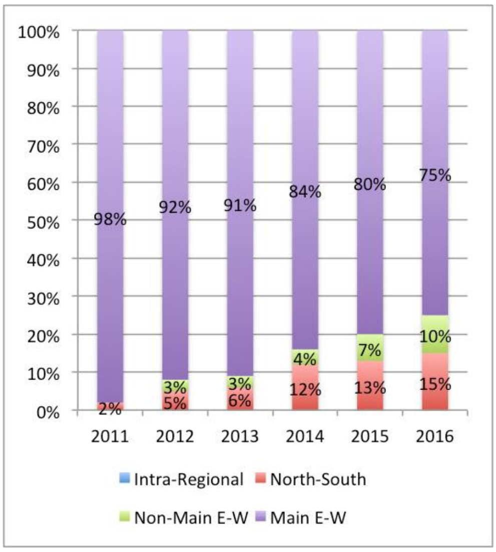


Figure 10: Estimated VLCS Deployment by Route (% of TEU)

Source: Compiled by author from Clarkson Research Services Ltd (2016b)

3.3.1.2 Large Container Ships

Figures 11 and 12 show an estimate of how the LCS fleet is being deployed among routes. As shown below, this size of ship is decreasingly being deployed to the Main East-West trade, from 53% in 2011 to 36% in 2016, while increasingly operating in the Intra-Regional and South-North trade. Here, the cascading effect continues as VLCSs enter the main-lane, the LCSs cascade down to the North-South and Intra-Regional route. Interestingly, the cascading effect seems to skip the Non-Main E-W route as the deployment of LCS in that route is rather stable while VLCSs increased by 12 points.

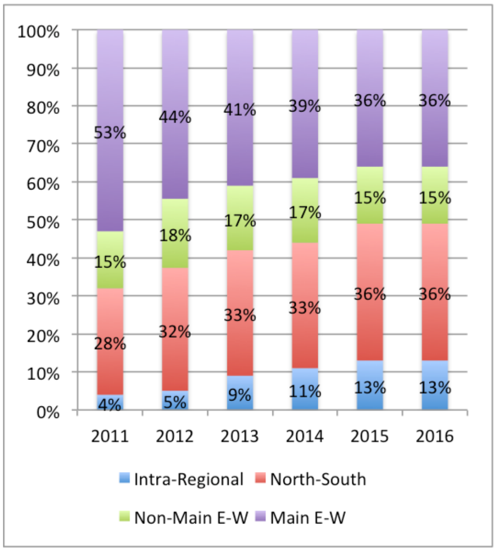


Figure 11: Estimated LCS Deployment by Route (% of No.)

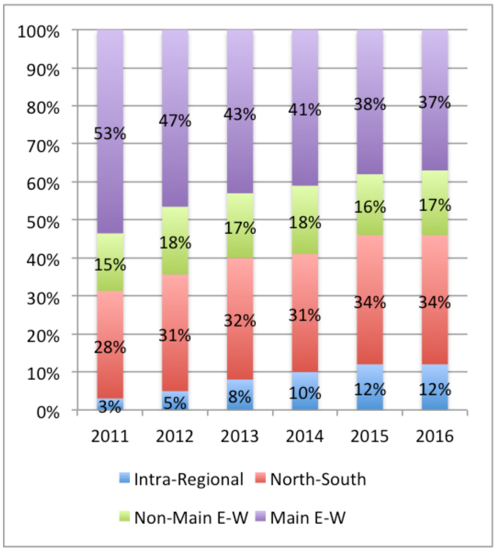


Figure 12: Estimated LCS Deployment by Route (% of TEU)

Source: Compiled by author from Clarkson Research Services Ltd

3.3.1.3 Intermediate

Figures 13 and 14 show an estimate of how the Intermediate fleet is being deployed among routes. In 2011, this category of ship operated 53% in the Intra-Regional route and 33% in the North-South trade. Now, in 2016, the Intra-Regional trade is up to 71% and the North-South trade is down to 22%. These vessels also are being decreasingly deployed to the East-West trades. These changes in deployment in only five years give a clear hint that these types of vessels are moving from North-South trade and engaging more in the short sea segment. The percentage of TEU deployment in Figure 13 is in sync with the number of ships in figure 14. The rational reason for less of a share of Intra-regional in TEU is that within this Intermediate category, Handysize vessels with lower capacity operate instead in short sea trade and the larger Sub-Panamax in North-South trade.

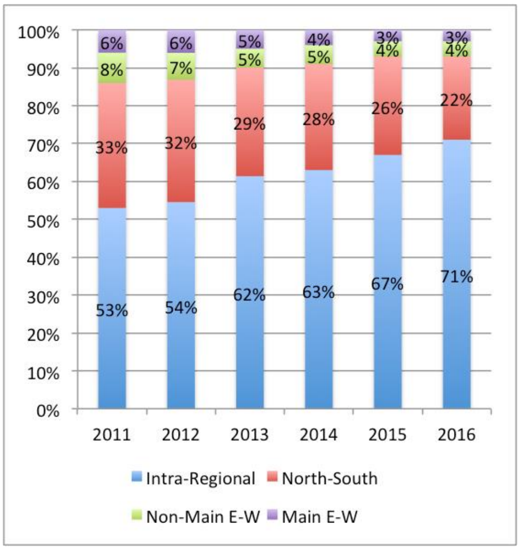


Figure 13: Estimated Intermediate Ship Deployment by Route (% of No.)

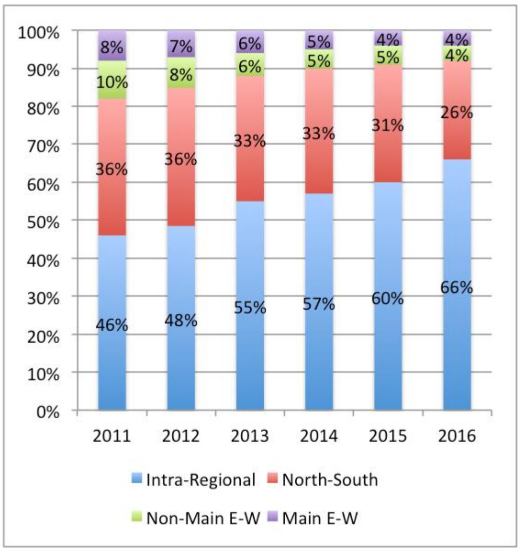


Figure 14: Estimated Intermediate Ship Deployment by Route (% of TEU)

Source: Compiled by author from Clarkson Research Services Ltd

3.3.1.4 Feeders

Figures 15 and 16 show an estimate of how the Feeder fleet is being deployed among routes. Here, the dynamics are not great and not surprising; the majority of the fleet is being deployed in the short sea market and with very stable deployment year to year. Most dynamic is the near abolition in the Non-Main E-W route, from 4% in 2001, down to 1% in 2016 for both number of ships and TEU.

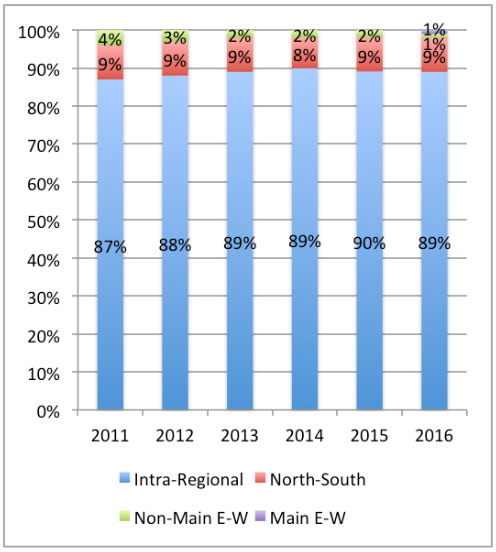


Figure 15: Estimated Feeder Deployment by Route (% of No.)

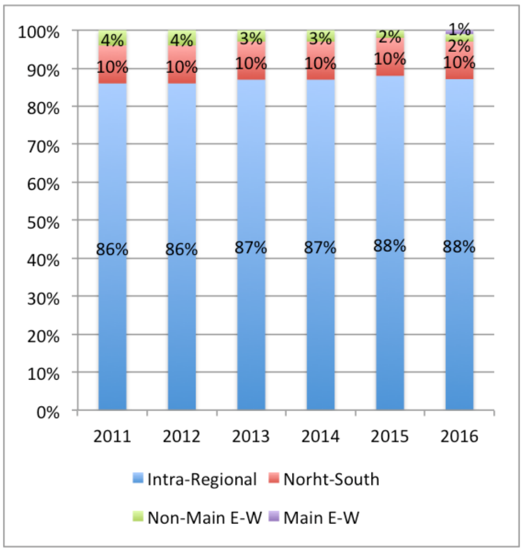


Figure 16: Estimated Feeder Deployment by Route (% of TEU)

Source: Compiled by author from Clarkson Research Services Ltd

3.3.2 Route Deployment by Ship Type

T Turning from ship deployment by route to route deployment by ship type begins with looking at the deep sea trade to capture the cascading effect.

3.3.2.1 Main East-West (deep-sea)

Figure 17 and 18 show the estimated deep sea route deployment by ship type. As shown, in 2011 only 25% of the vessels operating in this trade were VLCSs. Now, in 2016, they have doubled, gone up by 26 points, and now comprise 51% of the vessels operating in this trade. The LCSs are down by 21 points, going from 66% to 45%, and the Intermediate size has gone down from 9% to 4%. Because of the enormous capacity of the VLCSs, the change in TEU is even more dramatic as the deployment in TEU is up by 31 points for the VLCSs and the Intermediates are down to 1%, from 4% in 2011. As expected, there are no feeders operating in the deep sea trade.

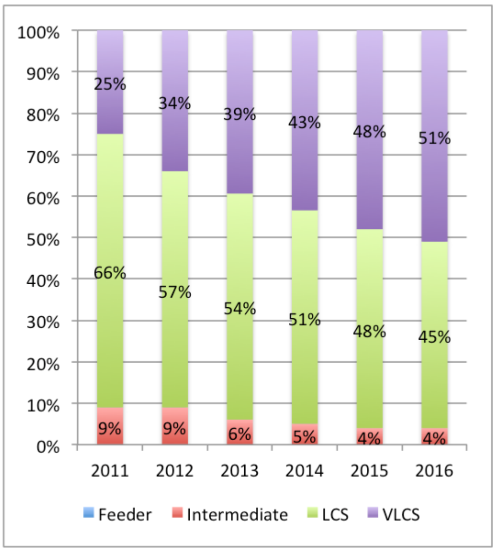


Figure 17: Estimated Deep-sea Route Deployment by Ship Type (% of No.)

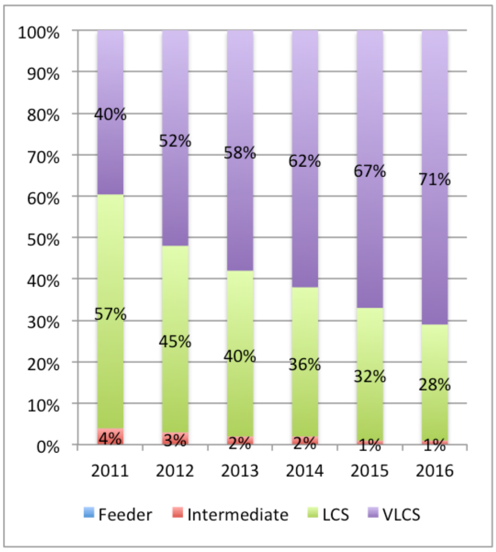


Figure 18: Estimated Deep-sea Route Deployment by Ship Type (% of TEU)

Source: Compiled by Author from Clarkson Research Services Ltd

3.3.2.2 Non-main East-West

Figures 19 and 20 show the estimated non-main east-west route deployment by ship type. As shown, the VLCSs entered this trade in 2012 and have grown rapidly since then at the expense of intermediate sizes. As expected, the dynamics in share of TEU are more dramatic than the number of vessels, given the large capacity of VLCSs.

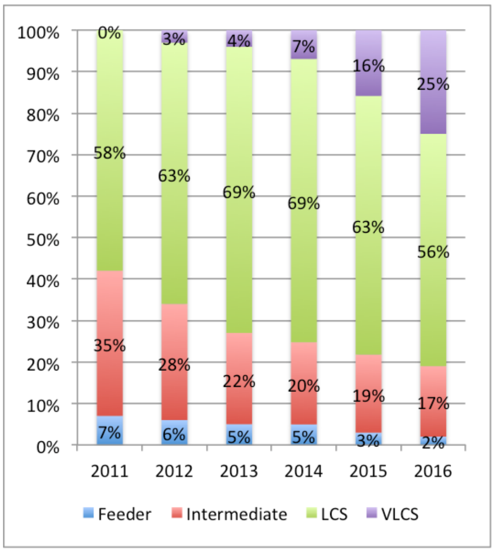


Figure 19: Estimated Non-main East-West Route Deployment by Ship Type (% of No.)

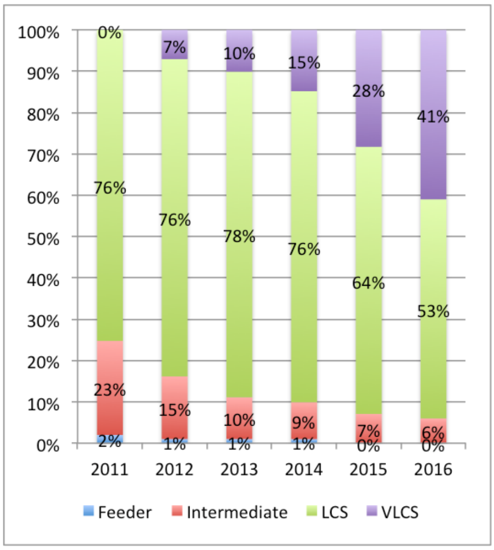


Figure 20: Estimated Non-main East-West Route Deployment by Ship Type (% of TEU)

Source: Compiled by author from Clarkson Research Services Ltd

3.3.2.3 North-South

Figures 21 and 22 show the estimated North-South route deployment by ship type. In this trade, a trend similar to that in the non-main east-west trade can be seen, where the VLCSs are gaining share every year. However, different from the non-main east-west trade, the LCSs are also gaining market share owing to a decrease of 20 points among the intermediate sizes from 53% down to 33%. As shown below, the intermediate vessels, which in recent years have been identified as mainly serving the North-South trade, are not dominant in this trade any more.

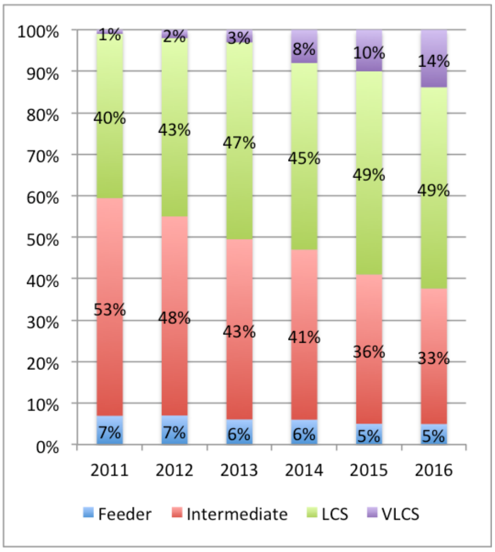


Figure 21: Estimated North-South Route Deployment by Ship Type (% of No.)

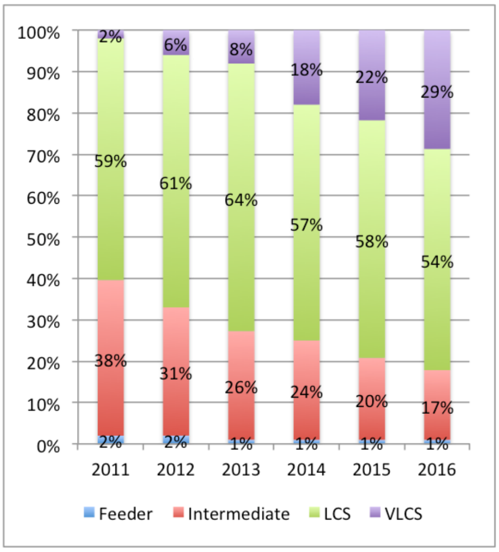


Figure 22: Estimated North-South Route Deployment by Ship Type (% of TEU)

Source: Compiled by author from Clarkson Research Services Ltd

3.3.2.4 Intra-regional (short sea)

Figures 23 and 24 show the estimated short sea route deployment by ship type. As shown below, in 2011, 43% of ships trading in the short sea market were Feeders, 54% were Intermediate, and only 3% were LCS. Five years later, the market share of Feeders in the short sea trade had dropped by 12 points, down to 31%, the intermediate ships had increased by 5 points, up to 59%, and LCS's increased by 7 points, up to 10%. Comparing the market share of Intermediate in other trades, we see that the loss they sustain in other trades, for example, 20 points in North-South, is not nearly made up for in the Intra-regional trade, were the increase is only 5 points. When looking to the market share by percentage of TEU, we see more dramatic changes. There we see the LCSs almost triple in market share of TEU which is, however, logical given their increase in the number of ships and that they can carry 3-8 times the volume of Feeders and 2-3 times the volume of Handysize and sub Panamax. As expected, no VLCSs are operating in the short sea market.

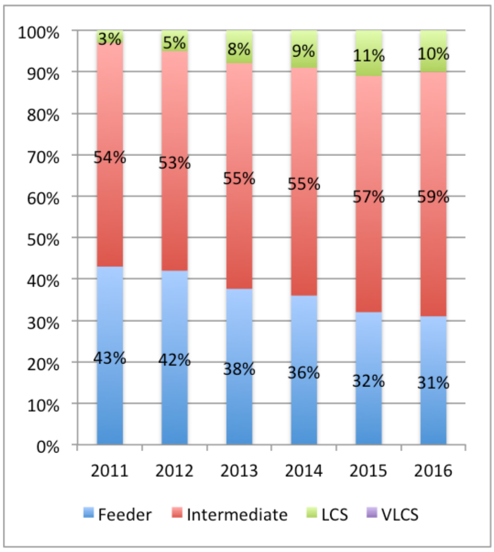


Figure 23: Estimated Short Sea Route Deployment by Ship Type (% of No.)

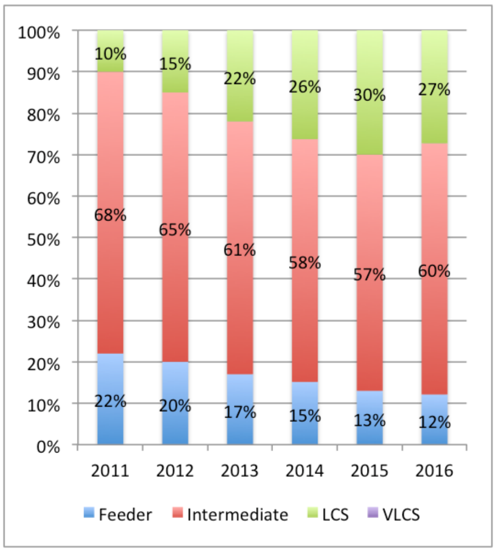


Figure 24: Estimated Short Sea Route Deployment by Ship Type (% of TEU)

Source: Compiled by author from Clarkson Research Services Ltd

3.3.3 Conclusion

Below is a summary of all estimations about fleet deployments as presented earlier and how they impact the vessel types under investigation.

Feeders are, as expected, staying within the intra-regional trade (short sea) with almost 90% of the fleet being deployed intra-regional, with little or no dynamics between years. However, we notice dynamics in the Feeders market share within the short sea route, as it has decreased from 43% in 2011 to 31% in 2016.

The Intermediate vessels, Handysize and Sub-Panamax, are moving down to the intra-regional trade with 71% of the fleet being deployed there in the beginning of 2016, compared to 53% in 2011. They are thus moving from bigger trades, especially from the North-South trade, where they went from 33% down to 22%. It can be concluded that the reason for this is the cascading effect of VLCS vessels. The intermediate vessels are now dominating the intra-regional trade with a 59% market share. Further, their market share in the North-South trade has gone from 53% down to 33% in five years, meaning they are not the most dominant fleet in that trade, like they used to be and were known for.

The numbers presented above indicate clearly how the deployment of the container fleets are changing at a rather high pace, presumably due to ever larger container vessels continuously arriving at the main east-west route. Although these numbers indicate lost market share in total for all routes for our fleets under investigation, it does not necessarily mean that the fleets sizes are decreasing at the same pace (although that conclusion can be made from Figure 8, that is, that this is the case with regard to the Feeder fleet). This is because while vessels are getting ever larger, fewer ports and terminals can service them, thus lowering the number of 'hubs' and increasing the number of 'spokes'. In other words, short sea trade and the importance of smaller container vessels is increasing.

We turn back now to the original vessel size categories for the remainder of this research; those are Feeders, Handysize, and Sub-Panamax.

3.4 Fleet Development and Orderbook

As seen in previous fleet development graphs, the short sea fleet has been declining in general since the economic crisis of 2009. By looking at the yearly growth in Figure 25, which shows how the shock of the economic crisis affected the fleet's development.

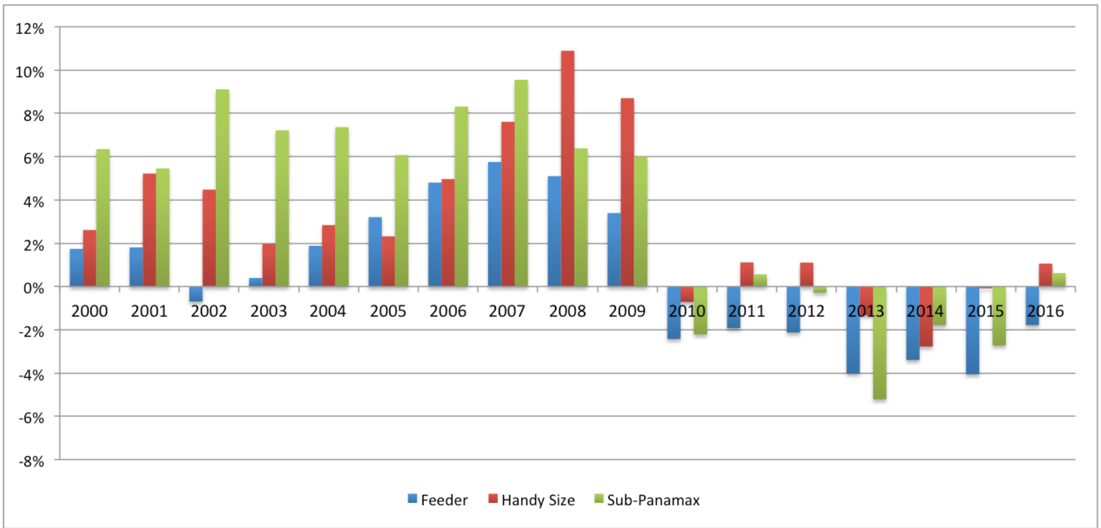


Figure 25: Yearly Growth of the Short Sea Fleets 2000-2016 (in %)
Source: Compiled by author from Clarkson Research Services Ltd

Figure 26 shows the development of the fleets orderbooks (a demonstrative figure for the cyclicality explained in the previous chapter).

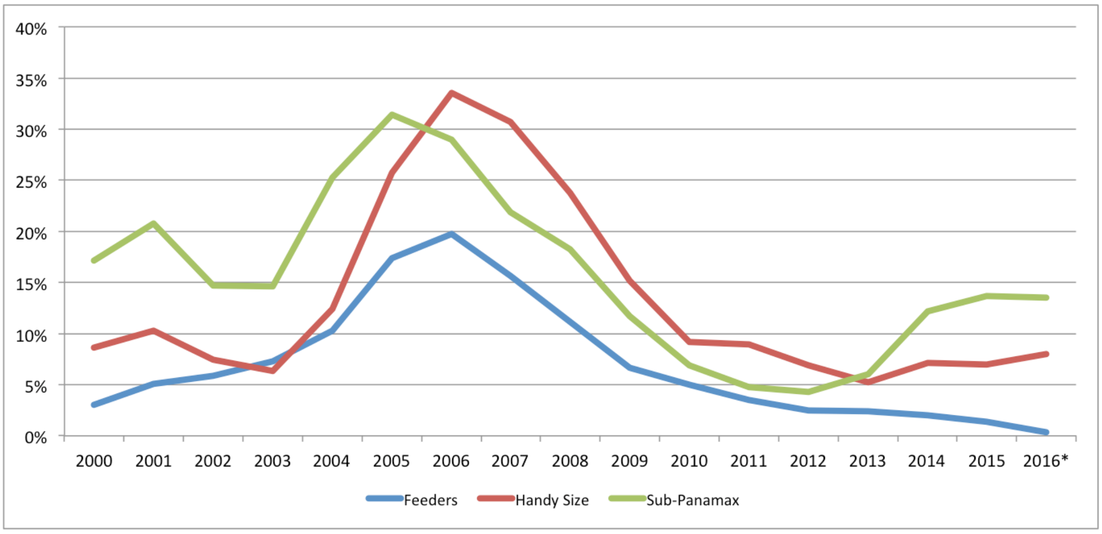


Figure 26: Orderbook as Percentage of Fleet 2000-2016
Source: Compiled by author from Clarkson Research Services Ltd

Looking at the two figures above simultaneously, we see no indications of recovery for the feeder fleet since the economic crisis in 2009. It has experienced continuous 2-4% negative growth since 2009 and a decreasing orderbook since 2007. Further, it is certain that this fleet will not see growth for at least two years, since the orderbook stood at a record low in June 2016, 0%. As expected when looking at these graphs, the average age of the Feeder fleet is high, 16.2 years in May 2016.

The Handysize fleet experienced the highest growth in the years before the economic crisis and has been rather close to the 0% base since then, compared to other fleets. So far in 2016, it looks as if the fleet will have a positive growth for the first time since 2012 which is then supported by an increase in the orderbook from 2016, thus indicating a recovery for the time being. The average age of this fleet was 12.1years in May 2016.

The Sub-Panamax fleet seems to be the most volatile, which probably has to do with the fact that it is the smallest fleet of the three. This fleet, like the Handysize fleet, shows a positive growth so far for 2016. The orderbook has been increasing since 2012, doubling in 2014 (6% to 12%), explaining the growth of the fleet so far this year. In June 2016, the orderbook stood at 13%, indicating possible growth in the next years, if scrapping does not exceed deliveries. The average age of this fleet is the same as the Handysize fleet, 12.1 years.

3.5 Short Sea Second-Hand Sale & Purchase Market

Looking at the dynamics of the fleets with regard to transactions in the second-hand market, Figure 27 shows the transactions made for every short sea fleet as well as the total transactions made.

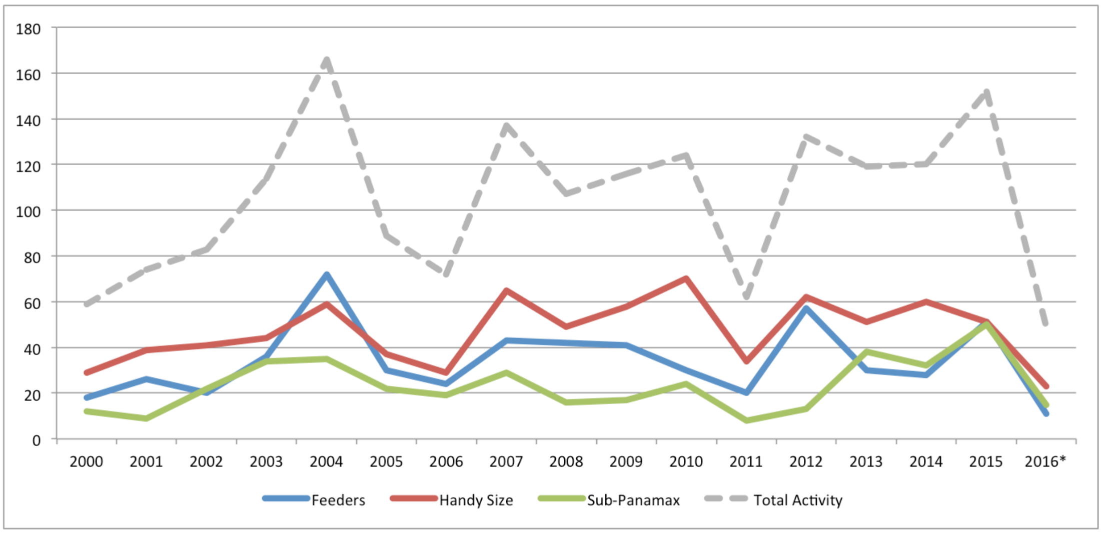


Figure 27: Transactions Made in the Second-Hand Market 2000-2016
****1st half of 2016. Source: Compiled by author from Clarkson Research database***

Transactions in the S&P market for Feeders show spikes in 2012 and 2015, but in the first half of 2016, only 11 sales had been completed, compared to 32 sales at same time in 2015. We see that the Handysize market usually has the most activity, which is rational given the size of the fleet. The activity has been rather stable since 2012, rocking between 50-60 sales a year. The Sub-Panamax fleet has had increasing activity since 2011 with an all-time record number of transactions of 50 in 2015. Interestingly, for the Sub-Panamax this is the same amount of the activity as for Handysize and Feeders, which both account for approximately double the number of ships compared to the Sub-Panamax fleet. Total transactions made in 2015 for all short sea fleets were 152, which was the highest since the pre-crisis year 2004. The activity so far in 2016 is not great, as it is just under one third of 2015's total transactions.

3.6 Outlook

While the smaller post-Panamax vessels seem to have built up a surplus capacity in last years as a result from cascading effect, the outlook for short sea vessels is quite fair (Clarkson Research Services Ltd 2016a). The intra-regional trade grew by 3,5% in 2015 and is expected to grow by 4% in 2016 according to Clarksons Research. The increasing transhipment and intra-regional Asian trade is expected to fuel the demand for short sea vessels. Although China manufacturing has slowed down in 2015, there are other major developing Asian countries that are growing, resulting in jobs and manufacture of goods being spread among more Asian countries, thus supporting intra-Asian trade growth (Clarkson Research Services Ltd 2016a). Further, policy makers are contributing to increased short sea shipping instead of more polluting and congested inland transport, as mentioned in Chapter 2.3.

3.7 Summary

In recent years, the continuous introduction of larger mega-size vessels to the main east-west trade has resulted in large vessels moving down to smaller trades, creating a cascading effect and changing the deployment of different sizes of container ships. The Sub-Panamax and Handysize vessels seem to be moving away from the North-

South trade and increasing their deployment in short sea trades. This creates a pressure on the Feeders, which materialises in lost market share in the short sea market. The growth of the short sea fleets has mostly been negative since the financial crisis, with the exception that so far in 2016 Handysize and Sub-Panamax fleets are experiencing growth. The orderbook of these two fleets has also picked up since 2013. In the last few years, the Sub-Panamax has experienced increasing activity in the S&P market while the Feeder and Handysize are more volatile.

All in all, according to fleet analysis, it seems that the Handysize and Sub-Panamax fleets are starting to recover from the financial crisis while the Feeder fleet has not shown any signs of redemption.

Chapter 4 Literature Review

This chapter will cover selected literature on ship prices and its modelling with the objective to answer the second research question.

Most literature reviews in this field start by mentioning that Tinbergen was the first one to investigate the newbuilding market of ships and its cyclicality. Tinbergen (1931) argues that the shipbuilding market is very dependent on the demand for shipping goods and that the freight rate is dependent on the tonnage available to ship those goods. This is what then causes shipbuilding market cycles, as there is a time lag between demand for capacity and the availably of new ships to meet this demand. To analyse this supply-demand problem, he makes use of the cobweb theorem which was then continued by Koopmans (1939). Koopmans points out that the newbuilding market is influenced by the expectations of the degree of the equilibrium between supply and aggregated demand. This reliance on expectations occurs because of the time lag mentioned earlier, since the market situation is based on orders made a few years earlier.

Beenstock (1985) investigated freight and ship markets with theoretical models, where the two markets are treated as interdependent and, further, second-hand ships treated as capital assets. A few years later, Beenstock & Vergottis (1989) apply this method to the dry bulk and tanker market by the use of an aggregated econometric model with annual data from 1950 to 1986, which assumes that investors have rational expectations. Their model includes freight rates, lay-up, new and second-hand prices and the fleet sizes. They assume that the price of a new built ship reflects the expectations of the future second-hand price and that the two are perfect substitutes. This is, however, challenged in other literatures (e.g. Tsolakis et al., 2003a), and it is argued that the two are rather close substitutes for the following reasons: The availability of the second-hand and new built are in different time frames; different trading conditions, costs, and risks apply as a result of timing; and technological improvements in vessel design are possible.

To examine the volatility of risk in the second-hand tanker market by vessel size, Kavussanos (1996) used Autoregressive Conditional Heterskedastic (ARCH) models. He finds that the smaller the vessel is the lower the volatility in prices. Furthermore, the oil price is found negatively related to change in prices but positively to the volatility of prices. Kavussanos further suggests that oil prices pass on signals to investors about whether to buy a VLCC, Suezmax or Aframax. One year later, Kavussanos published a similar study but now for the dry cargo sector. His results were similar to the tanker sector, that is, prices of small vessels are not as volatile as for larger vessels. Furthermore, the Generalized Autoregressive Conditional Heterskedastic (GARCH) model is a good source for second-hand dry bulk price modelling when using the time-charter rates and interest rates as independent variables (Kavussanos 1997).

According to Veenstra (1999), the price of various sizes of second-hand tanker and dry bulk vessels can be explained by time-charter rates, newbuilding price and scrap price. Veenstra uses monthly data to model firstly the price of five-year-old vessels and secondly ten-year-old vessels to capture the replacement purpose on the one hand and the speculating activities on the other. He proves that the variables used are non-stationary in their first differences and, moreover, that all variables in both the five-year-old model and ten-year-old model had three-cointegration equation relationship within a set of four variables. Veenstra then uses a Vector Autoregressive (VAR) model which illustrates the relationship between the second-hand price, voyage, and time charter rates.

Adland & Koekebakker (2007) were the first to use actual ship sales data instead of market price data when valuating the price of a ship, thereby taking into account not simply the values of generic vessels but vessel-specific factors such as cargo-handling gear, hull type, yard built in and so forth. This way, they can exclude the brokers bias when relying on market price as well as the influence of sticky pricing. The approach they use for the ship valuation is non-parametric multivariate density estimation (MDE) where they allow for the presence of non-linearity. They find that the value of a second-hand ship can be well described as a partially non-linear function of the factors DWT, age, and freight rates. Also, that 'non-linearity is an important issue in vessel valuation', at least for the factors of freight rates and vessel age.

Haralambides et al. (2004) used econometric modelling to evaluate the factors determining the price of newbuilt and second-hand bulkers and tankers. By the use of the Ordinary Least Squares (OLS) method, they found the most significant factor in the newbuilding prices for all types of ships to be, to no surprise, the building cost. For the second-hand prices the newbuilding price and time charter rates were found to be the most significant factors. These findings underline that the newbuilding prices are cost driven, while the second-hand prices are market driven.

Merikas et al.(2008) studied the relationship between newbuilding and second-hand price and factors affecting it in the tanker section. The dependent variable of their study is the ratio between the two prices (SH/NB). By looking at independent variables that are measurable (for example TC rate, volume, risk, LIBOR, CGT), the investor should be able to take a more vice investment decision. With the help of GARCH model and Maximum Likelihood Estimation (MLE) approach, they claim that the movement of the ratio of the prices is determined by the cyclicality of the shipping market and thke expectation of actors such as entrepreneurs, owners, and brokers.

Dikos & Marcus (2003) mention that only the ordering of a newbuilt ship and the scrapping decision made by ship owners affect the demand and supply of the market and, therefore, not second-hand sales and purchases, as those are just asset plays. For this reason, they also claim that the value of a second-hand ship can sufficiently be explained by the newbuilding price and charter rates. Furthermore, they used financial tools to formulate the equilibrium prices for second-hand ships to show the 'Real Option hidden in second-hand vessels'.

An interesting study of the relationship between price and volume in the second-hand market of dry bulk vessels was carried out by Alizadeh & Nomikos (2003). They adapt a common methodology from financial market studies where the relationship between trading volume and price variability is examined and used to investigate, for the first time, the relationship between ship sales volume and price movements for second-hand dry bulk ships. First, they explore whether the sales volume has indicators for the future fluctuation in the price and, second, they check whether there is a relationship between the volatility of price and transactions made in the market. To capture these relationships, they use a number of methodologies. They start with correlation analysis using simple regression to test the temporal relationship between the price change and trading volume. Next they apply the VAR (Vector Autoregressive) model to investigate if there exists a causal relationship between the price change and trading volume (assuming that both variables are stationary) with the support of the Granger causality concept. Last, they use the family of GARCH models to explore the relationship between the price volatility and trading volume. Their result shows a significant positive relationship between contemporaneous price change and activity in the market, which indicates that higher capital gains encourage more activity. Furthermore, they find that the volume has a negative impact on the volatility of price change and that an increase in market activity results in less volatile price changes.

The same authors (Alizadeh et al., 2006) looked at the trading strategies in the sale and purchase markets of second-hand dry bulk ships. Again, they adapt a method commonly used in the financial market which is, in this case, predicting the returns of an asset by looking at the ratio between price and earnings. They used a Vector Error Correction Model (VECM) where a cointegration relationship is established between the price and earnings and then they measure the deviation of the ratio from the long-run equilibrium. This approach could serve owners as an indicator of when to invest or divest in a ship. Their results show that this ratio is important information about future ship price behaviour and investors in shipping can benefit from applying technical trading rules when making investment decisions.

An interesting study about the behaviour of ship-owners was carried out by Luo & Fan (2011) by looking at investment-related data. Figure 28 shows the logic behind the decision-making process of ship owners. It is twofold: the investment decision and the ship choice decision. Luo & Fan start by using a binary choice model to analyse the ship investment decision (to invest or not to invest) where the dependent variables are demand, existing capacity, impact of speed on cost, and the freight rate. To analyse the ship choice decision, they use the nested logit model where the influencing factors under investigation are demand (global container throughput and growth rate), the capacity of the ship-owner investing, average vessel size of the ship-owner investing, time-charter rates, and the capacity for investments of other ship-owners.

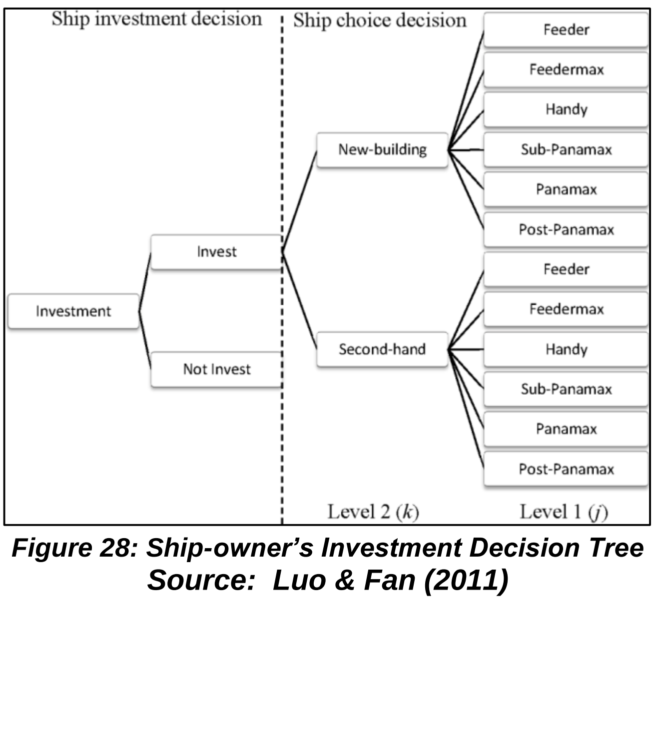


Figure 28: Ship-owner's Investment Decision Tree
Source: Luo & Fan (2011)

Their main result in preferences of new built or second-hand ships are: the longer the building time of newbuilt, the higher preference for newbuild, due to economies of scale of bigger vessels (longer building time); shipping companies with larger current capacity prefer newbuilt; when demand growth is high, second-hand ships are more favourable to meet the demand immediately; the price of new ships is not a critical factor; the nature of the second-hand market is that high price is a consequence of the high preference.

Luo et al. (2009) did an econometric analysis for the container shipping market. In particular, the effect that demand for container transport and the container fleet capacity have on freight rates. They used three-stage least square (3SLS) method for their regression analysis and the estimated model found was suitable for short term prediction of the container shipping market fluctuation in terms of the fleet size dynamics and freight rate fluctuations in the past 20 years (1988-2008).

To summarise, multiple studies have been reviewed related to our topic, merely on the price determinants of second-hand and newbuilt vessels and less extensively on transactions and decisions made in the markets. The most influential determinants for the second-hand and newbuild prices seem to be freight rate, newbuilding price, second-hand price, scrap price, orderbook, transaction volume, interest rates, and economic indicators such as GDP and inflation. In addition, some researchers use ratios such as between second-hand price and newbuilt price, and between second-hand price and earnings. Several econometric approaches have been identified, such as the ARCH, MDE, OLS, VAR, MLE, VECM and 3SLS models. However, the most dominant model, is the GARCH model.

Chapter 5 Methodology and Data

In this chapter will introduce the methodology that will be applied and also the selected data which the observations will be based on from the literature review. Two multiple regression models will be run for each three sizes of container ships (Feeders, Handysize and Sub-Panamax), which are: newbuilding price model, second-hand price model. The statistical software used to analyse our data is EViews 9.5 SV.

5.1 Methodology

5.1.1 ADF Unit Root Test

One of the conditions that have to be met when applying regression analysis is that all the time-series are stationary, in other words, a unit root does not exist. Due to continuous increase or decrease in the series values, they tend to be non-stationary, thus making estimators in the models inconsistent and false for statistical testing. To check the stationarity, we will apply the Augmented Dickey-Fuller (ADF) Unit Root Tests for all of our series. Our null hypothesis (H_0) for the t-test is that the variables have a unit root and the alternative (H_1) is that no unit root exists and thus, the series is stationary. Our significance level is 95%. If the data at levels turns out to be non-stationary, we need to check whether they are stationary in their first difference and further, if needed, second difference.

5.1.2 Testing for Multicollinearity

Multicollinearity is detected when a high correlation is between two independent variables. It is very rear that two variables a totally uncorrelated, thus, multicollinearity exists in all multiple regression models. If the correlation is high, a significant variable could become insignificant, by increasing its standard error. We run a Pearson Correlation test in EViews, where the null hypothesis (H_0) is that correlation exists between the two variables and we reject the H_0 at a 0,05 level. If correlation is observed between two variables (p-value lower than 0,05), then one of them is unnecessary and we need to drop the variable from our model.

To get the optimum results from our estimation we start by running the model with all variables, including correlated variables. We observe which one of these correlated variables is the least significant in the model (highest p-value), drop it from the model and run it again. We continue this process until our model does not include any correlated variables.

5.1.3 Testing for Cointegration

Cointegration testing is needed to make sure the time series have a long-run equilibrium relationship with one another. It is said that a group of non-stationary time series is cointegrated if there is a linear combination of them that is stationary (Haralambides et al. 2004). Testing for cointegration assures that the variables chosen for the final model have a long-run relationship and can, therefore, be used together in the models. We will apply the Johansen Cointegration (JC) in EViews to find if cointegration exists in the models containing more than one explanatory variable.

5.1.4 ARMA and ARIMA Method

Autoregressive Moving Average (ARMA) model is an approach that combines the autocorrelation (AR) and moving average (MA) methods into one. This is done to capture two things. First is the dependence of the level of its current observation on its level of lagged observation, which can be written as autoregressive model of order *p* (AR(*p*)):

$$r_t = \sum_{i=1}^{p} \varphi_i r_{t-i} + a_t$$

where a_t is white noise series.

Secondly, to capture not only the current shock but also the effect of previous shocks we can use the moving average model, which can be written as moving average model of order *q* (MA(*q*)):

$$r_t = \sum_{l=1}^{q} \theta_i a_{t-i} \ .$$

Then, if these two models above are combined, they create the ARMA(*p,q*) model:

$$r_t = \varphi_0 + \sum_{i=1}^{p} \varphi_i r_{t-i} + a_t - \sum_{l=1}^{q} \theta_i a_{t-i}$$

where φ_0 is a constant; $\varphi_i = \theta_l$.

As mentioned above, time series need to be stationary to avoid spurious regression. The Autoregressive Integrated Moving Average (ARIMA) model is applied if the time series turn out to be non-stationary at levels and is simply an extended version of the ARMA model with integrated variables. We would then add the order of integration *d* and create the ARIMA(*p,d,q*) model.

5.1.5 GARCH(1,1) Method

To explain the GARCH(1,1) model we start with the ARCH model. The ARCH models are simple and easy to manage, and take care of autocorrelation as well as nonlinearities. The model assumes that r_t follows a simple time series model such as the ARMA(*p,q*) model shown above, with the addition of explanatory variables (Matei 2009). It can be written as:

$$r_t = \mu_t + a_t \ , \ \mu_t = \varphi_0 + \sum_{i=1}^{k} \beta_i x_{it} + \sum_{i=1}^{p} \varphi_i r_{t-i} - \sum_{l=1}^{q} \theta_l a_{t-l}$$

where x_{it} are the explanatory variables and *k*, *p,* and *q* are non-negative integers; a_t is white noise series and μ_t is the mean equation of r_t (Matei 2009).

The ARCH model has some weaknesses, however. One is that it assumes that the shocks, whether they are negative or positive, have the same effect on volatility. This is a simplification of reality, as financial assets respond differently to these kinds of shocks. Further, because of how slow the responce of the model is to isolated shocks to the return series, they tend to over predict (Matei 2009). Additionally, the model does not give a straight understanding of the source of volatility in the series as it only describes the behaviour of the conditional variance (Matei 2009).

The Generalised ARCH model, or GARCH model, is a useful extension of the ARCH model. It is more parsimonious as it has only three parameters that allow for an infinite number of squared roots that affect the current conditional variance (Matei 2009). The GARCH model, additionally to the autocorrelation incorporated through the ARCH model, includes conditional heteroscedasticity. According to Matei (2009), the GARCH model is frequently used for financial time series to generate a good estimate of the volatility of returns, while including only few parameters. The conditional variance through GARCH is a weighted average of past residuals which declines, but never reaches zero. Further, the GARCH allows the conditional variance to be dependent upon previous own lags (Matei 2009).

In the GARCH model, similar to the ARCH model, the conditional variance is the weighted average of past residuals and the weights decline without ever reaching zero. The main advantage of GARCH is that it permits the conditional variance to be dependent on previous own lags (Matei 2009).

If we assume a log return series r_t and $a_t = r_t - \mu_t$ be the innovation at time *t*, We say that a_t follows a GARCH(*m,s*) model if

$$a_t = \sigma_t \varepsilon_t \, , \sigma_t^2 = \alpha_0 + \sum_{i=1}^{m} \alpha_i a_{t-1}^2 + \sum_{j=1}^{s} \beta_j \sigma_{t-j}^2 \, ,$$

where ε_t is a sequence of iid random variables with mean 0 and variance 1,

$$\alpha_0 > 0, \alpha_j \geq 0, \beta_j \geq 0 \; and \sum_{i=1}^{\max(m,s)} (\alpha_i + \beta_i) < 1.$$

Here it is understood that $\alpha_i = 0$ for i>m and $\beta_j = 0$ for j>s. The constraint for $\alpha_i + \beta_i$ implies that the unconditional variance of a_t is finite and its conditional variance σ_t^2 evolves over time (Matei 2009).

5.1.6 VECM method

The Vector Error Correction models are convenient for separating long-run and short-run components of the data generation process. The long-run cointegration relations can be used to explain the specific economic relations while the short-run dynamics describe the adjustment to the long-run relations when disturbances have occurred (Lutkepohl 2009).

The model can be written as

$$\Delta x_t = \Pi x_{t-1} + \Gamma_1 \Delta x_{t-1} + \cdots + \Gamma_p \Delta x_{t-p+1} + \mu_t \, .$$

Where the term Πx_{t-1} represents the long-run or the equilibrium correction term of the model and the $\Gamma_j' s (j = 1, \ldots, p-1)$ are the short term or short run parameters (Lutkepohl 2009). For further reference about the VECM method, please see Lutkepohl (2009).

5.2 Variable Identification

The dependent variables used for the price models, as the name implies, are the newbuilding price and the second-hand price of five-year-old vessels.

The supply and demand of container vessels can be explained by a set of independent variables. The most important variables identified affecting the prices are the prices of second-hand vessels for the new building model and the prices of new built vessels for the second-hand model. Further, for both models, the important variables are the charter rates and orderbook as a percentage of the fleet.

Finally, we will check for the effect of economic indicators such as GDP growth and inflation. The GDP growth can be an indicator for transport demand, thus if the growth is high, it could lead to higher ship price. Inflation could also lead to higher price. The cost of capital for investments in ships is depicted in the London Interbank Offered Rate (LIBOR). The newbuilding model has one additional variable over the second-hand model, the steel price, which is meant to represent the cost of new buildings.

Table 2: Dependent and Independent Variables

	Newbuilding Price Model	Second-hand Price Model
Dependent	**NBP**	**SHP**
Independent	SHP	NBP
	Time Charter Rates	Time Charter Rates
	Orderbook	Orderbook
	GDP	GDP
	Inflation	Inflation
	LIBOR	LIBOR
	Steel price	

5.3 Data Collection

All data is collected from the Clarksons Shipping Intelligence Network database except the GDP growth which is gathered from OECD (Organization for Economic Cooperation and Development) website. For this research, we use monthly data from January 2000 to June 2016. This period includes a world economic crisis which helps us to assess the markets reaction to a great shock, thus capturing the cyclicality of the shipping market.

The literature on modelling of the short sea container ship prices has been scares due to how heterogeneous the fleet is and it is also difficult to assess the prices in such an illiquid market as the sale and purchase market of container ship is. Thus, the data collected for specifics vessel sizes from Clarkson Intelligence Research database is for generic types of vessels and is as follows: Feeders data is the average of generic 300 TEUs and 725 TEUs geared container ships, Handysize data is for generic 1,700 TEUs geared container ships and the Sub-Panamax data is for generic 2,750 TEUs gearless container ships.

The maritime related factors are in more detail as follows: The prices for the second-hand vessels are for five-year-old vessels, the charter rates are average for 6- to 12 months' charter contracts in US dollars per day and orderbook is the percentage of the orderbook of the total fleet.

The economic variables are then as follows: GDP is the growth per quarter of the G20 (20 major economies), inflation is percentage change from same period in previous year of the OECD countries and the LIBOR are the percentage of interests per period. Furthermore, the steel price is the Japan Steel Ship Plate Commodity Price in US dollars per tonne.

5.3.1 Problems Experienced with the Data

It is important that the data collected for research is of good quality with the purpose of valid results. Clarkson Research Services was the source for all of the data except GDP, which means that the majority of our data should be of similar quality and resources. However, when collecting the data for MPP vessels, we could not find the same specified type of MPP vessel for different variables. For example, NBP data were specified for vessel size in TEU, while the SHP data were for vessel size in DWT. This is one of the major reasons we decided to drop MPP vessels from our study. Furthermore, the data for GDP was available only on a quarterly basis, thus the same growth was assumed for all months within that quarter. Additionally, the GDP data for the second quarter of 2016 were not yet available. This was solved by using exponential smoothing to forecast the values for the second quarter of 2016. Moreover, the GDP data available were for OECD countries or G20 economies. The G20 was preferred as it includes major economies that are not members/presented in OECD (e.g. China, India, Russia) and thus represents the world economy in a more sufficient way with regard to demand for transport.

5.4 Models Specifications

5.4.1 Testing for Stationarity (Unit Root)

The ADF test results for the specific vessel type related variables is shown in Table 3.

Table 3: ADF Test Results for Vessel Type Variables

	Levels		1st differences	
Series	**Probability**	**Stationary**	**Probability**	**Stationary**
Feeders				
nbp	0.5306	no	0.0000	yes
shp	0.4002	no	0.0000	yes
orderbook	0.4022	no	0.0000	yes
timecharter	0.4141	no	0.0000	yes
Handysize				
nbp	0.5042	no	0.0000	yes
shp	0.3499	no	0.0000	yes
orderbook	0.5146	no	0.0005	yes
timecharter	0.2047	no	0.0000	yes
Sub-Panamax				
nbp	0.4545	no	0.0000	yes
shp	0.2860	no	0.0000	yes
orderbook	0.4269	no	0.0000	yes
timecharter	0.3600	no	0.0000	yes

All the maritime related variables turn out to be non-stationary. Therefore, all variables are converted into their first difference and the ADF tests indicates that all of them become stationary.

The ADF test results for the economic and general variables are the same in both of our models. As seen in Table 4, only the steel price is non-stationary at levels while GDP, inflation and LIBOR are stationary. We then run the test again for the variables in their first difference and see that all series are stationary in their first differences. However, it can be argued that GDP growth and Inflation variables are already at first difference since they represent percentage changes from previous periods. Therefore, they will not be further differenced for modelling.

Table 4: ADF Test Results for Economic and Other General Variables

	Level		1st differences	
Series	**Probability**	**Stationary**	**Probability**	**Stationary**
gdp*	0.0069	yes	0.0000	yes
Inflation**	0.0311	yes	0.0000	yes
libor	0.0267	yes	0.0000	yes
steelprice	0.4122	no	0.0000	yes

**** Including constant***
***** Including constant and trend***

As all series are stationary in their first differences, we convert them from levels to their first differences and present them in a model using the Ordinary Least Square (OLS) method as shown below.

The newbuilding price basic estimation function will be as follows:

*d_nbp = c(1) + c(2)*d_shp + c(3)*d_orderbook + c(4)*d_timecharter + c(5)*gdp + c(6)*inflation + c(7)*d_libor + c(8)*d_steelprice*

… where

d_nbp = first difference of newbuilding price in dollars
d_shp = first difference of second-hand price in dollars
d_orderbook = first difference of orderbook percentage of total fleet
d_ timecharter = first difference of average 6- to 12-months' charter rate in dollars/day
gdp = percentage changes per quarter of GDP
inflation = percentage changes of inflation same period last year
d_libor = first difference of LIBOR interest rates in percentage
d_steelprice = first difference of steel price in dollar per tonne.

The second-hand price estimation function will be as follows:

*d_shp = c(1) + c(2)*d_nbp + c(3)*d_orderbook + c(4)*d_timecharter + c(5)*gdp + c(6)*inflation + c(7)*d_libor*

… where

d_nbp = first difference of newbuilding price in dollars
d_shp = first difference of second-hand price in dollars
d_orderbook = first difference of orderbook percentage of total fleet
d_ timecharter = first difference of average 6- to 12- months' charter rate in dollars/day
gdp = percentage changes per quarter of GDP
inflation = percentage changes of inflation same period last year
d_libor = first difference of LIBOR interest rates in percentage.

5.4.2 Diagnostic testing

One of the conditions desired for our model to be valid is that it is not autocorrelated (serially correlated), in other words, that the error terms (residuals) of the model are not correlated over time. To find out if our model is autocorrelated, the Q-statistic test is conducted in EViews.

Another condition sought for is that our models are homoscedastic, thus not heteroscedastic. Heteroscedasticity is detected when the variance of the error variable is not constant. For example, if the residuals are plotted against the predicted values of the dependent variables and they show an increasing pattern of deviation, as the dependent variable increases, we can assume that the model is heteroscedastic.

5.5 Data Presentation

The data we use for our models are presented graphically in the next two sub chapters. First, we look at the mutual economic indicators and steel price which are the same for all vessel type models. This is then followed by the vessel type specific data. The data observations are presented at levels on the left and then in its first difference on the right.

5.5.1 Mutual Economic Indicators and Steel price

The variables that are the same, for all vessel types are the GDP, Inflation, LIBOR and steel price and can be seen in Figures 29 to 36.

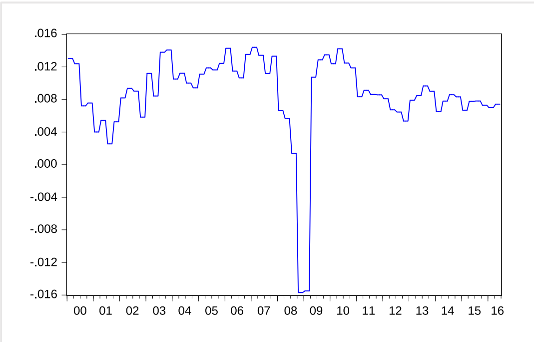


Figure 29: GDP
January 2000- June 2016

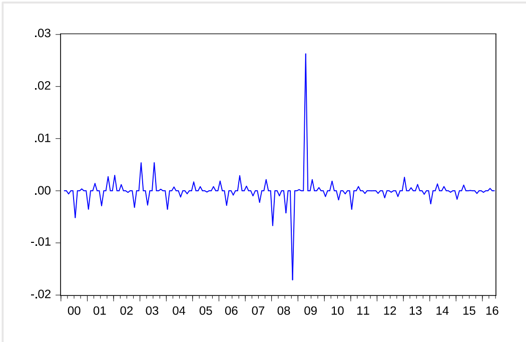


Figure 30: Differenced GDP
January 2000- June 2016

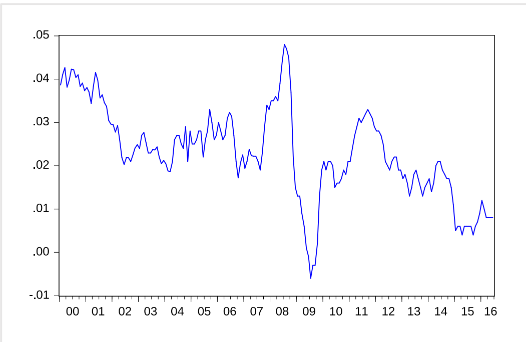


Figure 31: Inflation
January 2000- June 2016

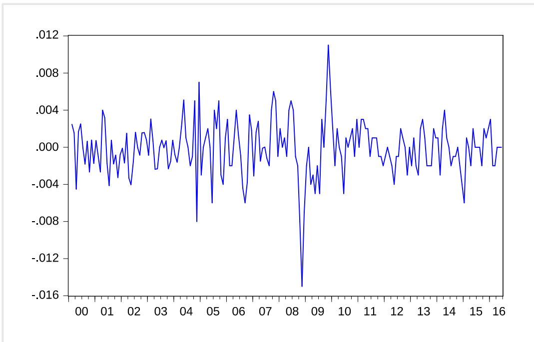


Figure 32: Differenced Inflation
January 2000- June 2016

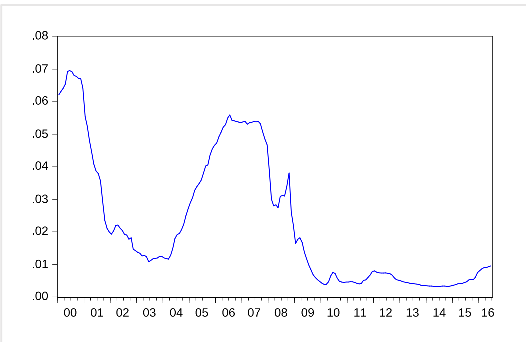


Figure 33: LIBOR
January 2000- June 2016

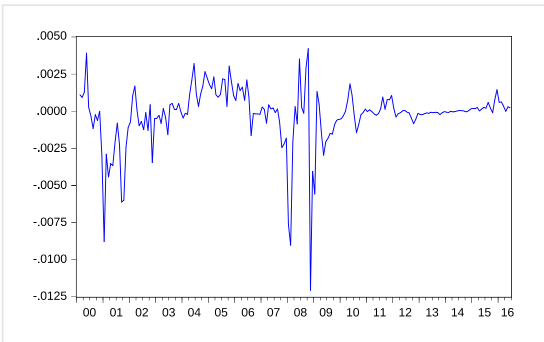
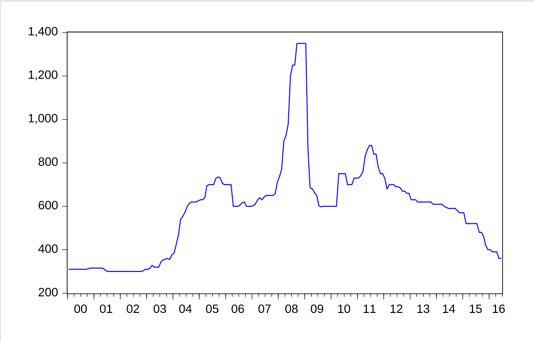


Figure 34: Differenced LIBOR
January 2000- June 2016



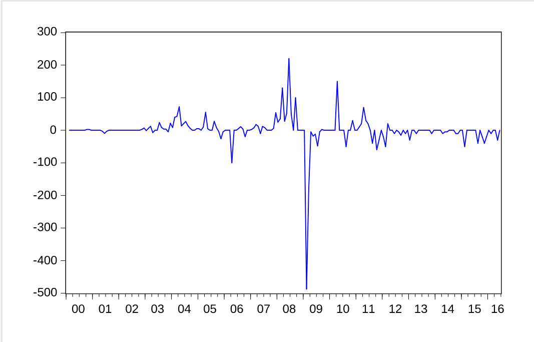
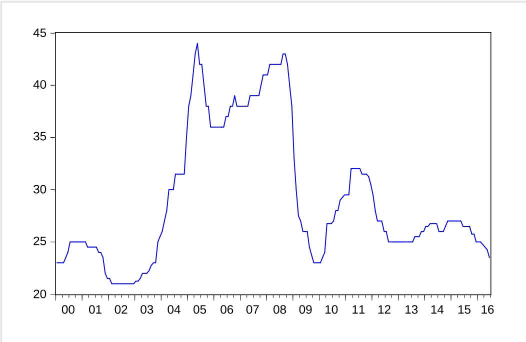


Figure 35: Steel Price January 2000- June 2016

Figure 36: Differenced Steel Price January 2000- June 2016

5.5.2 Handysize

The vessel specific variables are newbuilding prices, second-hand prices, newbuilding contract volume, second-hand sales volume, orderbook, and time charter rates. These variables are presented in Figures 37 to 48.



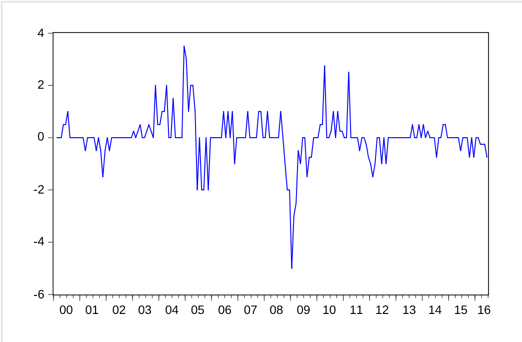
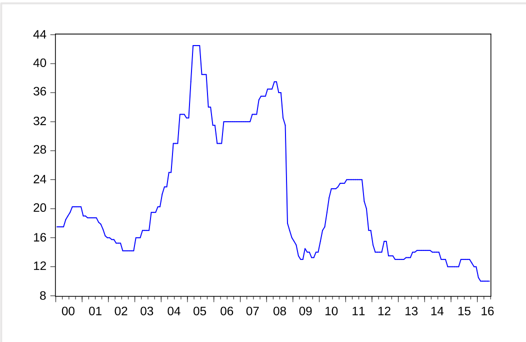


Figure 37: Newbuilding Prices 2000-2016 (million $)

Figure 38: Differenced Newbuilding Prices 2000-2016 (million $)



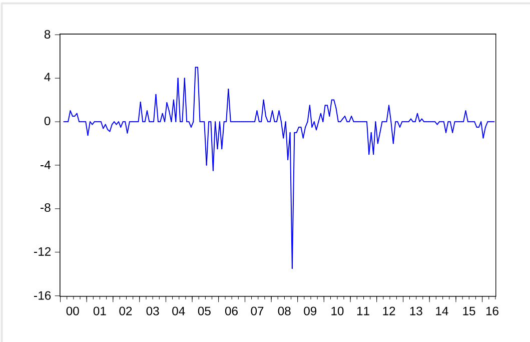


Figure 39: Second-Hand Prices 2000-2016 (million $)

Figure 40: Differenced Second-Hand Prices 2000-2016 (million $)

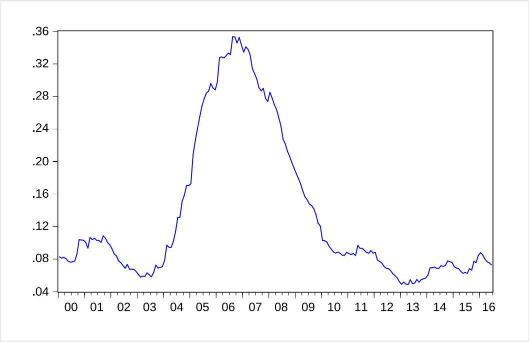


Figure 41: Orderbook (as % of fleet) 2000-2016

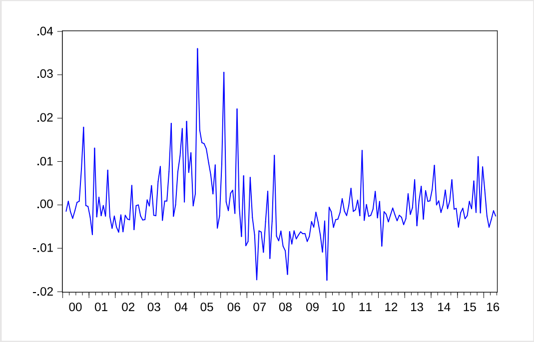


Figure 42: Differenced Orderbook (as % of fleet) 2000-2016

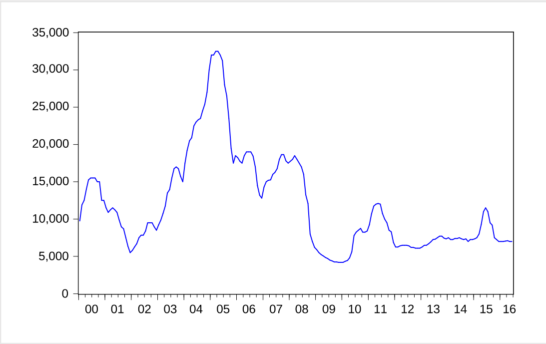


Figure 43: Time Charter Rates 2000-2016 (in $ per day)

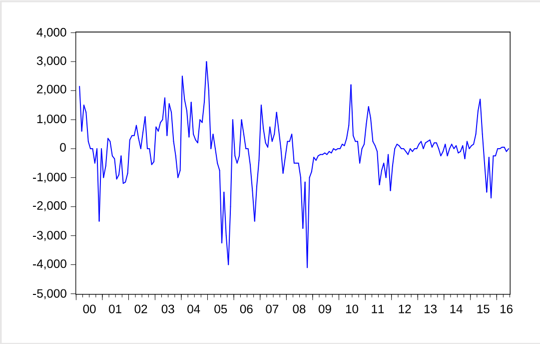


Figure 44: Differenced Time Charter Rates 2000-2016 (in $ per day)

Data observations for the Feeders and Sub-Panamax are presented in Appendix A.

The graphs presented above show clearly the effect of the economic crisis on multiple variables and are a good example of a cyclical shipping market. Prices of ships and time charter rates started to elevate in 2001 and rose high until 2005, when they started to descend again. Then, in 2008, the prices collapsed drastically as the economic crisis hit and this great shock is highly noticeable on the graphs with variables in their first difference, where downwards spikes appear.

Chapter 6 Newbuilding Price Models Results and Discussion

In this chapter the results of the OLS models as well as alternative models such as ARIMA, GARCH and VECM are presented and analysed. The models are designed to capture what determines the price, volatility of price and price dynamics of newbuilding short sea container ships. Most importantly, the objective of this chapter, and Chapter 7, is to answer the third sub research question. All estimations and tests are done with the statistical software EViews 9.5 and the outputs for model one is presented in this chapter. As for the rest of the models (two to six), are presented in appendices.

6.1 Model 1: The Newbuilding Price Model for Feeders

6.1.1 Multicollinearity test

Before running the model, we check for multicollinearity to be sure that none of the independent variables included in the model are correlated. The results from Pearson Correlations statistics is presented in Table 5.

Table 5: Correlation P-values Between Independent Variables in Model 1

	GDP	INFLATION	D_LIBOR	D_ORDER BOOK	D_SHP	D_STEEL PRICE	D_TIME CHARTER
GDP		0.5099	0.0000	0.0269	0.0000	0.0000	0.0000
INFLATION	0.5099		0.6689	0.4283	0.8133	0.0002	0.214
D_LIBOR	0.0000	0.6689		0.1554	0.1524	0.835	0.0181
D_ORDERBOOK	0.0269	0.4283	0.1554		0.0008	0.2400	0.0253
D_SHP	0.0000	0.8133	0.1524	0.0008		0.0002	0.0000
D_STEELPRICE	0.0000	0.0002	0.835	0.2400	0.0002		0.0940
D_TIMECHARTER	0.0000	0.214	0.0181	0.0253	0.0000	0.0940	

Note: The null hypothesis is that there is no correlation. The null hypothesis is rejected at a 0,05 statistical level.

We observe that there are number of variables correlated in the model (p-values marked with red font in Table 5). To find the best model with out correlated variables, multiple models are generated for all combinations of uncorrelated variables and best one chosen according to the lowest AIC value, indicating the least forecasting errors. For the newbuilding Feeders the best combination of uncorrelated independent variables are the SHP and LIBOR.

6.1.2 OLS Model Assessment

The results from estimation with Ordinary Least Squares method is presented in Table 6 below.

Table 6: Result from Newbuilding Price OSL Model for Feeders

Dependent Variable: D_NBP
Method: Least Squares
Date: 08/25/16 Time: 19:45
Sample (adjusted): 2000M02 2016M06
Included observations: 197 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D_SHP	0.516466	0.063490	8.134602	0.0000
D_LIBOR	19.17048	12.36194	1.550767	0.1226
C	0.008670	0.024860	0.348737	0.7277

R-squared	0.270436	Mean dependent var	-0.003092
Adjusted R-squared	0.262915	S.D. dependent var	0.402783
S.E. of regression	0.345804	Akaike info criterion	0.729219
Sum squared resid	23.19854	Schwarz criterion	0.779217
Log likelihood	-68.82812	Hannan-Quinn criter.	0.749459
F-statistic	35.95615	Durbin-Watson stat	1.584962
Prob(F-statistic)	0.000000		

First we start by checking if the variables chosen for the final model are cointegrated with the Johansen Cointegration test. This model turns out to have one cointegration relationship, which means that the variables have a long-run equilibrium relationship. Results from the JC test can be seen in Appendix B.1.

The fit is 0.27 (R^2) and adjusted R^2 is 0.26, thus we could say that our model has an average fit. The F-stat is 35.96 with a p-value of 0, which tells us that the NBP can be explained by at least one of the independent variables and that the model is statistically significant at 5% level.

The coefficients of the variables show the relationship the independent variables have with the NBP. If the coefficient of the independent variable is positive, it indicates how much the value of the dependent variable would increase if the independent variable would increase by one unit. On the contrary, if the coefficient of the independent variable is negative, it would indicate how much the value of the dependent variable would decrease if the independent variable would increase by one unit. For example, with the model above, if second-hand price would increase by one million dollars, the NBP would increase by 0.516 million dollars ($ 516.000). Further, the p-values of the variables indicate if they are statistically significant at 5% level. We see that only SHP is significant at 5% level, thus the only factor affecting the NBP for feeders.

The diagnostics testing is presented in Appendix C.1.To check whether the residuals are autocorrelated, we use Q-statistics. The null hypothesis is no autocorrelations. The test statistics for most lags are significant and therefore the null hypothesis is rejected and the model is autocorrelated.

To check for heteroscedasticity, the ARCH Heteroscedasticity test is applied. The null hypothesis is that there is no heteroscedasticity. The H_0 is rejected as the P-value is 0, which is lower than 5%. This means that heteroscedasticity exists.

As the model is both autocorrelated and heteroscedastic, it is not a good estimate. In next sub chapters, different kinds of models are tested in search for better estimates for NBP of Feeders.

6.1.3 ARIMA Model Assessment

ARIMA models include both autoregressive (AR) terms (*p*) and moving average (MA) terms (*q*) and are therefore known as ARIMA(*p,d,q*) where *d* is the number of integration. Similar to other regressions, the variables must be stationary, thus we insert the dependent variable in its first difference.

The best ARIMA model is found by exploring different combinations of terms (*p* and *q*) and then select the model with the lowest AIC value. We will limit the number of terms to 4, meaning, 16 combinations of *p* and *q* are estimated in search for the best ARIMA. The best ARIMA model for Feeders NBP according to the AIC value is the ARIMA(1,1,2) and is shown in Table 7.

Table 7: Results of ARIMA(1,1,2) Model for Newbuilding Price of Feeders

Dependent Variable: D_NBP
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 08/17/16 Time: 16:53
Sample: 2000M02 2016M06
Included observations: 197
Convergence achieved after 155 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.003493	0.059672	-0.058529	0.9534
AR(1)	0.087764	0.139376	0.629694	0.5296
MA(1)	0.364387	0.167712	2.172704	0.0310
MA(2)	0.302875	0.069879	4.334289	0.0000
SIGMASQ	0.122467	0.004890	25.04380	0.0000

R-squared	0.241266	Mean dependent var	-0.003092
Adjusted R-squared	0.225459	S.D. dependent var	0.402783
S.E. of regression	0.354481	Akaike info criterion	0.790501
Sum squared resid	24.12609	Schwarz criterion	0.873831
Log likelihood	-72.86433	Hannan-Quinn criter.	0.824233
F-statistic	15.26326	Durbin-Watson stat	1.992666
Prob(F-statistic)	0.000000		

Inverted AR Roots	.09	
Inverted MA Roots	-.18+.52i	-.18-.52i

The mode is statistically significant with p-value 0 and F-statistics 15.26. This model has a fit of 0.241 which means that 24.1% of the variation in newbuilding Feeders prices can be explained by this model. Only the moving average, MA(1) and MA(2), variables are significant in the model.

The residual testing show that the model is not autocorrelated as all the p-values for the Q-test are insignificant and we therefore accept the null hypothesis. However, this model is heteroscedastic like the OLS model and is therefore not a good estimator. We next try the GARCH(1,1) based on the best OSL model showed earlier.

6.1.4 GARCH(1,1) Model assessment

The GARCH(1,1) model is estimated and the results can be seen in Table 8.

Table 8: Results for Newbuilding Price GARCH(1,1) Model for Feeders

Dependent Variable: D_NBP
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Date: 08/25/16 Time: 20:06
Sample (adjusted): 2000M02 2016M06
Included observations: 197 after adjustments
Convergence achieved after 20 iterations
Coefficient covariance computed using outer product of gradients
Presample variance: backcast (parameter = 0.7)
GARCH = C(4) + C(5)*RESID(-1)^2 + C(6)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
D_SHP	0.321419	0.023014	13.96632	0.0000
D_LIBOR	4.543256	6.661399	0.682027	0.4952
C	0.003742	0.009658	0.387467	0.6984
Variance Equation				
C	0.005399	0.001107	4.876776	0.0000
RESID(-1)^2	0.523121	0.102561	5.100578	0.0000
GARCH(-1)	0.569848	0.040810	13.96335	0.0000

R-squared	0.226406	Mean dependent var	-0.003092
Adjusted R-squared	0.218431	S.D. dependent var	0.402783
S.E. of regression	0.356086	Akaike info criterion	-0.099982
Sum squared resid	24.59861	Schwarz criterion	1.42E-05
Log likelihood	15.84822	Hannan-Quinn criter.	-0.059503
Durbin-Watson stat	1.339967		

Both ARCH and GARCH variables are statistically significant since their P-values are below 5%. Their coefficients imply how much the external shocks affect the new building prices of Feeders. This effect is rather strong as their sum is 1.10, which implies that their importance in the formulation of the variance value of all previous disrupting terms' observations is elevated. Further, in this model, only the SHP variable is statistically significant, thus influencing the volatility of NBP. The model has a fit of R^2 equal to 0.226.

The Autocorrelation test indicates that we can accept the null hypothesis, as all of the P-values are larger than 5%, thus the residuals are not autocorrelated. The Heteroscedasticity test results show that the null hypothesis cannot be rejected at a 0.05 statistical level as the P-value is 0.970. Therefore, we accept the alternative hypothesis which is that homoscedasticity exists. The diagnostic test results are presented in Appendix E.1.

6.1.5 VEC Model Assessment

With Vector Error Correction Model, we can separate and observe the long-run and short-run dynamics of the variables. One of the condition to run this model is that our variables have a long-run cointegrated relationship. Further, the VEC model converts the variables into first differences, thus we insert the variables at levels to the model. We have already established in Chapter 5 that the non-stationary variables become stationary at first difference. Further, the Johansen Cointegration test indicated that the model has 1 relation. We run the VEC model with different choices of lags, while checking for autocorrelation and heteroscedasticity, and choose the best model according to AIC value. The best VEC model is with 5 lags and is shown in Table 9.

Table 9: Result from Newbuilding Price VEC Model for Handysize

Dependent Variable: D(NBP)
Method: Least Squares (Gauss-Newton / Marquardt steps)
Sample (adjusted): 2000M07 2016M06
Included observations: 192 after adjustments
D(NBP) = C(1)*(NBP(-1) - 0.511655028646*SHP(-1) - 38.1455740918 *LIBOR(-1) - 7.81090633056) + C(2)*D(NBP(-1)) + C(3)*D(NBP(-2)) + C(4)*D(NBP(-3)) + C(5)*D(NBP(-4)) + C(6)*D(NBP(-5)) + C(7)*D(SHP(-1)) + C(8)*D(SHP(-2)) + C(9)*D(SHP(-3)) + C(10)*D(SHP(-4)) + C(11) *D(SHP(-5)) + C(12)*D(LIBOR(-1)) + C(13)*D(LIBOR(-2)) + C(14) *D(LIBOR(-3)) + C(15)*D(LIBOR(-4)) + C(16)*D(LIBOR(-5))

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.048516	0.018866	-2.571661	0.0109
C(2)	0.304639	0.079935	3.811095	0.0002
C(3)	0.019155	0.075002	0.255390	0.7987
C(4)	-0.101919	0.072726	-1.401410	0.1629
C(5)	-0.080334	0.072624	-1.106163	0.2702
C(6)	0.026187	0.067663	0.387023	0.6992
C(7)	0.276249	0.067328	4.103015	0.0001
C(8)	0.104800	0.069953	1.498146	0.1359
C(9)	-0.033295	0.071696	-0.464390	0.6429
C(10)	0.243242	0.070657	3.442590	0.0007
C(11)	-0.079294	0.073100	-1.084730	0.2795
C(12)	42.51161	13.26900	3.203829	0.0016
C(13)	7.597948	14.20040	0.535052	0.5933
C(14)	33.02161	14.29028	2.310774	0.0220
C(15)	-64.60796	14.46966	-4.465064	0.0000
C(16)	7.467450	14.26927	0.523324	0.6014

R-squared	0.520497	Mean dependent var	-0.003173
Adjusted R-squared	0.479630	S.D. dependent var	0.408020
S.E. of regression	0.294332	Akaike info criterion	0.471439
Sum squared resid	15.24712	Schwarz criterion	0.742897
Log likelihood	-29.25816	Hannan-Quinn criter.	0.581382
Durbin-Watson stat	1.994054		

The model has a fit of 0.520. The C(1) variable represents the one relation identified by the Johansen Test and the coefficient of this error correction term tells us the speed of adjustment towards long run equilibrium per month. There is a long run causality if the coefficient is negative and if the p-value is significant at 5% level. In this case, the

C(1) is significant with a negative coefficient, indicating long-run causality on the newbuilding prices of Feeder vessels. The C(15) variable is also significant and with a negative coefficient, indicating that the 4th lag of LIBOR affects the newbuilding price.

To see if there is a short run causality running from one variable to the dependent variable, a Wald test is applied. For this, every coefficient of every lag of the a variable is tested jointly, for example testing all the coefficient (lags) of LIBOR in the model above, the null hypothesis would be C(7)=(8)=C(9)=C(10)=C(11)=0. If the test statistics are lower than 0.05, the null hypothesis is rejected, indicating the LIBOR has a short run causality effect on the newbuilding prices.

The Wald test indicates that a short run causality runs from newbuilding price, LIBOR and second-hand price to the newbuilding price as all test statistics were significant and null hypothesis rejected. The Wald tests are not presented in the thesis but can be provided by author upon request.

The diagnostic testing is presented in Appendix F.1. The Breusch-Godfrey Serial Correlation LM Test indicates that the model is not serially correlated as the Chi-square test statistics is insignificant. According to the ARCH heteroscedasticity test, the model is heteroscedastic at a 5% level since the p-value is 0.015. However, it is noted that it is not heteroscedastic at a 1% statistical level.

For the remaining models, all outputs from EViews will be presented in appendices.

6.2 Model 2: The newbuilding Price Model for Handysize

6.2.1 Multicollinearity test

We apply the Pearson correlation test to see if there is multicollinearity in the model. Results are shown in Table 10.

Table 10: Correlation P-values Between Independent Variables in Model 2

	GDP	INFLATIO N	D_LIBOR	D_ORDER BOOK	D_SHP	D_STEEL PRICE	D_TIME CHARTER
GDP		0.5099	0.0000	0.0071	0.0000	0.0000	0.0001
INFLATION	0.5099		0.6689	0.3981	0.1026	0.0002	0.0403
D_LIBOR	0.0000	0.6689		0.0167	0.5848	0.835	0.3723
D_ORDERBOOK	0.0071	0.3981	0.0167		0.0093	0.6914	0.5862
D_SHP	0.0000	0.1026	0.5848	0.0093		0.2513	0.0000
D_STEELPRICE	0.0000	0.0002	0.8350	0.6914	0.2513		0.4043
D_TIMECHARTER	0.0001	0.0403	0.3723	0.5862	0.0000	0.4043	

Note: The null hypothesis is that there is no correlation. The null hypothesis is rejected on a 0,05 statistical level.

The independent variables of the Handysize model are correlated to some extend. We therefore follow the same approach as in Model 1, by dropping one correlated variable at a time from the model. The best model is presented in Appendix C.2 and includes LIBOR, steel price and time charter rates.

6.2.2 OLS Model Assessment

The Johansen test for cointegration indicates that there is one relation in the model (see Appendix B.2). The F-statistic is 21.49 and the model is statistically significant with p-value close to 0. The R^2 coefficient indicates that 25.0% of the variation of NBP is explained by the model. The LIBOR, steel price and time charter rate are significant at a 5% level, and their coefficients indicate how the price of newbuilding changes if the value of the independent variable would increase by one unit. If the steel price would increase by $ 1 per tonne, the newbuilding price would increase by $6,000 ($0.006 million).

The diagnostic testing indicate that the model has no autocorrelation as all p-values are insignificant. The ARCH test further indicates that the model is homoscedastic, as the p-value is 0.177, thus heteroscedasticity does not exist. The diagnostic testing results can be found in Appendix C.2.

6.2.3 ARIMA Model Assessment

After estimating 16 combinations of *p* and *q* terms, the best ARIMA model with the lowest AIC turned out to be the ARIMA(4,1,2) for newbuilding Handysize prices and is depicted in Appendix D.2 .

The results indicate that the model is statistically significant, with p-value 0 and the R^2 indicates that 32.9% of the variation in newbuilding price can be explained by the model. All the independent variables are statistically significant except the constant C.

From the residual tests, it is observed that the model is not autocorrelated and is homoscedastic.

6.2.4 GARCH(1,1) Model assessment

The GARCH(1,1) model for Handysize newbuilding prices and the diagnostic test results can be seen in Appendix E.2.

Steel price and time charter rates are significant, same as in the OLS model, while LIBOR becomes insignificant. Both the ARCH and GARCH varibles are statistically significant with p-values equal to 0. The sum of their coefficient does not exceed 1 which means that their importance in the formulation of the variance of all the previous disrupting terms observations is descending. Further, the model has a fit of 22.1%.

The residuals testing shows that the model is homoscedastic and not autocorrelated.

6.2.5 VEC Model Assessment

The results from the Handysize newbuilding VECM model is presented in Appendix F.2. The results show that the model has a fit of 47.5% and is statistically significant with p-value 0. The C(1) variable is not significant and with a positive coefficient, indicating no long-run causality running to the newbuilding prices of Handysize vessels.

The Wald tests indicates that a short run causality runs from newbuilding price, LIBOR and time charter rate to the newbuilding price.

Lastly, the Breusch-Godfrey Serial Correlation test indicates that the model is not serially correlated and the ARCH test allows us to accept the null hypothesis, thus no heteroscedasticity.

6.3 Model 3: The newbuilding Price Model for Sub-Panamax

6.3.1 Multicollinearity test

The results from the multicollinearity test for Sub-Panamax newbuilding model can be seen in Table 11.

Table 11: Correlation P-values Between Independent Variables in Model 3

	GDP	INFLATION	D_LIBOR	D_ORDER BOOK	D_SHP	D_STEEL PRICE	D_TIME CHARTER
GDP		0.5099	0.0000	0.0324	0.0000	0,0000	0.0000
INFLATION	0.5099		0.6769	0.3775	0.1416	0.0002	0.0076
D_LIBOR	0.0000	0.6769		0.3386	0.2654	0.8350	0.5672
D_ORDERBOOK	0.0324	0.3775	0.3386		0.0730	0.5712	0.1000
D_SHP	0.0000	0.1416	0.2654	0.0730		0.1467	0.0000
D_STEELPRICE	0.0000	0.0002	0.8350	0.5712	0.1467		0.8162
D_TIMECHARTER	0.0000	0.0076	0.5672	0.1000	0.0000	0.8162	

Note: The null hypothesis is that there is no correlation. The null hypothesis is rejected on a 0,05 statistical level.

We see, similar to previous models, that there is correlation among the independent variables. We therefore drop one by one in the OLS estimation until the model shows no mulitcollinearity. The variables that are included in the best model after dropping correlated variables are LIBOR, second-hand prices, steel price and orderbook.

6.3.2 OLS Model Assessment

The results from the OLS model for newbuilding prices of Sub-Panamax can be seen in Appendix C.3.The JC test indicates that there is one relation within the model. The F-statistic is 17.91, the model is statistically significant and the fit (R^2) is 27.2%. Three variables are significant, the highest number of significant variables out of the three newbuilding price models. They are LIBOR, second-hand price and steel price.

The residual testing from the Q-statistics (shown in Appendix C.3.1) indicate that the model is autocorrelated. Further, the results from the ARCH test allows us to accept the null hypothesis, indicating that the model is homoscedastic

6.3.3 ARIMA Model Assessment

The best ARIMA model according to the lowest AIC value for the newbuilding Sub-Panamax price is the ARIMA(3,1,3) and is depicted in Appendix D.3.
The results show that the model has a fit of R^2 equal to 0.340 and the p-value of the F-statistics is 0. It is observed that all the AR and MA variables are significant at a 5% level except MA(3).

The residual testing indicates that the model is heteroscedastic as the p-value from the ARCH test is 0.021 and we reject the null hypothesis. The model is not autocorrelated according to the Q-test as shown in Appendix D.3.

6.3.4 GARCH(1,1) Model Assessment

The results from the GARCH(1,1) model for newbuilding Sub-Panamax prices is depicted in Appendix E.3.

It is observed that both the ARCH and GARCH variables are significant and their sum is larger than 1, which implies that their importance in the formulation of the variance value of all previous disrupting terms' observations is elevated. All the same variables as in the OLS model turn out to be statistically significant, that is LIBOR, second-hand prices and steel price. Further, this model explains 25.4% of the volatility in newbuilding prices of Sub Panamax.

The residual testing indicates that the model is neither autocorrelated nor heteroscedastic.

6.3.5 VEC Model Assessment

We estimate the VEC model for the newbuilding price of Sub-Panamax and find the best results are with 4 lags. The results are presented in Appendix F.3.

The model has a good fit of 64% and is statistically significant. The results show that the C(1) is not significant, indicating no long-run causality on the newbuilding prices of Sub-Panamax vessels. Other variables are however significant with a negative coefficient. They are the two months lagged NBP, three months lagged LIBOR, and, two and four months lagged steel price. The Wald tests show that the all the variables except orderbook (NBP, LIBOR, steel price and SHP) have a short run causality affect on the newbuilding price of Sub-Panamax.

Further, the Breusch-Godfrey Serial Correlation test indicates no serial correlation and the model is homoscedastic according to the ARCH test.

6.4 Summary and Discussion of Newbuilding Price Models Results

The main results of each newbuilding price model has been summarised in Table 12, followed by discussion of each vessel size category in subchapters.

Table 12: Summary of Results from Newbuilding Price Models

	Significant variables	**AIC**	**R^2**	**Auto-correlation**	**Hetero-scedastic**
Feeders					
OLS	SHP	0.729	0.270	Yes	Yes
ARIMA(1,1,2)	MA(1), MA(2)	0.791	0.241	No	Yes
GARCH(1,1)	SHP, RESID(-1)^2, GARCH(1)	-0.010	0.226	No	No
VECM	LR: C(1); LIBOR(-4); SR: NBP, SHP, LIBOR	0.471	0.520	No	Yes*
Handysize					
OLS	LIBOR, STEELPRICE, TIMECHARTER	2.359	0.250	No	No
ARIMA(4,1,2)	ALL SIGNIFICANT	2.295	0.329	No	No
GARCH(1,1)	STEELPRICE, TIMECHARTER, RESID(-1)^2, GARCH(1)	2.151	0.222	No	No
VECM	SR: NBP, TIMECHARTER, LIBOR	2.167	0.475	No	No
Sub-Panamax					
OLS	STEELPRICE, LIBOR, SHP	2.569	0.272	Yes	No
ARIMA(3,1,3)	AR(1,2 & 3), MA(1 & 2)	2.611	0.340	No	Yes
GARCH(1,1)	SHP, STEELPRICE, LIBOR, RESID(-1)^2, GARCH(1)	2.424	0.254	No	No
VECM	NBP(-2), LIBOR(-3), STEELPRICE(-2 & -4), ORDERBOOK(-2); SR: NBP, SHP, STEELPRICE	2.204	0.637	No	No

***Homoscedastic at a 1% statistical level**

6.4.1 Newbuilding Price model for Feeders

After conducting a multicollinearity test for the newbuilding model of Feeders, the only variables found to affect the newbuilding price of Feeders is the second-hand price. However, the model estimated with OLS was found to be both autocorrelated and heteroscedastic, thus not a good estimation. Furthermore, both the ARIMA(1,1,2) and VEC Models are heteroscedastic, and only the GARCH(1,1) model was found to be not autocorrelated and homoscedastic.

The GARCH(1,1) indicates that the volatility of previous month price can influence the volatility of the newbuilding price in current month. The results are that out of all models estimated in this research, the GARCH(1,1) model is the best model to explain the price changes in newbuilding for Feeders. Firstly, it has the lowest AIC value and secondly, it is the only model that has acceptable results from diagnostic testing. However, it should be mentioned that the VECM is homoscedastic at 1% statistical level and has a high fit compared to the GARCH(1,1), or 52%. The VEC model indicates a short run causality effect from NBP, SHP and LIBOR on newbuilding prices.

6.4.2 Newbuilding Price Model for Handysize

The estimations for Handysize newbuilding price indicate that steel price, LIBOR and time charter rates are the most significant variables in estimating the price. All models run for this category were not autocorrelated nor heteroscedastic, indicating no error in the residuals of the models. All variables were significant in the ARIMA(4,1,2) model, indicating significance of both previous terms new building prices as well as previous error terms. The GARCH(1,1) results show that the newbuilding price of Handysize vessels can be affected by the external shock of steel price and time charter rates. Further, the volatility of the newbuilding price can also be explained by it's ARCH and GARCH variables, thus its own shock from previous month.

The best model, according to the AIC is the GARCH(1,1) with value of 2.151. The VECM value however is very closed to the GARCH(1,1) AIC value, or 2.167. Further the VECM model has a much better fit than the GARCH(1,1), 47.5% versus 22.6% respectively. Given the small difference in AIC value and large difference in fit, the VEC model might be more suitable when estimating the newbuilding price. The VEC model indicates that there is no long run causality from the error correction term, while the Wald tests indicate that there is a short run causality running from new building price it self, time charter rates and LIBOR rates.

6.4.3 Newbuilding Price Model for Sub-Panamax

The variables affecting the newbuilding price of Sub-Panamax vessels are, according to the OLS estimation, LIBOR, steel price and second-hand price. The OSL model however shows to be autocorrelated. The ARIMA(3,1,3) has the best combinations of lags for the ARIMA models. However, this model, turned out to be heteroscedastic. The GARCH(1,1) model indicated that second-hand price, steel price and LIBOR have an external effect on newbuilding price. Further, the ARCH and GARCH variables are significant and indicate that their importance in the formulation of the variance value of all previous disrupting terms' observations is elevated.

The model with the lowest AIC value is the VECM. The results of the regressed cointegrated equation indicates that there is not a long run causality running to the newbuilding price. However, there is a short run causality running from newbuilding price, second-hand price and steel price. Furthermore, three month lagged LIBOR rates affect the newbuilding price and two and four months' lagged steel price.

6.4.4 Conclusion

According to the summary in Table 12, the factors that influence the newbuilding prices of short sea container ships are the second-hand prices, steel prices and LIBOR. Second-hand prices were found significant for Feeders and Sub-Panamax while the time charter rate was a better estimator for the newbuilding price of the Handysize vessels. It should be noted that time charter rate and second-hand price are highly correlated variables, and previous empirical studies of ships prices have shown that second-hand price is dependent on the time charter rate. This will be examined for short sea ships container ships in the next chapter.

All Feeder models were heteroscedastic at a 5% statistical level except the GARCH(1,1) model, thus the best model for estimating the newbuilding Feeder prices. As for the Handysize, we assume VECM is better suited than the GARCH(1,1), due to simplicity and better fit. Lastly, the VECM is best suited for estimating the Sub-Panamax newbuilding prices.

Chapter 7 Second-Hand Price Models Results and Discussion

In this chapter we will present the results for the second-hand price models and discuss them. The chapter has the same structure as Chapter 6 and the same objective, to answer sub research question three.

7.1 Model 4: The Second-Hand Price Model for Feeders

7.1.1 Multicollinearity test

Correlation test results for independent variables in the second-hand price model for Feeders are shown in Table 13.

Table 13: Correlation P-values Between Independent Variables in Model 4

	GDP	INFLATION	D_LIBOR	D_NBP	D_ORDER BOOK	D_TIME CHARTER
GDP		0.5099	0.0000	0.0000	0.0269	0.0000
INFLATION	0.5099		0.6689	0.7569	0.4283	0.2140
D_LIBOR	0.0000	0.6689		0.0394	0.1554	0.0181
D_NBP	0.0000	0.7569	0.0394		0.0070	0.0000
D_ORDERBOOK	0.0269	0.4283	0.1554	0.0070		0.0253
D_TIMECHARTER	0.0000	0.2140	0.0181	0.0000	0.0253	

Note: The null hypothesis is that there is no correlation. The null hypothesis is rejected on a 0,05 statistical level.

There is a high multicollinearity within the Feeder second-hand price model, thus, we drop correlated variables. The only independent variable included in the best OLS model is the time charter rate.

7.1.2 OLS Model assessment

The results from the OSL model for second-hand Feeders prices is depicted in Appendix C.4.

Since this is not a multivariate model, the Johansen Cointegration test in not run. Instead, the residuals are checked for stationarity with the ADF test. The ADF test, shown in Appendix B.4, indicates that the residuals are stationary, thus there is a cointegrated relationship between second-hand price and time charter rates.

The OSL model is statistically significant and the fit is similar to previous models, or 0.260. The only significant variable detected is the time charter rate, where the coefficient indicates that if the time charter rate increases by one dollar per day, the second-hand price would increase by 865 dollars ($0.000865 million).

The Q-statistics show that the model is autocorrelated. Further, we accept the null hypothesis of the ARCH test, indicating that there is no heteroscedasticity.

It can be noted that the model gives a very similar results when time charter rate is replaced by newbuilding price, as these variables are highly correlated. However, estimation including time charter rate is presented as it has slightly higher fit and lower AIC value, thus has a better statistical relationship with second-hand price.

7.1.3 ARIMA Model Assessment

The estimations for the ARIMA models revealed that the best model with the lowest AIC value is the ARIMA(2,1,2) (shown in Appendix D.4).

The model has a fit 0,198 and the F-statistics value is 9,42 with p-value 0. The only significant variable is the AR(2). The Q-statistics indicate that the model is not autocorrelated as p-values are all insignificant. Further, the model is homoscedastic.

7.1.4 GARCH(1,1) Model Assessment

The results from GARCH(1,1) model are depicted in Appendix E.4.

The results show that both ARCH and GARCH variables are significant and their sum is 1.07, which is higher than one, thus their importance in the formulation of the variance value of all previous disrupting terms' observations is elevated. Further, 19.6% of the volatility in second-hand price of feeders is explained by this estimation.

The Q-statistics of squared residuals show that the model is not autocorrelated as all p-values are higher than 0.05, and further the ARCH test indicates that the model is not heteroscedastic.

7.1.5 VEC Model Assessment

As newbuilding price and time charter rate variables turned out to be very correlated in the OLS model and giving similar results, the VEC model was estimated for both scenarios. The VECM with time charter rates is found to be a better estimation and is thus presented in Appendix F.4.

The model is statistically significant and has a fit of R^2 0.292. The only coefficient that is both statistical significant at 5% level and negative is C(1), which represents the long run error correction term. The Wald tests indicates that the second-hand price and time charter rate have a short term causality effect on second-hand price of Feeders.

The residual diagnostics shown in Appendix F.4 indicate that the model is not serially correlated and is homoscedastic.

7.2 Model 5: The Second-Hand Price Model for Handysize

7.2.1 Multicollinearity test

Table 14 shows the results of correlation between independent variables related to Handysize vessels.

Table 14: Correlation P-values Between Independent Variables in Model 5

	GDP	INFLATION	D_LIBOR	D_NBP	D_ORDER BOOK	D_TIME CHARTER
GDP		0.5099	0.0000	0.0000	0.0071	0.0001
INFLATION	0.5099		0.6689	0.0239	0.3981	0.0403
D_LIBOR	0.0000	0.6689		0.0045	0.0167	0.3723
D_NBP	0.0000	0.0239	0.0045		0.0073	0.0000
D_ORDERBOOK	0.0071	0.3981	0.0167	0.0073		0.5862
D_TIMECHARTER	0.0001	0.0403	0.3723	0.0000	0.5862	

Note: The null hypothesis is that there is no correlation. The null hypothesis is rejected on a 0,05 statistical level.

There is high mulitcollinearity and the variables that are included in the best OSL model are the time charter rates and orderbook.

7.2.2 OLS Model assessment

The results from the OSL model for the second-hand price of Handysize vessels is depicted in Appendix C.5.

The Johansen cointegration test indicates one relation among the variables. The results of the OLS model show that it is statistically significant and the F-statistic value is 34.1. The R^2 value is 0.260 indicating that 26.0% of the second-hand price can be explained by the model. The time charter rate and orderbook are significant and affect the second-hand price of Handysize vessels. According to the coefficients, if the orderbook (percentage of fleet) would in crease by 1 unit (which is 100%) the second-hand price would increase by $ 36.8 million, meaning that 1% point increase in orderbook would result in 0.37 million increase in second-hand price.

The autocorrelation test indicates that the model is not autocorrelated as all P-values are insignificant, thus accepting the null hypothesis. The ARCH test also allows us to accept the null hypothesis, that no heteroscedasticity exists.

7.2.3 ARIMA Model Assessment

The best ARIMA model is presented in Appendix D.5. The results of the ARIMA(2,1,1) model show that it is statistically significant, however the model has a low fit, or 9.7%. Further, the only significant variable is the AR(2) variable.

The residual test indicate that the model is homoscedastic and there is no autocorrelation.

7.2.4 GARCH(1,1) Model Assessment

The results from the GARCH(1,1) model are depicted in Appendix E.5.

The estimation shows that the ARCH and GARCH variables are statistically significant and their sum is 1.39, thus their importance in the formulation of the variance value of all previous disrupting terms' observations is elevated. The time charter rate is significant and thus helps to explain the volatility of second-hand prices of Handysize.

The p-value of the ARCH test is 0.34, indicating that the model is not heteroscedastic. Further, all the p-values for the autocorrelation test show high insignificance, thus the model is not serially correlated.

7.2.5 VEC Model Assessment

The results from the best VECM, that includes one cointegrating relations and four lags, are depicted in Appendix F.5.

The model has a fit of 0.241 and the results show that there is no long run causality effect on the SHP.

The Wald tests further indicate that time charter rate has a short run causality running to second-hand price of Handysize vessels.

The residual tests imply that the model is neither serial correlated nor heteroscedastic.

7.3 Model 6: The Second-Hand Price Model for Sub-Panamax

7.3.1 Multicollinearity test

Table 15 shows the results from the multicollinearity test for second-hand Sub-Panamax prices.

Table 15: Correlation P-values Between Independent Variables in Model 6

	GDP	INFLATION	D_LIBOR	D_NBP	D_ORDER BOOK	D_TIME CHARTER
GDP		0.5099	0.0000	0.0000	0.0324	0.0000
INFLATION	0.5099		0.6769	0.0097	0.3775	0.0076
D_LIBOR	0.0000	0.6769		0.0213	0.3386	0.5672
D_NBP	0.0000	0.0097	0.0213		0.0230	0.0010
D_ORDERBOOK	0.0324	0.3775	0.3386	0.0230		0.1000
D_TIMECHARTER	0.0000	0.0076	0.5672	0.0010	0.1000	

Note: The null hypothesis is that there is no correlation. The null hypothesis is rejected at a 0,05 statistical level.

There is high multicollinearity detected and after dropping few variables, the best OSL model includes time charter rates and LIBOR.

7.3.2 OLS Model assessment

The best OSL model is shown in Appendix C.6. The Johansen Cointegration test indicates that there is one relation within our model. The model is statistically significant and the F-statistics value is 29.52. Further, the model has a fit of 0.23. The time charter rate is the only significant variable, with p-value equal 0.

The diagnostic testing indicates that the model is not autocorrelated as most p-values are not significant. Furthermore, the ARCH test indicates that it is homoscedastic at a 5% statistical level.

7.3.3 ARIMA Model Assessment

The best ARIMA model found for the second-hand Sub-Panamax price is the ARIMA(4,1,4) shown in Appendix D.6. The R^2 value is 0.21 and the model is statistically significant. All the variable are significant except the AR(1) and MA(1).

The model is not autocorrelated as all p-values from the correlation test are insignificant. Further, the model is not heteroscedastic according to the ARCH test.

7.3.4 GARCH(1,1) Model assessment

The results of the GARCH(1,1) model are depicted in Appendix E.6. The results indicate that the model has a fit of 21.6%. Further, both the ARCH and GARCH variables are significant, with a sum of coefficients 0.94.

The time charter rates variable is significant and the LIBOR variable becomes significant in the GARCH(1,1) model. This indicates that LIBOR helps to explain the variance in volatility of second-hand prices. The residual tests, shown in Appendix E.6, indicate that the model is not autocorrelated and is homoscedastic.

7.3.5 VEC Model Assessment

Appendix F.6 shows the results from the VEC model with one cointegrated relation and three lags. The model shows a fit of 21.5%. There is no variable that has a negative coefficient and is significant, which indicates there is no long run causality running from the error correction term to the second-hand price.

However, the Wald tests indicate that there is a short term causality running from time charter rates to the second-hand price of Sub-Panamax.

The residual test indicate that the model is not serially correlated and not heteroscedastic.

7.4 Summary and Discussion of Second-Hand Price Models Results

The results from the second-hand price models are summarised in Table 16 and further discussed for each vessel type in subchapters.

Table 16: Summary of Results from Second-Hand Price Models

	Significant variables	**AIC**	**R^2**	**Auto-correlation**	**Hetero-scedastic**
Feeders					
OLS	TIMECHARTER	0.674	0.260	Yes	No
ARIMA(2,1,2)	AR(2)	0.798	0.198	No	No
GARCH(1,1)	TIMECHARTER, RESID(-1)^2, GARCH(1)	0.251	0.196	No	No
VECM	LR: C(1); SR: TIMECHARTER	0.696	0.292	No	No
Handysize					
OLS	TIMECHARTER, ORDERBOOK	3.351	0.260	No	No
ARIMA(2,1,1)	AR(2)	3.572	0.097	No	No
GARCH(1,1)	TIMECHARTER, RESID(-1)^2, GARCH(1)	3.022	0.180	No	No
VECM	SR: TIMECHARTER	3.498	0.241	No	No
Sub-Panamax					
OLS	TIMECHARTER	3.989	0.233	No	No
ARIMA(4,1,4)	AR(2,3 & 4), MA(2,3 & 4)	4.105	0.211	No	No
GARCH(1,1)	LIBOR, TIMECHARTER, RESID(-1)^2, GARCH(1)	3.798	0.195	No	No
VECM	SR: TIMECHARTER	4.135	0.215	No	No

7.4.1 Second-Hand Price Model for Feeders

After dropping high number of correlated variables, only one ended up in the final model and that is the time charter rates, indicating that out of all the variables, time charter rate alone is the best estimator for second-hand-prices. The ARIMA(2,1,2) is the best ARIMA model with only the two lagged autoregressive variable significant. The GARCH (1,1) model indicates that time charter rate affects the volatility of second-hand prices of Feeders. Further, there is an asymmetric effects of previous terms as both ARCH and GARCH variables are significant. The VECM indicates that the long term cointegrated relationship is significant and that time charter rates have a short term causality effect on second-hand prices.

Table 16 shows that the GARCH(1,1) model has the lowest AIC value and therefore has the least forecasting errors compared to other models for second-hand price of Feeders. The VEC model however, has the highest fit, 29.2% compared to 19.6% for the GARCH(1,1). Given the complexity of the GARCH method (forecasting variance based on past variance and past variance forecasts), other, more simple methods that give sufficient results, might be better suited for forecasting, as the VEC model in this case.

7.4.2 Second-Hand Price Model for Handysize model

The regression analysis of the second-hand Handysize vessels show that the orderbook and time charter rates are the most significant variables affecting the second-hand price. The best ARIMA model is the ARIMA(2,1,1), all combination of lags however, showed a very poor fit. The GARCH(1,1) indicates that the external shock of time charter rates has an affect on the second-hand prices and further that the ARCH and GARCH variables are significant. The VECM results indicate that the time charter rate has a short run causality effect on the second-hand price.

The GARCH(1,1) model has the lowest AIC value among the four estimations, while the OSL model had the best fit.

7.4.3 Second-Hand Price Model for Sub-Panamax

The basic OLS model for second-hand prices of Sub-Panamax vessels indicates that the time charter rate has the most influence on the second-hand price. The best ARIMA model estimated is the ARIMA(4,1,4), which indicated significant effect from the two, three and four lags of both autoregressive and moving average variables. The GARCH(1,1) model indicated that the volatility of second-hand price is effected by the external shock of the time charter rates and LIBOR. Further, the ARCH and GARCH effects are significant. The VECM indicated that there is a short run causality running from time charter rates to the second-hand price.

The GARCH(1,1) is the model with the lowest AIC value, while the VECM model has a better fit, 19.5% versus 21.5%, respectively.

7.4.4 Conclusion

All models in the second-hand price category are with sufficient diagnostic testing results, except the OLS model of Feeders which is autocorrelated. The GARCH(1,1) has the lowest AIC value in all categories indicating the least forecasting errors. However, the GARCH(1,1) methods' complexity weighs high and as all the VECM models have sufficient diagnostic test results, better fit, and are in general more simple, they are more convenient for application. Additional advantage of the VEC model over the GARCH(1,1), is that it identifies what external factors affect the future prices. For all the second-hand VEC models, the time charter rate appeared to have a short run causality running to the second-hand price.

The results of the second-hand price models are rather decisive, showing that the time charter rates have a high statistical relationship with the second-hand short sea ships prices. This is consistent with theory and previous empirical results about second-hand ships prices.

Chapter 8 Conclusions and Recommendations

8.1 Conclusions

In particular, this thesis has analysed the short sea container ship market with the main objective to observe how the fleet is developing and what determinants affect the price of newbuilding and second-hand vessels. The vessels that are characterised as short sea are vessels with a capacity under 3,000 TEU, Feeders, Handysize and Sub-Panamax.

To be able to satisfy the objectives of the research, three sub research questions were formulated. The first sub question aimed to find what are the dynamics of the short sea container fleet. To answer this question, an analysis of the fleet route deployment estimates, fleet development, and orderbook was carried out. The analysis shows that the route deployment of Handysize and Sub-Panamax vessels has changed in the last five years. These sizes of vessels are noticed to be moving from the North-South trade and increasing their market share and deployment in the intra-regional trade (short sea), thus putting pressure on the Feeders that have lost their market share in that segment. Further, after a negative growth of the short sea container ship fleets since the economic crisis hit in 2009, the Handysize and Sub-Panamax show signs of recovery according to recent growth numbers as they are positive in addition to increasing orderbooks. However, the Feeder fleet shows no such signs, with orderbook standing at 0% in June 2016.

The second sub research question was aimed to capture what analytical approaches are of use to analyse the factors that influence the price of newbuilding and second-hand prices of ships. The literature review provided a lot of econometric approaches to estimate the price of second-hand and newbuilt ships, as well as explanatory variables thought to be relevant in the estimations. Models chosen to explain the newbuilding and second-hand prices are the OLS, ARIMA, GARCH(1,1) and VECM. The GARCH model was found to be commonly used in modelling ships prices and is used mainly to capture the volatility of price. Further, the VEC method is used to capture the long run and short run causality effect on the prices. Additionally, to the methods identified in the literature review, the ARIMA method was applied to capture both the current shock as well as the effect of previous shocks effect on prices. The explanatory variables chosen for our models, based on the literature review, besides the ships prices, are the time charter rates, steel price, orderbook, GDP, inflation, and LIBOR.

All variables chosen for modelling are stationary at first differences according to the ADF tests, and, further, all models showed to have at least one cointegrating equation according to the JC test.

The objective of the third sub research question was to find which of these identified models are best suited to support the investment decision made in the short sea container ship market. The GARCH(1,1) was the only homoscedastic model for the newbuilding price of Feeders, therefore, the best suited model to determine the price. According to the AIC values, the GARCH(1,1) model is best model for all price categories except the newbuilding Sub-Panamax, where the VECM model was the best one. However, given the complexity of the GARCH(1,1) and sufficient results of the VECM, we conclude that the VECM is more convenient to determine future prices of newbuilt Handysize vessel, newbuilt Sub-Panamax vessels, and all second-hand vessels.

The indicators that are significant and investors should look out for when investing in newbuilt Feeders are the second-hand prices. The newbuilding Handysize price is effected by time charter rates and LIBOR, and finally the Sub-Panamax newbuilding price is dependent on steel price, second-hand prices and LIBOR. The second-hand prices of Feeders and Sub-Panamax are found to be effected most by the time charter rates. Further the second-hand prices for the Handysize vessels are affected by the time charter rates and orderbook.

The main research question can then be concluded. The Handysize and Sub-Panamax fleets are increasing their deployment in the intra-regional trade and show signs of positive growth in coming years, while the Feeder fleet is declining and experiencing pressure from the larger short sea ships. The variables that are found to have greatest effect on the newbuilding prices are the steel price and LIBOR. Further, the second-hand prices in all vessel categories are affected by the time charter rates. This indicates, similar to previous research and theory, that the newbuilding prices of short sea ships are cost-driven while the second-hand prices are market-driven.

8.2 Limitations

There are some limitations to this study. Firstly, the short sea container ship fleet is very heterogeneous compared to bulk ships, tanker ships, and larger container ships. Therefore, this research included market prices of generic ships, thus making predictions for different designs of short sea vessels not as accurate. Further, the data for GDP was gathered from the G20 economies and inflation from the OECD countries, thus not representing the whole world economy, which might give different results. Lastly, the time available to conduct this research was scarce, thus effecting its quality.

8.3 Recommendations

There are numerous interesting recommendations for further research. Firstly, to find the best estimation for newbuilding and second-hand prices, it would be interesting to see more variety of models applied, especially within the ARCH family of models.

Secondly, the modelling of transaction volumes of ships and estimating what effects the activity in the market would be of interest as there is scarce literature available on the subject.

Lastly, the MPP ship market could be further researched if accurate data can be obtained.

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Appendix A Data Observations Graphs

A.1 Feeder data

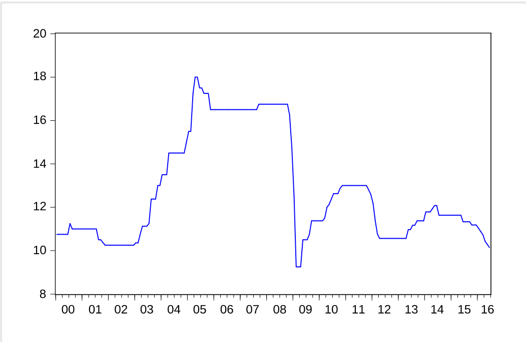

Figure A-1: Newbuilding Prices 2000-2016 (million $)

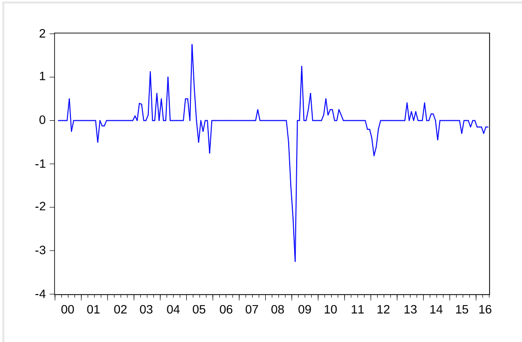

Figure A-2:Differenced Newbuilding Prices 2000-2016 (million $)

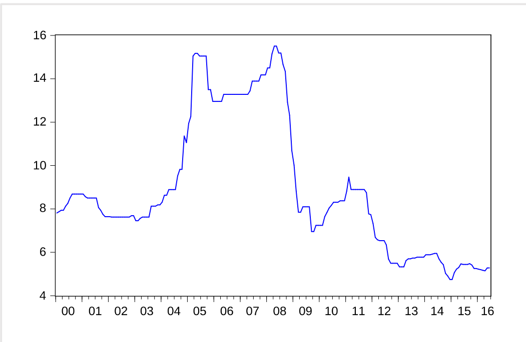

Figure A-3: Second Hand Prices 2000-2016 (million $)

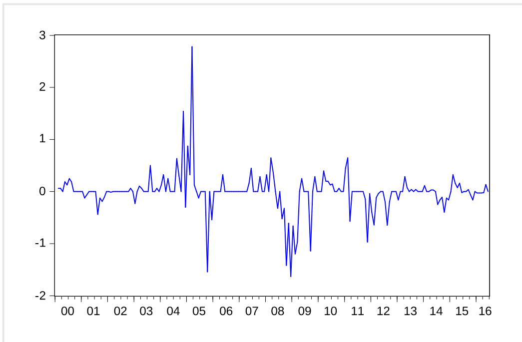

Figure A-4: Differenced Second Hand Prices 2000-2016 (million $)

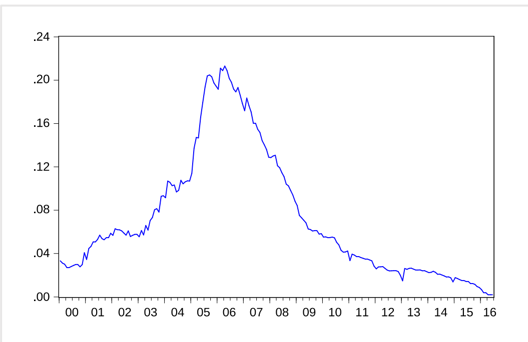

Figure A-5: Orderbook (as % of fleet) 2000-2016

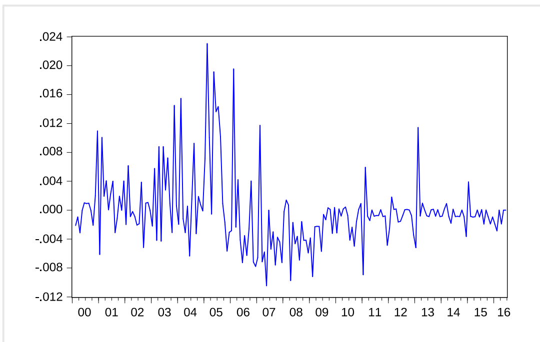

Figure A-6: Differenced Orderbook (as % of fleet) 2000-2016

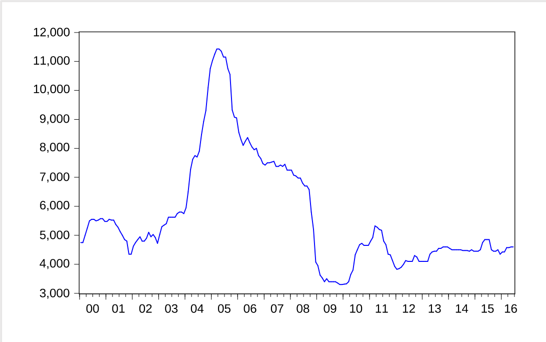

Figure A-7: Time Charter Rates 2000-2016 (in $ per day)

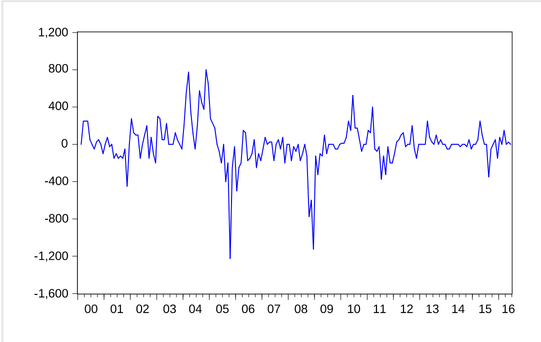

Figure A-8: Differenced Time Charter Rates 2000-2016 (in $ per day)

A.2 Sub-Panamax Data

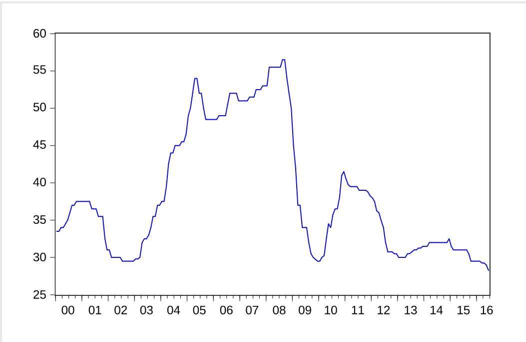

Figure A-9: Newbuilding Prices 2000-2016 (million $)

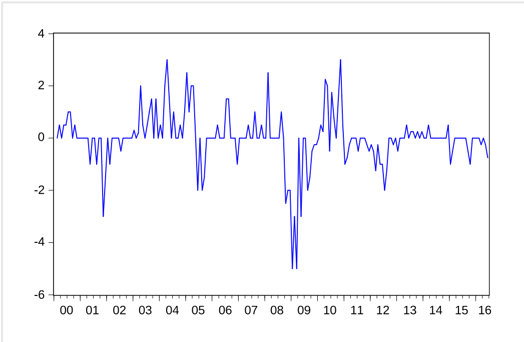

Figure A-10: Differenced Newbuilding Prices 2000-2016 (million $)

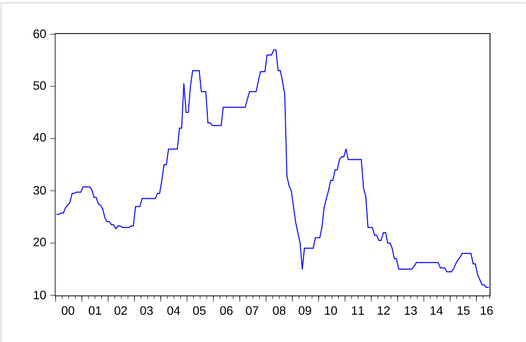

Figure A-11: Second Hand Prices 2000-2016 (million $)

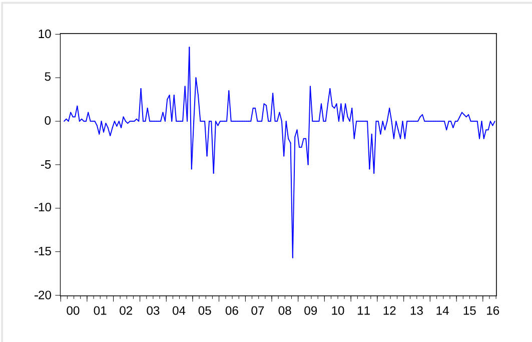

Figure A-12: Differenced Second Hand Prices 2000-2016 (million $)

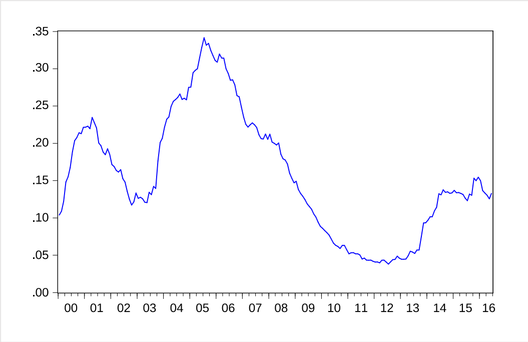

Figure A-13: Orderbook (as % of fleet) 2000-2016

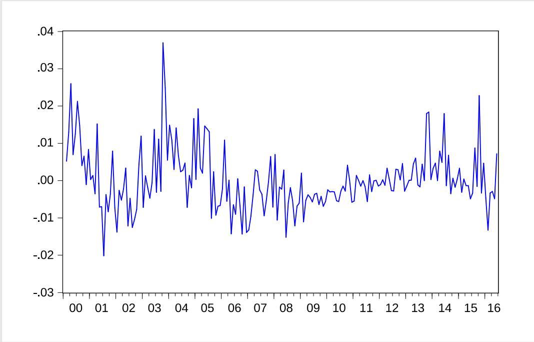

Figure A-14: Differenced Orderbook (as % of fleet) 2000-2016

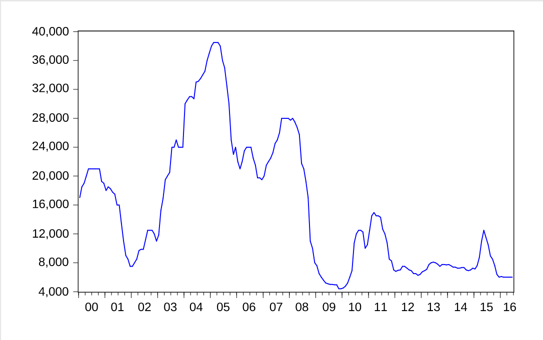

Figure A-15: Time Charter Rates 2000-2016 (in $ per day)

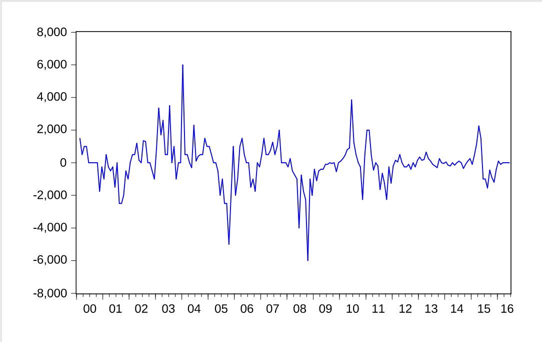

Figure A-16:Differenced Time Charter Rates 2000-2016 (in $ per day)

Appendix B Cointegration Tests

B.1 Model 1 Newbuilding Price Feeders

Date: 08/26/16 Time: 21:49
Sample (adjusted): 2000M06 2016M06
Included observations: 193 after adjustments
Trend assumption: No deterministic trend (restricted constant)
Series: NBP SHP LIBOR
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.105750	40.67757	35.19275	0.0116
At most 1	0.065505	19.10589	20.26184	0.0715
At most 2	0.030763	6.030412	9.164546	0.1884

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

B.2 Model 2 Newbuilding Price Handy Size

Date: 08/26/16 Time: 21:24
Sample (adjusted): 2000M06 2016M06
Included observations: 193 after adjustments
Trend assumption: No deterministic trend (restricted constant)
Series: NBP LIBOR STEELPRICE TCHR
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.162638	59.10882	54.07904	0.0166
At most 1	0.053641	24.85165	35.19275	0.4092
At most 2	0.042983	14.21092	20.26184	0.2751
At most 3	0.029261	5.731576	9.164546	0.2125

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

B.3 Model 3 Newbuilding Price Sub-Panamax

Date: 08/26/16 Time: 20:32
Sample (adjusted): 2000M06 2016M06
Included observations: 193 after adjustments
Trend assumption: No deterministic trend (restricted constant)
Series: NBP LIBOR SHP STEELPRICE ORDERBOOK
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.139707	78.36466	76.97277	0.0390
At most 1	0.124612	49.32165	54.07904	0.1243
At most 2	0.069331	23.63563	35.19275	0.4864
At most 3	0.031295	9.768196	20.26184	0.6626
At most 4	0.018641	3.631694	9.164546	0.4697

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

B.4 Model 4 Second Hand Price Feeders

Null Hypothesis: U has a unit root
Exogenous: None
Lag Length: 1 (Automatic - based on SIC, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.776563	0.0000
Test critical values:	1% level	-2.576875	
	5% level	-1.942465	
	10% level	-1.615617	

*MacKinnon (1996) one-sided p-values.

B.5 Model 5 Second Hand Price Handy Size

Date: 08/25/16 Time: 22:25
Sample (adjusted): 2000M06 2016M06
Included observations: 193 after adjustments
Trend assumption: No deterministic trend
Series: SHP TCHR ORDERBOOK
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.146500	39.92401	24.27596	0.0003
At most 1	0.041267	9.350853	12.32090	0.1496
At most 2	0.006288	1.217370	4.129906	0.3149

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

B.6 Model 6 Second Hand Price Sub-Panamax

Date: 08/26/16 Time: 20:52
Sample (adjusted): 2000M06 2016M06
Included observations: 193 after adjustments
Trend assumption: No deterministic trend (restricted constant)
Series: SHP TIMECHARTER LIBOR
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.124539	40.64632	35.19275	0.0117
At most 1	0.048525	14.97645	20.26184	0.2277
At most 2	0.027472	5.376198	9.164546	0.2447

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Appendix C OSL Estimation Outputs and Diagnostic Tests

C.1 Model 1 The Newbuilding Price Model for Feeder

C.1.1 Autocorrelation test

Date: 08/26/16 Time: 22:25
Sample: 2000M01 2016M06
Included observations: 197

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
.|* |	.|* |	1	0.207	0.207	8.5598	0.003
.|. |	.|. |	2	0.049	0.007	9.0493	0.011
*|. |	*|. |	3	-0.123	-0.141	12.123	0.007
*|. |	*|. |	4	-0.133	-0.086	15.742	0.003
.|. |	.|. |	5	-0.033	0.023	15.965	0.007
.|. |	.|. |	6	-0.053	-0.060	16.533	0.011
*|. |	*|. |	7	-0.160	-0.179	21.784	0.003
.|. |	.|. |	8	-0.056	-0.000	22.425	0.004
.|. |	.|* |	9	0.067	0.094	23.365	0.005
.|. |	.|. |	10	0.067	-0.013	24.313	0.007
.|* |	.|. |	11	0.080	0.012	25.664	0.007
.|. |	.|. |	12	0.040	0.039	26.006	0.011
.|. |	.|. |	13	0.049	0.055	26.515	0.014
*|. |	*|. |	14	-0.068	-0.117	27.499	0.017
.|. |	.|. |	15	-0.017	0.021	27.560	0.024
.|. |	.|. |	16	-0.060	-0.000	28.344	0.029
*|. |	*|. |	17	-0.107	-0.103	30.849	0.021
.|. |	.|. |	18	0.021	0.053	30.942	0.029
.|. |	.|. |	19	-0.034	-0.031	31.198	0.038
.|. |	.|. |	20	0.023	0.008	31.311	0.051
.|. |	*|. |	21	-0.020	-0.077	31.397	0.067
.|. |	.|. |	22	-0.053	-0.056	32.018	0.077
.|. |	.|. |	23	0.034	0.064	32.280	0.094
.|. |	.|. |	24	0.041	-0.015	32.662	0.111
.|. |	.|. |	25	-0.006	-0.039	32.670	0.140
.|. |	.|. |	26	0.038	0.064	33.008	0.162
*|. |	*|. |	27	-0.089	-0.087	34.828	0.143
.|. |	.|. |	28	-0.003	0.008	34.830	0.175
.|. |	.|. |	29	-0.041	-0.052	35.229	0.197
.|. |	.|. |	30	-0.021	0.011	35.337	0.231
.|. |	.|. |	31	-0.008	-0.025	35.353	0.270
.|. |	.|. |	32	-0.022	-0.028	35.472	0.308
.|. |	.|. |	33	-0.031	-0.034	35.706	0.342
.|. |	.|. |	34	-0.023	-0.037	35.830	0.383
.|. |	.|. |	35	0.013	0.010	35.870	0.427
.|. |	.|. |	36	0.051	0.014	36.499	0.445

C.1.2 Heteroscedasticity test

Heteroskedasticity Test: ARCH

F-statistic	30.28431	Prob. F(1,194)	0.0000
Obs*R-squared	26.46518	Prob. Chi-Square(1)	0.0000

C.2 Model 2 The Newbuilding Price Model for Handy Size

C.2.1 Estimation output

Dependent Variable: D_NBP
Method: Least Squares
Date: 08/20/16 Time: 13:34
Sample (adjusted): 2000M02 2016M06
Included observations: 197 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D_LIBOR_	83.86068	27.76740	3.020113	0.0029
D_STEELPRICE	0.006467	0.001180	5.479651	0.0000
D_TIMECHARTER	0.000259	5.69E-05	4.551966	0.0000
C	0.026995	0.056000	0.482052	0.6303

R-squared	0.250364	Mean dependent var	0.002538
Adjusted R-squared	0.238711	S.D. dependent var	0.892854
S.E. of regression	0.779031	Akaike info criterion	2.358565
Sum squared resid	117.1297	Schwarz criterion	2.425229
Log likelihood	-228.3186	Hannan-Quinn criter.	2.385551
F-statistic	21.48605	Durbin-Watson stat	1.643423
Prob(F-statistic)	0.000000		

C.2.2 Diagnostic Testing

C.2.2.1 Autocorrelation test

Date: 08/20/16 Time: 13:28
Sample: 2000M01 2016M06
Included observations: 197

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
.|* |	.|* |	1	0.096	0.096	1.8558	0.173
.|* |	.|* |	2	0.096	0.087	3.6988	0.157
.|. |	.|. |	3	0.024	0.008	3.8188	0.282
.|. |	.|. |	4	0.022	0.011	3.9201	0.417
.|* |	.|* |	5	0.132	0.129	7.4905	0.187
.|. |	.|. |	6	0.020	-0.005	7.5746	0.271
.|* |	.|* |	7	0.170	0.150	13.525	0.060
.|. |	.|. |	8	0.039	0.008	13.835	0.086
.|. |	.|. |	9	0.006	-0.028	13.842	0.128
.|. |	.|. |	10	-0.012	-0.033	13.873	0.179
.|. |	.|. |	11	0.058	0.064	14.592	0.202
.|. |	*|. |	12	-0.026	-0.077	14.736	0.256
.|. |	.|. |	13	0.020	0.016	14.820	0.319
.|* |	.|. |	14	0.077	0.063	16.092	0.308
.|. |	.|. |	15	0.070	0.057	17.138	0.311
.|. |	.|. |	16	-0.005	-0.041	17.143	0.376
.|. |	.|. |	17	-0.009	0.009	17.159	0.444
.|. |	*|. |	18	-0.049	-0.074	17.678	0.477
.|. |	.|. |	19	0.055	0.067	18.334	0.500
.|. |	.|. |	20	-0.010	-0.030	18.355	0.564
.|. |	.|. |	21	0.024	0.009	18.483	0.618
.|. |	.|. |	22	0.005	-0.028	18.489	0.677
*|. |	.|. |	23	-0.072	-0.043	19.646	0.663
.|. |	.|. |	24	-0.032	-0.039	19.872	0.704
*|. |	.|. |	25	-0.078	-0.044	21.275	0.677
.|* |	.|* |	26	0.118	0.121	24.448	0.550
.|. |	.|. |	27	0.057	0.065	25.209	0.563
.|. |	*|. |	28	-0.055	-0.090	25.907	0.578
.|. |	.|. |	29	-0.002	0.013	25.907	0.630
.|. |	.|. |	30	-0.056	-0.034	26.648	0.642
.|. |	.|. |	31	-0.022	-0.022	26.767	0.684
*|. |	.|. |	32	-0.077	-0.065	28.171	0.661
.|. |	.|. |	33	-0.018	-0.017	28.247	0.703
.|. |	.|. |	34	-0.018	-0.038	28.321	0.742
.|. |	.|. |	35	-0.026	0.016	28.481	0.774
.|. |	.|. |	36	-0.022	-0.003	28.594	0.805

C.2.2.2 Heteroscedasticity test

Heteroskedasticity Test: ARCH

F-statistic	1.819772	Prob. F(1,194)	0.1789
Obs*R-squared	1.821447	Prob. Chi-Square(1)	0.1771

C.3 Model 3 The newbuilding Price Model for Sub-Panamax

C.3.1 Estimation output

Dependent Variable: D_NBP
Method: Least Squares
Date: 08/10/16 Time: 23:29
Sample (adjusted): 2000M02 2016M06
Included observations: 197 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D_LIBOR	97.90351	32.32658	3.028577	0.0028
D_SHP	0.166996	0.032736	5.101242	0.0000
D_STEELPRICE	0.007106	0.001373	5.173777	0.0000
D_ORDERBOOK	12.02325	7.877094	1.526356	0.1286
C	0.007896	0.065026	0.121432	0.9035

R-squared	0.271754	Mean dependent var	-0.026650
Adjusted R-squared	0.256582	S.D. dependent var	1.047477
S.E. of regression	0.903152	Akaike info criterion	2.659202
Sum squared resid	156.6113	Schwarz criterion	2.742532
Log likelihood	-256.9314	Hannan-Quinn criter.	2.692934
F-statistic	17.91175	Durbin-Watson stat	1.790207
Prob(F-statistic)	0.000000		

C.3.2 Diagnostic Testing

C.3.2.1 Autocorrelation test

Date: 08/18/16 Time: 22:10
Sample: 2000M01 2016M06
Included observations: 197

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
.|* |	.|* |	1	0.080	0.080	1.2940	0.255
.|** |	.|** |	2	0.305	0.300	19.950	0.000
.|. |	.|. |	3	0.002	-0.043	19.951	0.000
.|. |	.|. |	4	0.045	-0.048	20.370	0.000
.|. |	.|. |	5	0.054	0.073	20.960	0.001
.|. |	.|. |	6	0.019	0.013	21.038	0.002
.|* |	.|. |	7	0.082	0.048	22.422	0.002
.|. |	.|. |	8	-0.005	-0.021	22.427	0.004
.|. |	.|. |	9	-0.021	-0.065	22.519	0.007
.|. |	.|. |	10	-0.025	-0.011	22.655	0.012
.|* |	.|** |	11	0.171	0.224	28.818	0.002
.|. |	*|. |	12	-0.047	-0.083	29.277	0.004
.|* |	.|. |	13	0.090	-0.028	31.020	0.003
.|. |	.|* |	14	0.019	0.077	31.098	0.005
.|. |	.|. |	15	0.009	-0.020	31.116	0.008
.|* |	.|. |	16	0.075	0.052	32.325	0.009
.|. |	.|. |	17	0.007	0.016	32.337	0.014
.|* |	.|. |	18	0.098	0.018	34.452	0.011
.|. |	.|. |	19	0.046	0.052	34.916	0.014
.|. |	.|. |	20	0.056	0.045	35.622	0.017
.|. |	*|. |	21	-0.018	-0.079	35.692	0.024
.|* |	.|. |	22	0.088	0.053	37.420	0.021
.|. |	.|. |	23	-0.054	-0.019	38.077	0.025
.|. |	*|. |	24	-0.037	-0.126	38.393	0.032
*|. |	.|. |	25	-0.084	-0.056	40.016	0.029
*|. |	.|. |	26	-0.076	-0.013	41.324	0.029
.|. |	.|. |	27	-0.042	-0.037	41.737	0.035
.|. |	.|. |	28	-0.042	0.024	42.137	0.042
.|. |	.|. |	29	0.065	0.074	43.138	0.044
.|. |	.|. |	30	0.033	0.015	43.400	0.054
*|. |	*|. |	31	-0.080	-0.128	44.901	0.051
.|. |	.|. |	32	0.036	0.070	45.206	0.061
.|. |	.|. |	33	0.014	0.040	45.251	0.076
.|. |	*|. |	34	-0.042	-0.101	45.680	0.087
.|. |	*|. |	35	-0.054	-0.070	46.386	0.094
.|. |	.|. |	36	-0.050	-0.001	46.988	0.104

C.3.2.2 Heteroscedasticity test

Heteroskedasticity Test: ARCH

F-statistic	1.264331	Prob. F(1,194)	0.2622
Obs*R-squared	1.269094	Prob. Chi-Square(1)	0.2599

C.4 Model 4 The Second Hand Price Model for Feeders

C.4.1 Estimation Output

Dependent Variable: D_SHP
Method: Least Squares
Date: 08/25/16 Time: 20:48
Sample (adjusted): 2000M02 2016M06
Included observations: 197 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D_TIMECHARTER	0.000865	0.000105	8.273461	0.0000
C	-0.012205	0.024034	-0.507817	0.6122

R-squared	0.259822	Mean dependent var	-0.012863
Adjusted R-squared	0.256026	S.D. dependent var	0.391096
S.E. of regression	0.337335	Akaike info criterion	0.674621
Sum squared resid	22.19004	Schwarz criterion	0.707953
Log likelihood	-64.45020	Hannan-Quinn criter.	0.688114
F-statistic	68.45015	Durbin-Watson stat	1.817745
Prob(F-statistic)	0.000000		

C.4.2 Diagnostic tests

C.4.2.1 Autocorrelation test

Date: 08/25/16 Time: 21:20
Sample: 2000M01 2016M06
Included observations: 197

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
.|* |	.|* |	1	0.091	0.091	1.6563	0.198
.|* |	.|* |	2	0.190	0.183	8.9311	0.011
.|. |	*|. |	3	-0.041	-0.075	9.2785	0.026
.|* |	.|* |	4	0.129	0.109	12.675	0.013
.|. |	.|* |	5	0.070	0.075	13.674	0.018
.|. |	.|. |	6	0.070	0.012	14.680	0.023
.|. |	.|. |	7	0.005	-0.013	14.685	0.040
.|. |	.|. |	8	-0.031	-0.051	14.887	0.061
.|. |	.|. |	9	-0.028	-0.031	15.052	0.090
.|. |	.|. |	10	0.037	0.045	15.335	0.120
.|. |	.|. |	11	-0.013	-0.022	15.370	0.166
*|. |	*|. |	12	-0.097	-0.112	17.357	0.137
*|. |	*|. |	13	-0.121	-0.086	20.491	0.084
.|. |	.|. |	14	-0.008	0.046	20.504	0.115
.|. |	.|. |	15	0.044	0.071	20.926	0.139
.|. |	.|. |	16	-0.009	-0.023	20.944	0.181
.|. |	.|. |	17	0.003	0.022	20.946	0.229
.|. |	.|. |	18	-0.024	0.010	21.070	0.276
.|. |	.|. |	19	0.069	0.069	22.105	0.279
.|. |	.|. |	20	-0.027	-0.053	22.272	0.326
.|. |	.|. |	21	0.048	0.006	22.778	0.356
*|. |	.|. |	22	-0.072	-0.055	23.927	0.351
.|. |	.|. |	23	-0.037	-0.047	24.232	0.391
.|. |	.|. |	24	-0.025	-0.002	24.371	0.441
.|. |	.|. |	25	0.007	-0.022	24.382	0.497
.|. |	.|. |	26	0.022	0.029	24.491	0.548
.|. |	.|. |	27	0.011	0.047	24.519	0.601
.|. |	.|. |	28	-0.036	-0.026	24.820	0.638
.|. |	.|. |	29	0.008	0.008	24.836	0.687
.|. |	.|. |	30	-0.043	-0.035	25.263	0.712
.|. |	.|. |	31	0.005	0.001	25.268	0.756
.|. |	.|. |	32	0.029	0.061	25.471	0.787
.|. |	.|. |	33	0.003	-0.017	25.473	0.822
.|* |	.|* |	34	0.087	0.078	27.273	0.787
.|* |	.|. |	35	0.079	0.073	28.781	0.762
.|* |	.|. |	36	0.099	0.040	31.177	0.697

C.4.2.2 Heteroscedasticity test

Heteroskedasticity Test: ARCH

F-statistic	0.012469	Prob. F(1,194)	0.9112
Obs*R-squared	0.012596	Prob. Chi-Square(1)	0.9106

C.5 Model 5 The Second Hand Price Model Handy Size

C.5.1 Estimation Output

Dependent Variable: D_SHP
Method: Least Squares
Date: 08/25/16 Time: 22:23
Sample (adjusted): 2000M02 2016M06
Included observations: 197 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D_TIMECHARTER	0.000719	9.34E-05	7.690658	0.0000
D_ORDERBOOK	33.66426	12.51048	2.690885	0.0077
C	-0.026351	0.091430	-0.288205	0.7735

R-squared	0.259841	Mean dependent var	-0.038071
Adjusted R-squared	0.252210	S.D. dependent var	1.483813
S.E. of regression	1.283125	Akaike info criterion	3.351585
Sum squared resid	319.4034	Schwarz criterion	3.401583
Log likelihood	-327.1311	Hannan-Quinn criter.	3.371825
F-statistic	34.05285	Durbin-Watson stat	2.002610
Prob(F-statistic)	0.000000		

C.5.2 Diagnostic Tests

C.5.2.1 Autocorrelation test

Date: 08/25/16 Time: 22:32
Sample: 2000M01 2016M06
Included observations: 197

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
.|. |	.|. |	1	-0.005	-0.005	0.0044	0.947
.|* |	.|* |	2	0.107	0.107	2.2867	0.319
*|. |	*|. |	3	-0.118	-0.118	5.1042	0.164
*|. |	*|. |	4	-0.067	-0.080	6.0214	0.198
.|. |	.|. |	5	0.009	0.036	6.0384	0.303
.|. |	.|. |	6	0.036	0.040	6.3098	0.389
.|. |	.|. |	7	-0.009	-0.032	6.3254	0.502
.|. |	.|. |	8	-0.035	-0.045	6.5768	0.583
.|. |	.|. |	9	-0.023	-0.006	6.6825	0.670
.|. |	.|. |	10	-0.047	-0.038	7.1420	0.712
.|. |	.|. |	11	-0.012	-0.023	7.1720	0.785
.|. |	.|. |	12	-0.045	-0.047	7.6008	0.815
*|. |	*|. |	13	-0.131	-0.142	11.246	0.590
.|* |	.|* |	14	0.087	0.095	12.881	0.536
.|. |	.|. |	15	-0.028	-0.009	13.052	0.598
*|. |	*|. |	16	-0.124	-0.198	16.364	0.428
.|. |	.|. |	17	-0.022	-0.018	16.466	0.491
*|. |	.|. |	18	-0.094	-0.043	18.398	0.430
.|. |	.|. |	19	0.025	-0.014	18.538	0.487
.|. |	.|. |	20	-0.022	-0.061	18.643	0.545
.|. |	.|. |	21	0.011	-0.023	18.668	0.606
*|. |	*|. |	22	-0.112	-0.119	21.473	0.492
*|. |	*|. |	23	-0.090	-0.127	23.280	0.445
*|. |	*|. |	24	-0.098	-0.105	25.435	0.382
.|. |	.|. |	25	0.033	-0.019	25.689	0.424
.|. |	.|. |	26	0.039	-0.029	26.039	0.461
.|. |	.|. |	27	0.007	-0.038	26.050	0.516
.|. |	.|. |	28	0.045	-0.022	26.515	0.545
.|. |	*|. |	29	-0.045	-0.110	26.988	0.572
.|. |	.|. |	30	0.058	0.042	27.769	0.583
.|. |	.|. |	31	0.023	-0.018	27.898	0.626
.|* |	.|* |	32	0.145	0.078	32.905	0.423
.|. |	.|. |	33	-0.012	-0.061	32.941	0.470
.|. |	.|. |	34	0.062	0.001	33.878	0.474
.|. |	.|. |	35	0.029	0.023	34.082	0.512
.|* |	.|. |	36	0.076	0.043	35.496	0.492

C.5.2.2 Heteroscedasticity test

Heteroskedasticity Test: ARCH

F-statistic	0.001444	Prob. F(1,194)	0.9697
Obs*R-squared	0.001459	Prob. Chi-Square(1)	0.9695

C.6 Model 6 The Second Hand Price Model Sub-Panamax

C.6.1 Estimation Output

Dependent Variable: D_SHP
Method: Least Squares
Date: 08/26/16 Time: 20:50
Sample (adjusted): 2000M02 2016M06
Included observations: 197 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D_TIMECHARTER	0.000745	9.83E-05	7.578388	0.0000
D_LIBOR	-99.09282	62.79949	-1.577924	0.1162
C	-0.056055	0.126913	-0.441676	0.6592

R-squared	0.233323	Mean dependent var	-0.071066
Adjusted R-squared	0.225420	S.D. dependent var	2.004668
S.E. of regression	1.764313	Akaike info criterion	3.988511
Sum squared resid	603.8834	Schwarz criterion	4.038509
Log likelihood	-389.8684	Hannan-Quinn criter.	4.008751
F-statistic	29.52010	Durbin-Watson stat	2.043897
Prob(F-statistic)	0.000000		

C.6.2 Diagnostic Tests

C.6.2.1 Autocorrelation test

Date: 08/26/16 Time: 20:57
Sample: 2000M01 2016M06
Included observations: 197

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
.|. |	.|. |	1	-0.023	-0.023	0.1031	0.748
.|* |	.|* |	2	0.077	0.076	1.2850	0.526
.|* |	.|* |	3	0.103	0.107	3.4239	0.331
.|. |	.|. |	4	0.062	0.063	4.2129	0.378
.|* |	.|* |	5	0.086	0.076	5.7359	0.333
.|* |	.|. |	6	0.077	0.065	6.9618	0.324
.|* |	.|* |	7	0.154	0.140	11.853	0.106
*|. |	*|. |	8	-0.140	-0.164	15.911	0.044
.|. |	.|. |	9	0.062	0.009	16.701	0.054
*|. |	*|. |	10	-0.119	-0.153	19.691	0.032
.|. |	.|. |	11	0.053	0.046	20.280	0.042
.|. |	.|. |	12	-0.024	-0.032	20.404	0.060
*|. |	*|. |	13	-0.168	-0.161	26.401	0.015
.|. |	.|. |	14	0.054	0.057	27.020	0.019
.|. |	.|* |	15	0.016	0.106	27.075	0.028
.|. |	.|. |	16	-0.005	0.015	27.079	0.041
*|. |	.|. |	17	-0.093	-0.051	28.946	0.035
*|. |	*|. |	18	-0.082	-0.144	30.427	0.033
*|. |	.|. |	19	-0.074	-0.028	31.618	0.034
.|. |	.|. |	20	0.002	0.033	31.619	0.048
.|. |	.|. |	21	0.010	-0.019	31.640	0.064
.|. |	.|. |	22	0.017	0.052	31.705	0.083
.|. |	.|. |	23	0.002	0.014	31.706	0.106
*|. |	*|. |	24	-0.161	-0.102	37.599	0.038
.|. |	.|. |	25	0.005	0.012	37.605	0.051
.|. |	.|. |	26	0.039	0.003	37.953	0.061
.|. |	.|. |	27	-0.059	-0.055	38.745	0.067
.|. |	.|* |	28	0.062	0.082	39.650	0.071
*|. |	*|. |	29	-0.094	-0.119	41.697	0.060
.|. |	.|. |	30	0.016	0.031	41.755	0.075
.|. |	.|. |	31	0.008	0.025	41.769	0.094
.|. |	.|. |	32	-0.005	-0.026	41.774	0.116
*|. |	*|. |	33	-0.125	-0.111	45.485	0.073
.|. |	.|. |	34	0.012	-0.006	45.520	0.090
.|. |	.|. |	35	0.044	0.054	45.979	0.101
.|. |	.|* |	36	0.029	0.114	46.188	0.119

C.6.2.2 Heteroscedasticity test

Heteroskedasticity Test: ARCH

F-statistic	1.871672	Prob. F(1,194)	0.1729
Obs*R-squared	1.872898	Prob. Chi-Square(1)	0.1711

Appendix D ARIMA Estimation Outputs and Diagnostic Tests

D.1 Model 1 Newbuilding Feeders Diagnostic tests

D.1.1 Autocorrelation test

Date: 08/17/16 Time: 21:17
Sample: 2000M01 2016M06
Included observations: 197
Q-statistic probabilities adjusted for 3 ARMA terms

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
.|. |	.|. |	1	0.004	0.004	0.0026	
.|. |	.|. |	2	-0.013	-0.013	0.0351	
.|. |	.|. |	3	0.002	0.002	0.0360	
.|. |	.|. |	4	-0.029	-0.029	0.2022	0.653
.|. |	.|. |	5	0.033	0.033	0.4181	0.811
.|. |	.|. |	6	-0.017	-0.019	0.4807	0.923
*|. |	*|. |	7	-0.091	-0.090	2.1889	0.701
.|. |	.|. |	8	0.026	0.025	2.3277	0.802
.|. |	.|. |	9	0.020	0.020	2.4126	0.878
*|. |	*|. |	10	-0.067	-0.069	3.3533	0.851
.|* |	.|* |	11	0.087	0.086	4.9497	0.763
.|. |	.|. |	12	0.044	0.049	5.3537	0.802
.|. |	.|. |	13	-0.004	-0.008	5.3566	0.866
.|. |	.|. |	14	-0.041	-0.052	5.7081	0.892
.|. |	.|. |	15	-0.035	-0.019	5.9654	0.918
.|. |	.|. |	16	0.003	-0.000	5.9676	0.947
.|. |	*|. |	17	-0.053	-0.070	6.5846	0.950
.|. |	.|. |	18	-0.028	-0.009	6.7580	0.964
.|. |	.|. |	19	0.005	0.015	6.7638	0.978
.|. |	.|. |	20	0.041	0.029	7.1293	0.982
.|. |	.|. |	21	-0.036	-0.041	7.4170	0.986
*|. |	*|. |	22	-0.090	-0.092	9.2282	0.969
.|. |	.|. |	23	0.045	0.044	9.6926	0.973
.|. |	.|. |	24	-0.023	-0.044	9.8097	0.981
.|. |	.|. |	25	0.002	0.000	9.8107	0.988
.|. |	.|. |	26	0.014	0.030	9.8558	0.992
*|. |	*|. |	27	-0.072	-0.067	11.054	0.989
.|. |	.|. |	28	0.024	0.014	11.187	0.992
.|. |	.|. |	29	-0.019	-0.027	11.269	0.995
.|. |	.|. |	30	0.009	0.028	11.287	0.997
.|. |	.|. |	31	-0.008	-0.037	11.301	0.998
.|. |	.|. |	32	-0.042	-0.054	11.720	0.998
.|. |	.|. |	33	0.021	0.052	11.823	0.999
.|. |	.|. |	34	-0.001	-0.019	11.823	0.999
.|. |	.|. |	35	-0.011	-0.012	11.851	1.000
.|. |	.|. |	36	0.060	0.057	12.733	0.999

D.1.2 Heteroscedasticity Test

Heteroskedasticity Test: ARCH

F-statistic	68.92473	Prob. F(1,194)	0.0000
Obs*R-squared	51.38066	Prob. Chi-Square(1)	0.0000

D.2 Model 2 Newbuilding Handy Size

D.2.1 Estimation output

Dependent Variable: D_NBP
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 08/17/16 Time: 19:36
Sample: 2000M02 2016M06
Included observations: 197
Convergence achieved after 168 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.006299	0.158610	-0.039712	0.9684
AR(1)	1.051042	0.080035	13.13223	0.0000
AR(2)	-0.967102	0.105221	-9.191108	0.0000
AR(3)	0.281546	0.086972	3.237220	0.0014
AR(4)	0.165086	0.067186	2.457144	0.0149
MA(1)	-0.687050	0.067275	-10.21249	0.0000
MA(2)	0.962051	0.068471	14.05039	0.0000
SIGMASQ	0.532135	0.030261	17.58499	0.0000

R-squared	0.329078	Mean dependent var	0.002538
Adjusted R-squared	0.304229	S.D. dependent var	0.892854
S.E. of regression	0.744755	Akaike info criterion	2.295013
Sum squared resid	104.8307	Schwarz criterion	2.428341
Log likelihood	-218.0588	Hannan-Quinn criter.	2.348985
F-statistic	13.24315	Durbin-Watson stat	1.991803
Prob(F-statistic)	0.000000		

Inverted AR Roots	.71	.30+.89i	.30-.89i	-.26
Inverted MA Roots	.34+.92i	.34-.92i		

D.2.2 Diagnostic tests

D.2.2.1 Autocorrelation test

Date: 08/17/16 Time: 21:41
Sample: 2000M01 2016M06
Included observations: 197
Q-statistic probabilities adjusted for 6 ARMA terms

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
.|. |	.|. |	1	0.003	0.003	0.0013	
.|. |	.|. |	2	0.017	0.017	0.0596	
.|. |	.|. |	3	0.036	0.036	0.3214	
.|. |	.|. |	4	-0.038	-0.038	0.6088	
.|. |	.|. |	5	-0.009	-0.010	0.6248	
.|. |	.|. |	6	-0.051	-0.051	1.1660	
.|. |	.|. |	7	-0.002	0.001	1.1671	0.280
.|. |	.|. |	8	-0.042	-0.041	1.5285	0.466
.|. |	.|. |	9	0.036	0.040	1.8048	0.614
.|. |	.|. |	10	0.062	0.060	2.6173	0.624
.|. |	.|. |	11	-0.047	-0.046	3.0735	0.689
.|. |	.|. |	12	0.025	0.015	3.2056	0.783
.|. |	.|. |	13	0.020	0.019	3.2917	0.857
*|. |	*|. |	14	-0.112	-0.110	5.9648	0.651
.|. |	.|. |	15	-0.055	-0.056	6.6262	0.676
.|. |	.|. |	16	-0.008	0.000	6.6412	0.759
.|. |	.|. |	17	0.011	0.021	6.6655	0.825
.|. |	.|. |	18	0.017	0.019	6.7258	0.875
*|. |	*|. |	19	-0.133	-0.149	10.601	0.644
.|. |	.|. |	20	0.072	0.064	11.745	0.627
*|. |	*|. |	21	-0.084	-0.084	13.314	0.578
*|. |	*|. |	22	-0.076	-0.088	14.604	0.554
.|. |	.|. |	23	-0.009	-0.014	14.622	0.623
.|. |	.|. |	24	-0.037	-0.007	14.936	0.666
.|. |	.|. |	25	0.042	0.029	15.347	0.700
.|. |	.|. |	26	-0.016	-0.019	15.402	0.753
.|. |	*|. |	27	-0.050	-0.075	15.987	0.770
.|. |	.|. |	28	-0.042	-0.049	16.401	0.795
.|. |	*|. |	29	-0.059	-0.073	17.217	0.798
.|* |	.|* |	30	0.113	0.095	20.220	0.684
.|. |	.|. |	31	0.007	0.043	20.232	0.735
*|. |	*|. |	32	-0.089	-0.097	22.095	0.684
.|. |	.|. |	33	-0.004	-0.053	22.098	0.732
.|* |	.|* |	34	0.090	0.103	24.065	0.678
.|. |	.|. |	35	0.062	0.050	24.982	0.679
.|. |	.|. |	36	-0.019	-0.044	25.066	0.722

D.2.2.2 Heteroscedasticity test

Heteroskedasticity Test: ARCH

F-statistic	2.362187	Prob. F(1,194)	0.1259
Obs*R-squared	2.357830	Prob. Chi-Square(1)	0.1247

D.3 Model 3 Newbuilding Sub-Panamax

D.3.1 Estimation output

Dependent Variable: D_NBP
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 08/17/16 Time: 20:11
Sample: 2000M02 2016M06
Included observations: 197
Convergence not achieved after 500 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.030304	0.187632	-0.161505	0.8719
AR(1)	0.797576	0.075162	10.61141	0.0000
AR(2)	-0.949867	0.062155	-15.28221	0.0000
AR(3)	0.734964	0.077671	9.462536	0.0000
MA(1)	-0.432483	0.111857	-3.866387	0.0002
MA(2)	1.025454	0.515768	1.988206	0.0482
MA(3)	-0.355279	0.229773	-1.546218	0.1237
SIGMASQ	0.720328	0.353800	2.035974	0.0431

R-squared	0.340140	Mean dependent var	-0.026650
Adjusted R-squared	0.315701	S.D. dependent var	1.047477
S.E. of regression	0.866497	Akaike info criterion	2.611419
Sum squared resid	141.9045	Schwarz criterion	2.744747
Log likelihood	-249.2247	Hannan-Quinn criter.	2.665391
F-statistic	13.91779	Durbin-Watson stat	1.998662
Prob(F-statistic)	0.000000		

Inverted AR Roots	.78	.01-.97i	.01+.97i
Inverted MA Roots	.36	.04-1.00i	.04+1.00i

D.3.2 Diagnostic tests

D.3.2.1 Autocorrelation test

Date: 08/17/16 Time: 21:56
Sample: 2000M01 2016M06
Included observations: 197
Q-statistic probabilities adjusted for 6 ARMA terms

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
.|. |	.|. |	1	-0.001	-0.001	5.E-05	
.|. |	.|. |	2	-0.002	-0.002	0.0012	
.|. |	.|. |	3	0.051	0.051	0.5330	
.|. |	.|. |	4	-0.019	-0.019	0.6043	
*|. |	*|. |	5	-0.073	-0.073	1.6861	
.|. |	.|. |	6	0.055	0.053	2.3107	
.|. |	.|. |	7	0.030	0.032	2.4939	0.114
.|. |	.|. |	8	-0.031	-0.025	2.6935	0.260
.|. |	.|. |	9	0.042	0.034	3.0663	0.382
.|* |	.|. |	10	0.078	0.072	4.3260	0.364
*|. |	*|. |	11	-0.114	-0.105	7.0667	0.216
.|* |	.|* |	12	0.103	0.103	9.3335	0.156
.|. |	.|. |	13	-0.040	-0.056	9.6765	0.208
*|. |	*|. |	14	-0.182	-0.169	16.782	0.032
*|. |	*|. |	15	-0.095	-0.100	18.720	0.028
.|. |	.|. |	16	-0.010	-0.027	18.743	0.044
.|. |	.|. |	17	0.022	0.060	18.847	0.064
.|. |	.|. |	18	0.012	0.010	18.879	0.091
.|. |	*|. |	19	-0.032	-0.074	19.110	0.120
*|. |	*|. |	20	-0.078	-0.075	20.459	0.116
*|. |	*|. |	21	-0.134	-0.119	24.480	0.057
.|. |	.|. |	22	-0.039	-0.058	24.814	0.073
.|. |	.|* |	23	0.032	0.082	25.046	0.094
.|. |	.|. |	24	-0.016	-0.005	25.101	0.122
.|. |	.|. |	25	0.045	0.030	25.553	0.143
.|. |	.|. |	26	0.022	0.025	25.663	0.177
.|. |	.|. |	27	0.050	0.055	26.236	0.198
.|. |	.|. |	28	-0.038	-0.056	26.567	0.228
.|. |	*|. |	29	-0.065	-0.121	27.562	0.233
.|. |	.|. |	30	-0.031	-0.052	27.787	0.269
.|. |	.|. |	31	-0.042	-0.005	28.198	0.299
.|. |	.|. |	32	-0.053	-0.045	28.871	0.317
.|* |	.|* |	33	0.111	0.112	31.790	0.240
.|. |	.|. |	34	0.055	0.032	32.529	0.254
.|. |	*|. |	35	0.015	-0.076	32.584	0.295
.|. |	*|. |	36	-0.023	-0.087	32.718	0.335

D.3.2.2 Heteroscedasticity test

Heteroskedasticity Test: ARCH

F-statistic	5.399632	Prob. F(1,194)	0.0212
Obs*R-squared	5.307572	Prob. Chi-Square(1)	0.0212

D.4 Model 4 Second Hand Feeders

D.4.1 Estimation output

Dependent Variable: D_SHP
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 08/17/16 Time: 15:38
Sample: 2000M02 2016M06
Included observations: 197
Convergence achieved after 76 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.011076	0.061687	-0.179557	0.8577
AR(1)	-0.064796	0.111678	-0.580199	0.5625
AR(2)	0.654905	0.139123	4.707369	0.0000
MA(1)	0.256399	0.140627	1.823264	0.0698
MA(2)	-0.308099	0.180483	-1.707080	0.0894
SIGMASQ	0.122075	0.005406	22.58214	0.0000

R-squared	0.197821	Mean dependent var	-0.012863
Adjusted R-squared	0.176821	S.D. dependent var	0.391096
S.E. of regression	0.354838	Akaike info criterion	0.797648
Sum squared resid	24.04879	Schwarz criterion	0.897644
Log likelihood	-72.56828	Hannan-Quinn criter.	0.838127
F-statistic	9.420276	Durbin-Watson stat	2.012511
Prob(F-statistic)	0.000000		

Inverted AR Roots	.78	-.84
Inverted MA Roots	.44	-.70

D.4.2 Diagnostic tests

D.4.2.1 Autocorrelation test

Date: 08/17/16 Time: 22:07
Sample: 2000M01 2016M06
Included observations: 197
Q-statistic probabilities adjusted for 4 ARMA terms

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
.|. |	.|. |	1	-0.006	-0.006	0.0081	
.|. |	.|. |	2	-0.008	-0.008	0.0211	
.|. |	.|. |	3	0.032	0.032	0.2318	
.|. |	.|. |	4	0.067	0.068	1.1540	
.|. |	.|. |	5	0.045	0.047	1.5635	0.211
.|. |	.|. |	6	-0.014	-0.014	1.6065	0.448
*|. |	*|. |	7	-0.098	-0.103	3.5865	0.310
*|. |	*|. |	8	-0.080	-0.092	4.9162	0.296
.|. |	.|. |	9	-0.038	-0.048	5.2100	0.391
.|. |	.|. |	10	0.025	0.030	5.3413	0.501
.|. |	.|. |	11	-0.033	-0.010	5.5775	0.590
.|. |	.|. |	12	-0.037	-0.013	5.8752	0.661
.|. |	.|. |	13	-0.006	0.001	5.8839	0.751
.|. |	.|. |	14	-0.002	-0.014	5.8850	0.825
.|. |	.|. |	15	0.055	0.040	6.5291	0.836
.|. |	*|. |	16	-0.060	-0.068	7.2982	0.837
*|. |	*|. |	17	-0.085	-0.089	8.8544	0.784
.|. |	.|. |	18	-0.031	-0.043	9.0627	0.827
.|. |	.|. |	19	0.032	0.022	9.2812	0.862
*|. |	*|. |	20	-0.072	-0.069	10.421	0.844
.|. |	.|. |	21	0.008	0.026	10.435	0.884
.|. |	.|. |	22	-0.004	0.015	10.438	0.917
.|. |	.|. |	23	-0.035	-0.040	10.715	0.933
.|. |	.|. |	24	-0.003	-0.024	10.717	0.953
.|. |	.|. |	25	-0.001	-0.030	10.717	0.968
.|. |	.|. |	26	0.010	0.003	10.741	0.978
.|. |	.|. |	27	0.005	0.001	10.746	0.986
.|. |	.|. |	28	-0.015	-0.021	10.797	0.990
.|. |	.|. |	29	-0.008	-0.019	10.814	0.994
*|. |	*|. |	30	-0.085	-0.097	12.523	0.988
.|. |	.|. |	31	0.010	-0.002	12.549	0.992
.|. |	.|. |	32	0.002	-0.004	12.549	0.995
.|. |	.|. |	33	0.000	0.005	12.549	0.997
.|. |	.|. |	34	0.047	0.047	13.088	0.997
.|* |	.|* |	35	0.118	0.135	16.432	0.985
.|* |	.|* |	36	0.133	0.134	20.711	0.938

D.4.2.2 Heteroscedasticity test

Heteroskedasticity Test: ARCH			
F-statistic	0.117717	Prob. F(1,194)	0.7319
Obs*R-squared	0.118858	Prob. Chi-Square(1)	0.7303

D.5 Model 5 Second Hand Price Handy Size

D.5.1 Estimation output

Dependent Variable: D_SHP
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 08/17/16 Time: 20:41
Sample: 2000M02 2016M06
Included observations: 197
Convergence achieved after 39 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.037291	0.231623	-0.160999	0.8723
AR(1)	0.401680	0.275947	1.455645	0.1471
AR(2)	0.190176	0.080309	2.368056	0.0189
MA(1)	-0.274786	0.266166	-1.032387	0.3032
SIGMASQ	1.978016	0.076578	25.83009	0.0000

R-squared	0.097012	Mean dependent var	-0.038071
Adjusted R-squared	0.078200	S.D. dependent var	1.483813
S.E. of regression	1.424615	Akaike info criterion	3.571586
Sum squared resid	389.6692	Schwarz criterion	3.654916
Log likelihood	-346.8013	Hannan-Quinn criter.	3.605319
F-statistic	5.156867	Durbin-Watson stat	1.998837
Prob(F-statistic)	0.000574		

Inverted AR Roots	.68	-.28
Inverted MA Roots	.27	

D.5.2 Diagnostic tests

D.5.2.1 Autocorrelation test

Date: 08/17/16 Time: 22:17
Sample: 2000M01 2016M06
Included observations: 197
Q-statistic probabilities adjusted for 3 ARMA terms

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
.|. |	.|. |	1	0.001	0.001	7.E-05	
.|. |	.|. |	2	0.004	0.004	0.0027	
.|. |	.|. |	3	-0.002	-0.002	0.0039	
.|. |	.|. |	4	-0.015	-0.015	0.0515	0.820
.|. |	.|. |	5	0.065	0.065	0.9187	0.632
.|. |	.|. |	6	0.012	0.012	0.9483	0.814
.|. |	.|. |	7	-0.050	-0.051	1.4697	0.832
.|. |	.|. |	8	-0.049	-0.050	1.9771	0.852
.|. |	.|. |	9	0.006	0.009	1.9841	0.921
.|. |	.|. |	10	-0.023	-0.026	2.0929	0.955
.|. |	.|. |	11	0.043	0.040	2.4881	0.962
.|. |	.|. |	12	-0.024	-0.019	2.6146	0.978
*|. |	*|. |	13	-0.112	-0.106	5.2812	0.872
.|* |	.|* |	14	0.112	0.111	7.9458	0.718
.|. |	.|. |	15	-0.016	-0.017	8.0017	0.785
*|. |	*|. |	16	-0.115	-0.129	10.844	0.624
.|. |	.|. |	17	-0.024	-0.024	10.970	0.688
*|. |	*|. |	18	-0.102	-0.083	13.263	0.582
.|. |	.|. |	19	-0.040	-0.054	13.615	0.627
.|. |	*|. |	20	-0.054	-0.072	14.271	0.648
.|. |	.|. |	21	-0.027	-0.013	14.432	0.701
.|. |	.|. |	22	-0.014	-0.006	14.478	0.755
.|. |	.|. |	23	-0.047	-0.059	14.982	0.777
.|. |	.|. |	24	-0.002	0.002	14.983	0.824
.|. |	.|. |	25	0.060	0.044	15.803	0.826
.|. |	.|. |	26	-0.029	-0.058	15.999	0.855
.|. |	.|. |	27	-0.052	-0.035	16.629	0.864
.|. |	.|. |	28	0.034	0.011	16.894	0.886
*|. |	*|. |	29	-0.112	-0.144	19.823	0.800
.|. |	.|. |	30	-0.030	-0.032	20.030	0.829
.|. |	.|. |	31	0.015	-0.001	20.083	0.861
.|* |	.|* |	32	0.104	0.108	22.639	0.793
.|. |	*|. |	33	-0.055	-0.086	23.351	0.801
.|. |	.|. |	34	0.030	0.024	23.562	0.828
.|. |	.|* |	35	0.071	0.075	24.788	0.815
.|* |	.|* |	36	0.197	0.160	34.243	0.408

D.5.2.2 Heteroscedasticity test

Heteroskedasticity Test: ARCH

F-statistic	0.006315	Prob. F(1,194)	0.9367
Obs*R-squared	0.006380	Prob. Chi-Square(1)	0.9363

D.6 Model 6 Second Hand Price Sub-Panamax

D.6.1 Estimation Output

Dependent Variable: D_SHP
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 08/17/16 Time: 20:53
Sample: 2000M02 2016M06
Included observations: 197
Convergence achieved after 73 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.071014	0.305967	-0.232097	0.8167
AR(1)	0.083104	0.125534	0.662006	0.5088
AR(2)	0.526124	0.105314	4.995764	0.0000
AR(3)	0.245072	0.101734	2.408943	0.0170
AR(4)	-0.603465	0.130815	-4.613136	0.0000
MA(1)	-0.038152	0.088459	-0.431296	0.6668
MA(2)	-0.379094	0.088406	-4.288104	0.0000
MA(3)	-0.182317	0.076547	-2.381760	0.0182
MA(4)	0.869454	0.083588	10.40171	0.0000
SIGMASQ	3.154625	0.188015	16.77862	0.0000

R-squared	0.211007	Mean dependent var	-0.071066
Adjusted R-squared	0.173034	S.D. dependent var	2.004668
S.E. of regression	1.822998	Akaike info criterion	4.105179
Sum squared resid	621.4612	Schwarz criterion	4.271839
Log likelihood	-394.3601	Hannan-Quinn criter.	4.172644
F-statistic	5.556777	Durbin-Watson stat	1.957786
Prob(F-statistic)	0.000001		

Inverted AR Roots	.74+.41i	.74-.41i	-.70-.59i	-.70+.59i
Inverted MA Roots	.76+.56i	.76-.56i	-.74-.66i	-.74+.66i

D.6.2 Diagnostic tests

D.6.2.1 Autocorrelation test

Date: 08/17/16 Time: 22:28
Sample: 2000M01 2016M06
Included observations: 197
Q-statistic probabilities adjusted for 8 ARMA terms

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th></th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>Prob</th></tr>
<tr><td>.|. |</td><td>.|. |</td><td>1</td><td>0.021</td><td>0.021</td><td>0.0886</td><td></td></tr>
<tr><td>.|. |</td><td>.|. |</td><td>2</td><td>-0.014</td><td>-0.014</td><td>0.1267</td><td></td></tr>
<tr><td>.|. |</td><td>.|. |</td><td>3</td><td>0.068</td><td>0.068</td><td>1.0491</td><td></td></tr>
<tr><td>.|. |</td><td>.|. |</td><td>4</td><td>-0.043</td><td>-0.046</td><td>1.4256</td><td></td></tr>
<tr><td>.|. |</td><td>.|. |</td><td>5</td><td>0.005</td><td>0.010</td><td>1.4313</td><td></td></tr>
<tr><td>.|. |</td><td>.|. |</td><td>6</td><td>0.022</td><td>0.016</td><td>1.5294</td><td></td></tr>
<tr><td>.|* |</td><td>.|* |</td><td>7</td><td>0.109</td><td>0.115</td><td>3.9610</td><td></td></tr>
<tr><td>*|. |</td><td>*|. |</td><td>8</td><td>-0.075</td><td>-0.085</td><td>5.1348</td><td></td></tr>
<tr><td>.|. |</td><td>.|. |</td><td>9</td><td>-0.000</td><td>0.006</td><td>5.1348</td><td>0.023</td></tr>
<tr><td>.|. |</td><td>.|. |</td><td>10</td><td>0.049</td><td>0.033</td><td>5.6328</td><td>0.060</td></tr>
<tr><td>.|. |</td><td>.|. |</td><td>11</td><td>-0.011</td><td>0.009</td><td>5.6580</td><td>0.129</td></tr>
<tr><td>.|. |</td><td>.|. |</td><td>12</td><td>-0.028</td><td>-0.039</td><td>5.8211</td><td>0.213</td></tr>
<tr><td>*|. |</td><td>*|. |</td><td>13</td><td>-0.103</td><td>-0.112</td><td>8.1015</td><td>0.151</td></tr>
<tr><td>.|. |</td><td>.|. |</td><td>14</td><td>0.040</td><td>0.042</td><td>8.4366</td><td>0.208</td></tr>
<tr><td>.|. |</td><td>.|. |</td><td>15</td><td>0.006</td><td>0.023</td><td>8.4447</td><td>0.295</td></tr>
<tr><td>.|. |</td><td>.|. |</td><td>16</td><td>-0.043</td><td>-0.041</td><td>8.8387</td><td>0.356</td></tr>
<tr><td>*|. |</td><td>**|. |</td><td>17</td><td>-0.187</td><td>-0.221</td><td>16.484</td><td>0.057</td></tr>
<tr><td>*|. |</td><td>*|. |</td><td>18</td><td>-0.107</td><td>-0.091</td><td>19.002</td><td>0.040</td></tr>
<tr><td>.|. |</td><td>.|. |</td><td>19</td><td>-0.058</td><td>-0.041</td><td>19.752</td><td>0.049</td></tr>
<tr><td>.|. |</td><td>.|. |</td><td>20</td><td>-0.044</td><td>-0.004</td><td>20.177</td><td>0.064</td></tr>
<tr><td>.|. |</td><td>.|. |</td><td>21</td><td>0.004</td><td>-0.042</td><td>20.181</td><td>0.091</td></tr>
<tr><td>.|. |</td><td>.|. |</td><td>22</td><td>0.004</td><td>0.005</td><td>20.185</td><td>0.124</td></tr>
<tr><td>.|. |</td><td>.|. |</td><td>23</td><td>-0.035</td><td>-0.006</td><td>20.464</td><td>0.155</td></tr>
<tr><td>*|. |</td><td>*|. |</td><td>24</td><td>-0.104</td><td>-0.072</td><td>22.937</td><td>0.115</td></tr>
<tr><td>.|. |</td><td>.|. |</td><td>25</td><td>0.033</td><td>0.014</td><td>23.187</td><td>0.143</td></tr>
<tr><td>.|. |</td><td>.|. |</td><td>26</td><td>0.041</td><td>0.034</td><td>23.580</td><td>0.169</td></tr>
<tr><td>*|. |</td><td>.|. |</td><td>27</td><td>-0.079</td><td>-0.043</td><td>25.013</td><td>0.160</td></tr>
<tr><td>.|* |</td><td>.|* |</td><td>28</td><td>0.078</td><td>0.079</td><td>26.416</td><td>0.153</td></tr>
<tr><td>.|. |</td><td>*|. |</td><td>29</td><td>-0.060</td><td>-0.094</td><td>27.256</td><td>0.163</td></tr>
<tr><td>.|. |</td><td>.|. |</td><td>30</td><td>0.014</td><td>-0.002</td><td>27.304</td><td>0.200</td></tr>
<tr><td>.|. |</td><td>.|. |</td><td>31</td><td>0.037</td><td>0.030</td><td>27.620</td><td>0.230</td></tr>
<tr><td>.|. |</td><td>.|. |</td><td>32</td><td>-0.012</td><td>-0.014</td><td>27.652</td><td>0.275</td></tr>
<tr><td>*|. |</td><td>*|. |</td><td>33</td><td>-0.110</td><td>-0.155</td><td>30.546</td><td>0.205</td></tr>
<tr><td>.|. |</td><td>.|. |</td><td>34</td><td>0.001</td><td>-0.023</td><td>30.546</td><td>0.246</td></tr>
<tr><td>.|* |</td><td>.|* |</td><td>35</td><td>0.131</td><td>0.082</td><td>34.672</td><td>0.147</td></tr>
<tr><td>.|* |</td><td>.|* |</td><td>36</td><td>0.178</td><td>0.202</td><td>42.361</td><td>0.040</td></tr>
</table>

D.6.2.2 Heteroscedasticity test

Heteroskedasticity Test: ARCH

F-statistic	0.100034	Prob. F(1,194)	0.7521
Obs*R-squared	0.101013	Prob. Chi-Square(1)	0.7506

Appendix E GARCH(1,1) Estimation Outputs and Diagnostic Tests

E.1 Model 1 Newbuilding Price Feeders Diagnostic Tests

E.1.1 Autocorrelation test

Date: 08/25/16 Time: 20:13
Sample: 2000M01 2016M06
Included observations: 197

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
.|. |	.|. |	1	0.003	0.003	0.0014	0.970
.|. |	.|. |	2	-0.022	-0.022	0.1003	0.951
.|. |	.|. |	3	-0.010	-0.010	0.1192	0.989
.|. |	.|. |	4	-0.019	-0.019	0.1915	0.996
.|. |	.|. |	5	0.028	0.028	0.3503	0.997
*|. |	*|. |	6	-0.072	-0.073	1.4220	0.965
.|. |	.|. |	7	0.032	0.033	1.6271	0.978
.|* |	.|* |	8	0.160	0.158	6.9364	0.544
*|. |	*|. |	9	-0.071	-0.074	8.0016	0.534
*|. |	*|. |	10	-0.078	-0.077	9.2714	0.507
.|. |	.|. |	11	-0.007	0.002	9.2818	0.596
.|. |	*|. |	12	-0.059	-0.066	10.017	0.614
.|. |	.|. |	13	0.036	0.029	10.295	0.670
.|. |	.|. |	14	-0.054	-0.034	10.927	0.692
.|* |	.|* |	15	0.103	0.090	13.203	0.587
.|. |	.|. |	16	0.003	-0.034	13.205	0.658
.|. |	.|. |	17	-0.036	-0.004	13.493	0.703
.|. |	.|. |	18	-0.051	-0.044	14.070	0.725
.|* |	.|* |	19	0.087	0.097	15.727	0.675
.|. |	.|. |	20	-0.032	-0.041	15.953	0.720
*|. |	*|. |	21	-0.072	-0.078	17.119	0.704
.|. |	.|. |	22	-0.049	-0.047	17.649	0.727
.|. |	*|. |	23	-0.062	-0.096	18.517	0.729
.|* |	.|* |	24	0.127	0.133	22.154	0.570
.|. |	.|. |	25	-0.052	-0.024	22.764	0.591
.|. |	.|. |	26	-0.038	-0.041	23.093	0.628
.|. |	.|. |	27	0.000	-0.031	23.093	0.680
*|. |	*|. |	28	-0.097	-0.096	25.268	0.613
.|. |	.|. |	29	-0.063	-0.042	26.198	0.615
.|. |	.|. |	30	-0.065	-0.064	27.181	0.614
.|. |	.|. |	31	-0.059	-0.050	27.989	0.622
.|. |	.|. |	32	0.025	-0.059	28.138	0.663
*|. |	*|. |	33	-0.084	-0.067	29.807	0.627
*|. |	*|. |	34	-0.066	-0.092	30.853	0.623
.|. |	*|. |	35	-0.059	-0.080	31.685	0.629
.|. |	.|. |	36	-0.026	0.020	31.852	0.666

*Probabilities may not be valid for this equation specification.

E.1.2 Heteroscedasticity test

Heteroskedasticity Test: ARCH

F-statistic	0.001394	Prob. F(1,194)	0.9703
Obs*R-squared	0.001408	Prob. Chi-Square(1)	0.9701

E.2 Model 2 Newbuilding Price Handy Size

E.2.1 Estimation output

Dependent Variable: D_NBP
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Date: 08/20/16 Time: 13:37
Sample (adjusted): 2000M02 2016M06
Included observations: 197 after adjustments
Convergence achieved after 30 iterations
Coefficient covariance computed using outer product of gradients
Presample variance: backcast (parameter = 0.7)
GARCH = C(5) + C(6)*RESID(-1)^2 + C(7)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
D_LIBOR_	33.83841	22.11433	1.530157	0.1260
D_STEELPRICE	0.006336	0.001122	5.647245	0.0000
D_TIMECHARTER	0.000157	4.26E-05	3.678031	0.0002
C	0.050074	0.056140	0.891938	0.3724
Variance Equation				
C	0.035563	0.009658	3.682162	0.0002
RESID(-1)^2	0.159283	0.031164	5.111123	0.0000
GARCH(-1)	0.793873	0.042250	18.78977	0.0000

R-squared	0.221523	Mean dependent var	0.002538
Adjusted R-squared	0.209423	S.D. dependent var	0.892854
S.E. of regression	0.793876	Akaike info criterion	2.150682
Sum squared resid	121.6360	Schwarz criterion	2.267344
Log likelihood	-204.8422	Hannan-Quinn criter.	2.197908
Durbin-Watson stat	1.502775		

E.2.2 R Diagnostic Testing

E.2.2.1 Autocorrelation test

Date: 08/25/16 Time: 21:22
Sample: 2000M01 2016M06
Included observations: 197

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
.|. |	.|. |	1	-0.049	-0.049	0.4754	0.491
.|. |	.|. |	2	-0.020	-0.022	0.5535	0.758
.|. |	.|. |	3	-0.005	-0.007	0.5586	0.906
.|* |	.|* |	4	0.175	0.175	6.7912	0.147
*|. |	.|. |	5	-0.068	-0.053	7.7370	0.171
*|. |	*|. |	6	-0.077	-0.078	8.9512	0.176
.|* |	.|* |	7	0.106	0.103	11.276	0.127
.|. |	.|. |	8	-0.010	-0.036	11.296	0.185
.|* |	.|* |	9	0.087	0.113	12.873	0.168
.|. |	.|. |	10	-0.028	0.002	13.040	0.221
.|. |	.|. |	11	-0.007	-0.056	13.051	0.290
.|. |	.|. |	12	-0.012	0.005	13.080	0.363
.|. |	*|. |	13	-0.055	-0.084	13.713	0.394
.|. |	.|. |	14	-0.059	-0.063	14.461	0.416
.|. |	.|* |	15	0.054	0.084	15.084	0.445
.|. |	.|. |	16	-0.021	-0.051	15.179	0.512
.|. |	.|. |	17	-0.024	0.002	15.300	0.574
.|. |	.|. |	18	-0.003	0.006	15.301	0.641
.|. |	.|. |	19	0.058	0.015	16.048	0.654
.|. |	.|. |	20	-0.056	-0.019	16.749	0.669
*|. |	*|. |	21	-0.097	-0.088	18.864	0.594
.|. |	.|. |	22	-0.013	-0.032	18.901	0.651
*|. |	*|. |	23	-0.073	-0.077	20.097	0.636
.|. |	.|. |	24	-0.032	-0.042	20.326	0.678
*|. |	.|. |	25	-0.089	-0.062	22.128	0.628
.|* |	.|* |	26	0.096	0.077	24.251	0.562
.|* |	.|* |	27	0.113	0.146	27.205	0.453
*|. |	.|. |	28	-0.071	-0.060	28.381	0.444
.|. |	.|. |	29	-0.042	-0.020	28.794	0.476
.|. |	*|. |	30	-0.056	-0.086	29.541	0.489
.|* |	.|. |	31	0.087	0.043	31.326	0.450
*|. |	.|. |	32	-0.070	0.021	32.477	0.443
.|. |	*|. |	33	-0.061	-0.079	33.353	0.450
.|. |	.|. |	34	0.002	-0.023	33.354	0.499
.|. |	.|. |	35	0.027	-0.022	33.526	0.539
.|. |	.|. |	36	0.055	0.037	34.261	0.551

*Probabilities may not be valid for this equation specification.

E.2.2.2 Heteroscedasticity test

Heteroskedasticity Test: ARCH

F-statistic	0.462692	Prob. F(1,194)	0.4972
Obs*R-squared	0.466350	Prob. Chi-Square(1)	0.4947

E.3 Model 3 Newbuilding Price Sub-Panamax

E.3.1 Estimation output

Dependent Variable: D_NBP
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Date: 08/17/16 Time: 21:59
Sample (adjusted): 2000M02 2016M06
Included observations: 197 after adjustments
Convergence achieved after 29 iterations
Coefficient covariance computed using outer product of gradients
Presample variance: backcast (parameter = 0.7)
GARCH = C(6) + C(7)*RESID(-1)^2 + C(8)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
D_LIBOR	39.11594	8.731273	4.479981	0.0000
D_SHP	0.192808	0.019141	10.07327	0.0000
D_STEELPRICE	0.007480	0.001179	6.342912	0.0000
D_ORDERBOOK	8.808311	5.919630	1.487983	0.1368
C	0.004016	0.047541	0.084474	0.9327
Variance Equation				
C	0.145082	0.031464	4.611104	0.0000
RESID(-1)^2	0.844052	0.179941	4.690714	0.0000
GARCH(-1)	0.270182	0.086712	3.115840	0.0018

R-squared	0.254437	Mean dependent var	-0.026650
Adjusted R-squared	0.238905	S.D. dependent var	1.047477
S.E. of regression	0.913827	Akaike info criterion	2.423764
Sum squared resid	160.3352	Schwarz criterion	2.557092
Log likelihood	-230.7408	Hannan-Quinn criter.	2.477736
Durbin-Watson stat	1.813208		

E.3.2 Diagnostic Testing

E.3.2.1 Autocorrelation test

Date: 08/28/16 Time: 17:13
Sample: 2000M01 2016M06
Included observations: 197

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
.|. |	.|. |	1	-0.050	-0.050	0.4914	0.483
.|. |	.|. |	2	-0.034	-0.037	0.7265	0.695
.|. |	.|. |	3	-0.032	-0.036	0.9397	0.816
.|. |	.|. |	4	-0.023	-0.028	1.0448	0.903
.|. |	.|. |	5	-0.028	-0.033	1.2008	0.945
.|* |	.|. |	6	0.076	0.070	2.3794	0.882
.|. |	.|. |	7	-0.009	-0.005	2.3950	0.935
.|. |	.|. |	8	-0.032	-0.031	2.6107	0.956
.|. |	.|. |	9	-0.002	-0.002	2.6112	0.978
.|. |	.|. |	10	-0.015	-0.015	2.6593	0.988
.|. |	.|. |	11	0.044	0.044	3.0617	0.990
*|. |	*|. |	12	-0.066	-0.071	3.9904	0.984
.|. |	.|. |	13	-0.046	-0.052	4.4363	0.986
.|. |	.|. |	14	0.007	0.004	4.4470	0.992
.|. |	.|. |	15	-0.043	-0.050	4.8406	0.993
.|. |	.|. |	16	0.040	0.033	5.1853	0.995
.|* |	.|* |	17	0.210	0.203	14.807	0.609
.|. |	.|. |	18	0.022	0.053	14.909	0.668
.|. |	.|* |	19	0.065	0.099	15.827	0.669
.|. |	.|. |	20	0.009	0.033	15.845	0.726
.|. |	.|. |	21	-0.019	0.008	15.924	0.774
.|. |	.|. |	22	0.023	0.035	16.040	0.814
.|. |	.|. |	23	-0.020	-0.045	16.135	0.849
.|. |	.|. |	24	0.018	0.018	16.204	0.881
.|. |	.|. |	25	-0.033	-0.041	16.457	0.901
.|. |	.|. |	26	-0.029	-0.036	16.647	0.919
.|. |	.|. |	27	0.017	0.019	16.716	0.938
.|. |	.|. |	28	0.035	0.017	17.004	0.949
.|. |	.|. |	29	-0.014	0.029	17.051	0.961
.|. |	.|. |	30	0.004	0.027	17.055	0.972
*|. |	*|. |	31	-0.086	-0.071	18.792	0.958
.|. |	.|* |	32	0.055	0.089	19.510	0.959
.|. |	.|. |	33	0.060	0.045	20.372	0.958
.|. |	.|. |	34	0.001	-0.037	20.372	0.969
.|. |	*|. |	35	-0.061	-0.086	21.262	0.967
.|. |	.|. |	36	0.024	-0.031	21.399	0.974

*Probabilities may not be valid for this equation specification.

E.3.2.2 Heteroscedasticity test

Heteroskedasticity Test: ARCH

F-statistic	0.479669	Prob. F(1,194)	0.4894
Obs*R-squared	0.483419	Prob. Chi-Square(1)	0.4869

E.4 Model 4 Second Hand Price Feeders

E.4.1 Estimation output

Dependent Variable: D_SHP
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Date: 08/25/16 Time: 21:22
Sample (adjusted): 2000M02 2016M06
Included observations: 197 after adjustments
Convergence achieved after 17 iterations
Coefficient covariance computed using outer product of gradients
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2 + C(5)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
D_TIMECHARTER	0.000439	5.10E-05	8.606219	0.0000
C	-0.000405	0.014258	-0.028391	0.9774
Variance Equation				
C	0.005154	0.001221	4.222547	0.0000
RESID(-1)^2	0.397108	0.060218	6.594514	0.0000
GARCH(-1)	0.676945	0.033997	19.91195	0.0000

R-squared	0.195975	Mean dependent var	-0.012863
Adjusted R-squared	0.191852	S.D. dependent var	0.391096
S.E. of regression	0.351583	Akaike info criterion	0.251450
Sum squared resid	24.10414	Schwarz criterion	0.334780
Log likelihood	-19.76784	Hannan-Quinn criter.	0.285183
Durbin-Watson stat	1.665851		

E.4.2 Diagnostic Testing

E.4.2.1 Autocorrelation test

Date: 08/25/16 Time: 21:22
Sample: 2000M01 2016M06
Included observations: 197

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
.|. |	.|. |	1	-0.049	-0.049	0.4754	0.491
.|. |	.|. |	2	-0.020	-0.022	0.5535	0.758
.|. |	.|. |	3	-0.005	-0.007	0.5586	0.906
.|* |	.|* |	4	0.175	0.175	6.7912	0.147
*|. |	.|. |	5	-0.068	-0.053	7.7370	0.171
*|. |	*|. |	6	-0.077	-0.078	8.9512	0.176
.|* |	.|* |	7	0.106	0.103	11.276	0.127
.|. |	.|. |	8	-0.010	-0.036	11.296	0.185
.|* |	.|* |	9	0.087	0.113	12.873	0.168
.|. |	.|. |	10	-0.028	0.002	13.040	0.221
.|. |	.|. |	11	-0.007	-0.056	13.051	0.290
.|. |	.|. |	12	-0.012	0.005	13.080	0.363
.|. |	*|. |	13	-0.055	-0.084	13.713	0.394
.|. |	.|. |	14	-0.059	-0.063	14.461	0.416
.|. |	.|* |	15	0.054	0.084	15.084	0.445
.|. |	.|. |	16	-0.021	-0.051	15.179	0.512
.|. |	.|. |	17	-0.024	0.002	15.300	0.574
.|. |	.|. |	18	-0.003	0.006	15.301	0.641
.|. |	.|. |	19	0.058	0.015	16.048	0.654
.|. |	.|. |	20	-0.056	-0.019	16.749	0.669
*|. |	*|. |	21	-0.097	-0.088	18.864	0.594
.|. |	.|. |	22	-0.013	-0.032	18.901	0.651
*|. |	*|. |	23	-0.073	-0.077	20.097	0.636
.|. |	.|. |	24	-0.032	-0.042	20.326	0.678
*|. |	.|. |	25	-0.089	-0.062	22.128	0.628
.|* |	.|* |	26	0.096	0.077	24.251	0.562
.|* |	.|* |	27	0.113	0.146	27.205	0.453
*|. |	.|. |	28	-0.071	-0.060	28.381	0.444
.|. |	.|. |	29	-0.042	-0.020	28.794	0.476
.|. |	*|. |	30	-0.056	-0.086	29.541	0.489
.|* |	.|. |	31	0.087	0.043	31.326	0.450
*|. |	.|. |	32	-0.070	0.021	32.477	0.443
.|. |	*|. |	33	-0.061	-0.079	33.353	0.450
.|. |	.|. |	34	0.002	-0.023	33.354	0.499
.|. |	.|. |	35	0.027	-0.022	33.526	0.539
.|. |	.|. |	36	0.055	0.037	34.261	0.551

*Probabilities may not be valid for this equation specification.

E.4.2.2 Heteroscedasticity test

Heteroskedasticity Test: ARCH

F-statistic	0.462692	Prob. F(1,194)	0.4972
Obs*R-squared	0.466350	Prob. Chi-Square(1)	0.4947

E.5 Model 5 Second Hand Price Handy Size

E.5.1 Estimation output

Dependent Variable: D_SHP
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Date: 08/25/16 Time: 22:33
Sample (adjusted): 2000M02 2016M06
Included observations: 197 after adjustments
Convergence achieved after 23 iterations
Coefficient covariance computed using outer product of gradients
Presample variance: backcast (parameter = 0.7)
GARCH = C(4) + C(5)*RESID(-1)^2 + C(6)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
D_TIMECHARTER	0.000393	3.97E-05	9.897727	0.0000
D_ORDERBOOK	-1.687891	8.227802	-0.205145	0.8375
C	-0.016072	0.044129	-0.364200	0.7157
Variance Equation				
C	0.086458	0.036502	2.368571	0.0179
RESID(-1)^2	0.874096	0.154541	5.656086	0.0000
GARCH(-1)	0.519615	0.076537	6.789083	0.0000

R-squared	0.179799	Mean dependent var	-0.038071
Adjusted R-squared	0.171344	S.D. dependent var	1.483813
S.E. of regression	1.350723	Akaike info criterion	3.022546
Sum squared resid	353.9438	Schwarz criterion	3.122542
Log likelihood	-291.7208	Hannan-Quinn criter.	3.063026
Durbin-Watson stat	1.816817		

E.5.2 Diagnostic Testing

E.5.2.1 Autocorrelation test

Date: 08/25/16 Time: 22:34
Sample: 2000M01 2016M06
Included observations: 197

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
.|. |	.|. |	1	-0.064	-0.064	0.8136	0.367
.|. |	.|. |	2	0.058	0.054	1.4804	0.477
.|. |	.|. |	3	-0.035	-0.028	1.7303	0.630
.|. |	.|. |	4	-0.024	-0.031	1.8502	0.763
.|. |	.|. |	5	-0.029	-0.030	2.0271	0.845
.|. |	.|. |	6	-0.001	-0.002	2.0272	0.917
.|. |	.|. |	7	-0.022	-0.021	2.1251	0.953
.|. |	.|. |	8	-0.002	-0.007	2.1260	0.977
.|. |	.|. |	9	0.001	0.001	2.1263	0.989
.|. |	.|. |	10	-0.019	-0.021	2.2018	0.995
.|. |	.|. |	11	-0.012	-0.017	2.2344	0.997
.|. |	.|. |	12	-0.055	-0.057	2.8794	0.996
.|. |	.|. |	13	0.071	0.065	3.9584	0.992
.|. |	.|. |	14	-0.046	-0.035	4.4058	0.992
.|. |	.|. |	15	0.037	0.019	4.6963	0.994
.|. |	.|. |	16	0.019	0.027	4.7750	0.997
.|. |	.|. |	17	-0.004	-0.007	4.7781	0.998
.|. |	.|. |	18	-0.001	-0.002	4.7783	0.999
.|. |	.|. |	19	-0.041	-0.042	5.1409	0.999
.|. |	.|. |	20	0.001	0.001	5.1410	1.000
.|. |	.|. |	21	-0.038	-0.036	5.4677	1.000
.|. |	.|. |	22	-0.032	-0.041	5.6923	1.000
.|. |	.|. |	23	-0.028	-0.030	5.8677	1.000
.|. |	.|. |	24	-0.017	-0.024	5.9336	1.000
.|. |	.|. |	25	-0.027	-0.025	6.0960	1.000
.|. |	.|. |	26	-0.028	-0.045	6.2707	1.000
.|. |	.|. |	27	-0.047	-0.047	6.7739	1.000
.|. |	.|. |	28	-0.025	-0.038	6.9178	1.000
.|. |	.|. |	29	0.018	0.008	6.9927	1.000
.|. |	.|. |	30	-0.038	-0.044	7.3355	1.000
.|. |	.|. |	31	-0.017	-0.040	7.4004	1.000
.|. |	.|. |	32	-0.044	-0.050	7.8665	1.000
.|. |	.|. |	33	-0.017	-0.039	7.9376	1.000
.|. |	.|. |	34	-0.027	-0.035	8.1190	1.000
.|** |	.|** |	35	0.323	0.321	33.368	0.547
.|. |	.|. |	36	-0.007	0.031	33.379	0.594

*Probabilities may not be valid for this equation specification.

E.5.2.2 Heteroscedasticity test

Heteroskedasticity Test: ARCH

F-statistic	0.792697	Prob. F(1,194)	0.3744
Obs*R-squared	0.797610	Prob. Chi-Square(1)	0.3718

E.6 Model 6 Second Hand Sub-Panamax

E.6.1 Estimation Output

Dependent Variable: D_SHP
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Date: 08/26/16 Time: 20:54
Sample (adjusted): 2000M02 2016M06
Included observations: 197 after adjustments
Convergence achieved after 23 iterations
Coefficient covariance computed using outer product of gradients
Presample variance: backcast (parameter = 0.7)
GARCH = C(4) + C(5)*RESID(-1)^2 + C(6)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
D_TIMECHARTER	0.000823	7.83E-05	10.51216	0.0000
D_LIBOR	-209.6934	60.48051	-3.467124	0.0005
C	-0.183199	0.129927	-1.410020	0.1585
Variance Equation				
C	0.216142	0.132228	1.634612	0.1021
RESID(-1)^2	0.102584	0.039932	2.568985	0.0102
GARCH(-1)	0.838146	0.072725	11.52492	0.0000

R-squared	0.216374	Mean dependent var	-0.071066
Adjusted R-squared	0.208295	S.D. dependent var	2.004668
S.E. of regression	1.783709	Akaike info criterion	3.900758
Sum squared resid	617.2342	Schwarz criterion	4.000754
Log likelihood	-378.2246	Hannan-Quinn criter.	3.941237
Durbin-Watson stat	1.992706		

E.6.2 Diagnostic Testing

E.6.2.1 Autocorrelation test

Date: 08/26/16 Time: 20:59
Sample: 2000M01 2016M06
Included observations: 197

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
.|. |	.|. |	1	-0.006	-0.006	0.0065	0.936
.|. |	.|. |	2	0.010	0.010	0.0273	0.986
.|. |	.|. |	3	0.010	0.010	0.0456	0.997
.|. |	.|. |	4	-0.036	-0.036	0.3020	0.990
.|. |	.|. |	5	-0.024	-0.024	0.4170	0.995
.|. |	.|. |	6	-0.002	-0.002	0.4182	0.999
.|. |	.|. |	7	0.061	0.063	1.1929	0.991
.|. |	.|. |	8	0.020	0.020	1.2722	0.996
.|. |	.|. |	9	0.034	0.031	1.5124	0.997
.|. |	.|. |	10	-0.016	-0.018	1.5640	0.999
.|. |	.|. |	11	-0.030	-0.028	1.7568	0.999
.|. |	.|. |	12	-0.005	-0.001	1.7616	1.000
.|. |	.|. |	13	-0.012	-0.008	1.7949	1.000
.|. |	.|. |	14	-0.023	-0.026	1.9076	1.000
.|. |	.|. |	15	-0.033	-0.038	2.1358	1.000
.|. |	.|. |	16	-0.004	-0.010	2.1386	1.000
.|. |	.|. |	17	0.023	0.025	2.2582	1.000
.|. |	.|. |	18	-0.002	0.001	2.2591	1.000
.|. |	.|. |	19	-0.034	-0.036	2.5203	1.000
.|. |	.|. |	20	-0.008	-0.008	2.5329	1.000
.|. |	.|. |	21	-0.018	-0.013	2.6036	1.000
.|. |	.|. |	22	0.001	0.008	2.6036	1.000
.|. |	.|. |	23	-0.035	-0.034	2.8773	1.000
.|. |	.|. |	24	-0.001	-0.006	2.8776	1.000
.|. |	.|. |	25	-0.003	-0.007	2.8798	1.000
.|. |	.|. |	26	-0.038	-0.038	3.2129	1.000
.|. |	.|. |	27	-0.040	-0.041	3.5803	1.000
.|. |	.|. |	28	0.031	0.035	3.8102	1.000
.|. |	.|. |	29	0.022	0.022	3.9218	1.000
.|. |	.|. |	30	-0.033	-0.034	4.1706	1.000
.|. |	.|. |	31	-0.035	-0.041	4.4566	1.000
.|. |	.|. |	32	-0.036	-0.033	4.7578	1.000
.|. |	.|. |	33	-0.022	-0.016	4.8742	1.000
.|. |	.|. |	34	-0.030	-0.029	5.0859	1.000
.|* |	.|* |	35	0.090	0.085	7.0267	1.000
.|. |	.|. |	36	-0.028	-0.033	7.2141	1.000

*Probabilities may not be valid for this equation specification.

E.6.2.2 Heteroscedasticity test

Heteroskedasticity Test: ARCH

F-statistic	0.006347	Prob. F(1,194)	0.9366
Obs*R-squared	0.006412	Prob. Chi-Square(1)	0.9362

Appendix F VECM Estimation Outputs and Diagnostic Tests

F.1 Model 1 Newbuilding Feeders Diagnostic Tests

F.1.1 Serial Correlation test

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.024893	Prob. F(2,174)	0.9754
Obs*R-squared	0.054921	Prob. Chi-Square(2)	0.9729

F.1.2 Heteroscedasticity test

Heteroskedasticity Test: ARCH			
F-statistic	5.989093	Prob. F(1,189)	0.0153
Obs*R-squared	5.866568	Prob. Chi-Square(1)	0.0154

F.2 Model 2 Newbuilding Handy Size

F.2.1 Estimation output

Table 17: Result from Newbuilding Price VEC Model for Handy Size

Dependent Variable: D(NBP)
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 08/20/16 Time: 13:45
Sample (adjusted): 2000M06 2016M06
Included observations: 193 after adjustments
D(NBP) = C(1)*(NBP(-1) - 348.27434489*LIBOR(-1) - 0.0261098661306
*STEELPRICE(-1) + 0.000362229461815*TCHR(-1) - 10.5657146302
) + C(2)*D(NBP(-1)) + C(3)*D(NBP(-2)) + C(4)*D(NBP(-3)) + C(5)
*D(NBP(-4)) + C(6)*D(LIBOR(-1)) + C(7)*D(LIBOR(-2)) + C(8)
*D(LIBOR(-3)) + C(9)*D(LIBOR(-4)) + C(10)*D(STEELPRICE(-1)) +
C(11)*D(STEELPRICE(-2)) + C(12)*D(STEELPRICE(-3)) + C(13)
*D(STEELPRICE(-4)) + C(14)*D(TCHR(-1)) + C(15)*D(TCHR(-2)) +
C(16)*D(TCHR(-3)) + C(17)*D(TCHR(-4)) + C(18)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.003520	0.011202	0.314198	0.7537
C(2)	0.234289	0.077893	3.007838	0.0030
C(3)	0.124515	0.082031	1.517901	0.1308
C(4)	0.080039	0.079742	1.003726	0.3169
C(5)	-0.065195	0.077192	-0.844590	0.3995
C(6)	-3.936950	31.00351	-0.126984	0.8991
C(7)	126.9010	32.36675	3.920722	0.0001
C(8)	-49.02388	34.12764	-1.436486	0.1526
C(9)	-32.71766	31.85896	-1.026953	0.3059
C(10)	0.001445	0.001322	1.092729	0.2760
C(11)	-0.001426	0.001297	-1.099724	0.2730
C(12)	0.001244	0.001281	0.971271	0.3328
C(13)	-0.001261	0.001221	-1.032823	0.3031
C(14)	0.000177	6.57E-05	2.696097	0.0077
C(15)	0.000133	7.56E-05	1.762890	0.0797
C(16)	6.18E-06	7.62E-05	0.081025	0.9355
C(17)	7.88E-05	7.02E-05	1.122073	0.2634
C(18)	0.021395	0.050428	0.424266	0.6719

R-squared	0.475179	Mean dependent var	0.000000
Adjusted R-squared	0.424197	S.D. dependent var	0.901388
S.E. of regression	0.683988	Akaike info criterion	2.166873
Sum squared resid	81.87203	Schwarz criterion	2.471165
Log likelihood	-191.1032	Hannan-Quinn criter.	2.290101
F-statistic	9.320425	Durbin-Watson stat	1.997029
Prob(F-statistic)	0.000000		

F.2.2 Diagnostic Testing

F.2.2.1 Serial Correlation test

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.443848	Prob. F(2,173)	0.6423
Obs*R-squared	0.985264	Prob. Chi-Square(2)	0.6110

F.2.2.2 Heteroscedasticity test

Heteroskedasticity Test: ARCH			
F-statistic	0.867914	Prob. F(1,190)	0.3527
Obs*R-squared	0.873061	Prob. Chi-Square(1)	0.3501

F.3 Model 3 Newbuilding Sub-Panamax

F.3.1 Estimation output

Dependent Variable: D(NBP)
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 08/26/16 Time: 20:34
Sample (adjusted): 2000M07 2016M06
Included observations: 192 after adjustments
D(NBP) = C(1)*(NBP(-1) - 374.298138808*LIBOR(-1) - 0.0772959117781
*SHP(-1) - 0.0203511575775*STEELPRICE(-1) + 3.51151820672
*ORDERBOOK(-1) - 17.5865899559) + C(2)*D(NBP(-1)) + C(3)
*D(NBP(-2)) + C(4)*D(NBP(-3)) + C(5)*D(NBP(-4)) + C(6)*D(NBP(-5)) +
C(7)*D(LIBOR(-1)) + C(8)*D(LIBOR(-2)) + C(9)*D(LIBOR(-3)) + C(10)
*D(LIBOR(-4)) + C(11)*D(LIBOR(-5)) + C(12)*D(SHP(-1)) + C(13)
*D(SHP(-2)) + C(14)*D(SHP(-3)) + C(15)*D(SHP(-4)) + C(16)*D(SHP(
-5)) + C(17)*D(STEELPRICE(-1)) + C(18)*D(STEELPRICE(-2)) + C(19)
*D(STEELPRICE(-3)) + C(20)*D(STEELPRICE(-4)) + C(21)
*D(STEELPRICE(-5)) + C(22)*D(ORDERBOOK(-1)) + C(23)
*D(ORDERBOOK(-2)) + C(24)*D(ORDERBOOK(-3)) + C(25)
*D(ORDERBOOK(-4)) + C(26)*D(ORDERBOOK(-5))

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.013647	0.013431	-1.016083	0.3111
C(2)	0.379929	0.075651	5.022133	0.0000
C(3)	-0.208277	0.075079	-2.774125	0.0062
C(4)	0.234576	0.072823	3.221160	0.0015
C(5)	-0.098943	0.070171	-1.410034	0.1604
C(6)	-0.075824	0.065553	-1.156672	0.2491
C(7)	46.71047	34.38250	1.358554	0.1761
C(8)	85.17165	36.91942	2.306961	0.0223
C(9)	-78.76954	37.21777	-2.116450	0.0358
C(10)	81.68170	41.78905	1.954620	0.0523
C(11)	-63.44854	39.35111	-1.612370	0.1088
C(12)	0.085771	0.029435	2.913895	0.0041
C(13)	0.083261	0.030202	2.756816	0.0065
C(14)	0.064662	0.030834	2.097137	0.0375
C(15)	0.068388	0.031215	2.190888	0.0299
C(16)	0.082895	0.032131	2.579914	0.0107
C(17)	0.003035	0.001555	1.951282	0.0527
C(18)	-0.003906	0.001436	-2.720732	0.0072
C(19)	0.004688	0.001331	3.522197	0.0006
C(20)	-0.007721	0.001405	-5.493725	0.0000
C(21)	0.004042	0.001426	2.835119	0.0052
C(22)	14.71469	7.335648	2.005916	0.0465
C(23)	-16.34430	7.619124	-2.145168	0.0334
C(24)	8.853328	7.773613	1.138895	0.2564
C(25)	-4.250641	7.338104	-0.579256	0.5632
C(26)	8.785334	7.068990	1.242799	0.2157

R-squared	0.637115	Mean dependent var	-0.035156
Adjusted R-squared	0.582463	S.D. dependent var	1.059006
S.E. of regression	0.684299	Akaike info criterion	2.204481
Sum squared resid	77.73190	Schwarz criterion	2.645600
Log likelihood	-185.6301	Hannan-Quinn criter.	2.383137
Durbin-Watson stat	2.022630		

F.3.2 Diagnostic Testing

F.3.2.1 Serial Correlation test

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.118663	Prob. F(2,164)	0.8882
Obs*R-squared	0.277445	Prob. Chi-Square(2)	0.8705

F.3.2.2 Heteroscedasticity test

Heteroskedasticity Test: ARCH			
F-statistic	0.038737	Prob. F(1,189)	0.8442
Obs*R-squared	0.039139	Prob. Chi-Square(1)	0.8432

F.4 Model 4 Second Hand Price Feeders

F.4.1 Estimation Output

Dependent Variable: D(SHP)
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 08/25/16 Time: 21:34
Sample (adjusted): 2000M05 2016M06
Included observations: 194 after adjustments
D(SHP) = C(1)*(SHP(-1) - 0.00153172432737*TIMECHARTER(-1)) + C(2)
*D(SHP(-1)) + C(3)*D(SHP(-2)) + C(4)*D(SHP(-3)) + C(5)
*D(TIMECHARTER(-1)) + C(6)*D(TIMECHARTER(-2)) + C(7)
*D(TIMECHARTER(-3))

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.033229	0.014016	-2.370717	0.0188
C(2)	0.055250	0.076333	0.723802	0.4701
C(3)	0.198582	0.072439	2.741371	0.0067
C(4)	-0.089949	0.073577	-1.222512	0.2231
C(5)	8.90E-05	0.000140	0.637400	0.5246
C(6)	0.000281	0.000148	1.902926	0.0586
C(7)	0.000263	0.000144	1.834657	0.0681

R-squared	0.292360	Mean dependent var	-0.013707
Adjusted R-squared	0.269655	S.D. dependent var	0.394047
S.E. of regression	0.336753	Akaike info criterion	0.696482
Sum squared resid	21.20630	Schwarz criterion	0.814395
Log likelihood	-60.55878	Hannan-Quinn criter.	0.744228
Durbin-Watson stat	1.987466		

F.4.2 Diagnostic Testing

F.4.2.1 Serial Correlation test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.637622	Prob. F(2,185)	0.5297
Obs*R-squared	1.328128	Prob. Chi-Square(2)	0.5148

F.4.2.2 Heteroscedasticity test

Heteroskedasticity Test: ARCH

F-statistic	0.028944	Prob. F(1,191)	0.8651
Obs*R-squared	0.029242	Prob. Chi-Square(1)	0.8642

F.5 Model 5 Second Hand Price Handy Size

F.5.1 Estimation Output

Dependent Variable: D(SHP)
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 08/25/16 Time: 22:37
Sample (adjusted): 2000M06 2016M06
Included observations: 193 after adjustments
D(SHP) = C(1)*(SHP(-1) + 48.4679737242*ORDERBOOK(-1) - 0.00236214213268*TCHR(-1)) + C(2)*D(SHP(-1)) + C(3)*D(SHP(-2)) + C(4)*D(SHP(-3)) + C(5)*D(SHP(-4)) + C(6)*D(ORDERBOOK(-1)) + C(7)*D(ORDERBOOK(-2)) + C(8)*D(ORDERBOOK(-3)) + C(9)*D(ORDERBOOK(-4)) + C(10)*D(TCHR(-1)) + C(11)*D(TCHR(-2)) + C(12)*D(TCHR(-3)) + C(13)*D(TCHR(-4))

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.002394	0.016563	0.144565	0.8852
C(2)	-0.063852	0.082869	-0.770522	0.4420
C(3)	0.088409	0.079443	1.112868	0.2672
C(4)	-0.063976	0.077580	-0.824647	0.4107
C(5)	-0.102478	0.078118	-1.311840	0.1912
C(6)	-1.899563	16.93480	-0.112169	0.9108
C(7)	-12.28183	16.27495	-0.754646	0.4514
C(8)	36.30577	16.23880	2.235742	0.0266
C(9)	12.86983	16.28201	0.790432	0.4303
C(10)	0.000328	0.000144	2.276352	0.0240
C(11)	0.000211	0.000157	1.347722	0.1794
C(12)	0.000333	0.000157	2.116925	0.0356
C(13)	0.000101	0.000151	0.671234	0.5029

R-squared	0.241495	Mean dependent var	-0.044041
Adjusted R-squared	0.190928	S.D. dependent var	1.497297
S.E. of regression	1.346795	Akaike info criterion	3.498315
Sum squared resid	326.4944	Schwarz criterion	3.718081
Log likelihood	-324.5874	Hannan-Quinn criter.	3.587313
Durbin-Watson stat	2.000897		

F.5.2 Diagnostic Testing

F.5.2.1 Serial Correlation test

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.218628	Prob. F(2,178)	0.8038
Obs*R-squared	0.472942	Prob. Chi-Square(2)	0.7894

F.5.2.2 Heteroscedasticity test

Heteroskedasticity Test: ARCH			
F-statistic	0.009249	Prob. F(1,190)	0.9235
Obs*R-squared	0.009346	Prob. Chi-Square(1)	0.9230

F.6 Model 6 Second-Hand Price Sub-Panamax

F.6.1 Estimation Output

Dependent Variable: D(SHP)
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 08/26/16 Time: 21:13
Sample (adjusted): 2000M06 2016M06
Included observations: 193 after adjustments
D(SHP) = C(1)*(SHP(-1) + 0.00218889599734*TIMECHARTER(-1) - 2333.86299706*LIBOR(-1) - 22.5038594307) + C(2)*D(SHP(-1)) + C(3)*D(SHP(-2)) + C(4)*D(SHP(-3)) + C(5)*D(SHP(-4)) + C(6) *D(TIMECHARTER(-1)) + C(7)*D(TIMECHARTER(-2)) + C(8) *D(TIMECHARTER(-3)) + C(9)*D(TIMECHARTER(-4)) + C(10) *D(LIBOR(-1)) + C(11)*D(LIBOR(-2)) + C(12)*D(LIBOR(-3)) + C(13) *D(LIBOR(-4))

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.003768	0.003898	-0.966707	0.3350
C(2)	-0.119666	0.079296	-1.509109	0.1330
C(3)	0.052736	0.080789	0.652765	0.5147
C(4)	0.122605	0.080019	1.532197	0.1272
C(5)	0.092514	0.079791	1.159461	0.2478
C(6)	0.000371	0.000130	2.846615	0.0049
C(7)	0.000166	0.000138	1.200415	0.2316
C(8)	5.38E-05	0.000139	0.386431	0.6996
C(9)	0.000256	0.000134	1.903928	0.0585
C(10)	-115.3263	83.90226	-1.374531	0.1710
C(11)	-31.62356	92.44537	-0.342078	0.7327
C(12)	34.64302	92.21610	0.375672	0.7076
C(13)	77.50990	80.91792	0.957883	0.3394

R-squared	0.214912	Mean dependent var	-0.079016
Adjusted R-squared	0.162573	S.D. dependent var	2.023805
S.E. of regression	1.852006	Akaike info criterion	4.135397
Sum squared resid	617.3865	Schwarz criterion	4.355164
Log likelihood	-386.0658	Hannan-Quinn criter.	4.224396
Durbin-Watson stat	2.029751		

F.6.2 Diagnostic Testing

F.6.2.1 Serial Correlation test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.923480	Prob. F(2,178)	0.1491
Obs*R-squared	4.082903	Prob. Chi-Square(2)	0.1298

F.6.2.2 Heteroscedasticity test

Heteroskedasticity Test: ARCH

F-statistic	0.180150	Prob. F(1,190)	0.6717
Obs*R-squared	0.181874	Prob. Chi-Square(1)	0.6698