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ΠΡΟΓΡΑΜΜΑ ΜΕΤΑΠΤΥΧΙΑΚΩΝ ΣΠΟΥΔΩΝ στην ΝΑΥΤΙΛΙΑ

ASSESSMENT OF INTERACTIONS BETWEEN FACTORS AND FREIGHT MARKET IN THE DRY BULK SECTOR

Κωστούλας Χρήστος

Διπλωματική Εργασία

που υποβλήθηκε στο Τμήμα Ναυτιλιακών Σπουδών του Πανεπιστημίου Πειραιώς ως μέρος των απαιτήσεων για την απόκτηση του Μεταπτυχιακού Διπλώματος Ειδίκευσης στην Ναυτιλία

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Thank you.

Christos Kostoulas

“Just as ancient kings had their soothsayers and astrologists, modern tycoons and prime ministers have their economic forecasters.”

Paul A. Samuelson (1965)

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List of Abbreviations

AIS	Automatic Identification System
BDI	Baltic Dry Index
BIMCO	Baltic and International Maritime Council
CGT	Compensated Gross Ton
CHF	Swiss franc
DB	DataBase
DWT	Deadweight tonnage
EUR	Euro
FFA	Forward Freight Agreement
GBP	Pound sterling
GDP	Gross Domestic Product
GT	Gross tonnage
HFO	Heavy Fuel Oil
IMO	International Maritime Organization
JPY	Japanese yen
KPSS	Kwiatkowski–Phillips–Schmidt–Shin
LIBOR	London Interbank Offered Rate
MT	Metric Tonnes
NARMAX	Nonlinear AutoRegressive Moving Average model with eXogenous
OECD	Organisation for Economic Co-operation and Development
PSD	Parcel Size Distribution
RPM	Revolutions Per Minute
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
USD	United States Dollar

ABSTRACT

The aim of this Thesis is to analyze the possible interactions between the Freight Market in the dry Bulk Sector and various Economic Factors. The Freight market will be represented by the Baltic Exchange Indexes. In this thesis Macroeconomic indicators like GDP and International Trade data as long as shipping indicators such as Average Haul, scraping prices, fuel prices, vessel's operational speed, Shipbuilding Production etc. are considered as Economic factors.

An analysis of the Four Shipping Markets and the supply and demand model will be used in an attempt to explain and assess the mechanisms which determine freight rates in a consistent way. Differences in freight rates across major dry bulk shipping routes and geographical distribution of shipping activities are also investigated.

Statistical quantitative methods will be the main tool for the above approach. The data will be analyzed and possible correlation will be assessed. The analysis will be based on data from various sources (Clarksons, UNCTAD, OECD, etc). Furthermore, a software code will be developed in the fourth-generation programming language Matlab to assess the above analysis.

Key words: Freight Rate, Shipping, Dry Bulk, Time series, Economic Factors, Correlation,

1 INTRODUCTION

Shipping is both a growth industry and a cyclical industry. Shipping's target is to efficiently transport commodities, merchandise goods and cargo. Shipping, as it is known, is the lifeblood of the world economy, carrying 90% of international trade with 85094 commercial vessels worldwide (Equasis, 2015, p. 6). For the major players in the shipping industry however, the aim is different. Their goal is to take advantage of the shipping cycles, allowing them to operate at the most profitable period and further manage to buy low and sell high their vessels.

The freight market represents the balance at any given time of the supply and demand for shipping tonnage. It is well known that the dry cargo freight market fluctuates, sometimes violently due to the complexity of the market and the diversification of the participants who are interacting in a sometimes irrational way.

Some of the parameters which influence the freight market, according to studies, are the trade flow, fleet capacity, shipbuilding schedule, scrapings, and industrial production. Also economical and geopolitical effects such as wars, canal disputes, oil shocks, and economic boom and bust cycles have all effected shipping one way or the other during the ages. All these theoretical effects are analyzed in depth in the literature from (Stopford, Maritime Economics, 2009) , (Talley, 2012), (Gkiziakis, Papadopoulos, & Plomaritou, 2010) and many others.

During the past years, many attempts have been made for predicting the freight market with a lot of different ways. Some have focused on the historic pattern, others have focused on supply and demand parameters.

For example, (Beenstock & Vergottis, 1989) developed an integrated structural econometric model of the dry cargo markets. They used the structure of the four main markets in the shipping industry and they tried to determine the freight value with the help of the supply and demand function. Demand, in their work was taken as exogenous and they assumed that it is inelastic to the freight rates.

Such models had limitations as (Duru & Yoshida, 2009) had noticed. Quantitative methods need a historical background and similar events (patterns) must be experienced before. In their opinion there are empirical studies that suggest judgmental forecasts which outperform statistical techniques, particularly in unforeseeable situations.

The recent financial crisis taught us that economic modelling is not a game for beginners. In this thesis, timeseries for almost any parameter who is referring to the literature are examined. This thesis takes a step back and does not try to model nor to predict the market. Instead, the aim here is to identify parameters with high values of correlation which could act as a signal for possible causality. Also the time lag between those parameters are examined in order to provide some validity to the analysis of the correlation values. The results can be used to a further research for a forecasting model.

In Chapter 2, a brief analysis of the dry bulk shipping theory is attempted. The shipping cycles and the four shipping markets are explained. And the "maritime market model" is mentioned. Further economic factors, which have been linked with the shipping market, are analyzed in order to close the economical part of the theory.

In Chapter 3, the required for the statistical analysis mathematical background is presented. Starting from the stationarity concept and the necessary, for the stationarity, data transformations the basis for data analysis are explained. The theory and the equations for auto and cross correlation are also presented.

In Chapter 4, the data structure and sources are cited. The issue of the “Super Cycle” and a way to overcome it is mentioned. Finally the structure of the code which has been developed is given.

The results are presented in Chapter 5 along with some comments in order to explain them. Finally in Chapter 6 the general conclusions and the suggested further research are presented.

2 SHIPPING THEORY

2.1 DRY BULK

2.1.1 Definition of 'Bulk Shipping'

The classical definition of dry bulk shipping has been derived as "transport by sea on a one cargo/one ship basis" according to (Talley, 2012) and (Stopford, Maritime Economics, 2009). There are also other definitions of dry bulk based on contract type in order to distinguish dry bulk shipping for liner shipping (Talley, 2012).

Bulk shipping developed as the major maritime sector in the previous decades after the Second World War. Bulk shipping became a rapidly expanding sector of the shipping industry, and bulk tonnage now accounts for about three-quarters of the world merchant fleet. Especially the Dry Bulk accounts for 43.5% of the merchant fleet tonnage (UNCTAD, 2015) and carries the 54.7% of the seaborne trade for 2015 (UNCTAD, 2015).

Most of the bulk cargoes are drawn from the raw material trades such as oil, iron ore, coal and grain, and are often described as 'bulk commodities' on the assumption that, all of that type of cargo (e.g. iron ore) is shipped in bulk and it is transported unpackaged in large quantities. The need of several important industries, notably steel, aluminum and fertilizer manufacture for high-quality raw materials lead to the development of a large bulk carriers fleet to service the trade. According to (Stopford, Maritime Economics, 2009) there are four main characteristics of the bulk commodities which influence their suitability for transport in bulk

- Volume
- Handling and Stowage
- Cargo value
- Regularity of trade flow

The main categories of the dry bulk cargo according to (Stopford, Maritime Economics, 2009) are:

- The five *major bulks* (iron ore, grain, coal, phosphates and bauxite). They are homogeneous bulk cargoes which can be transported satisfactorily in a conventional dry bulk carrier.
- *Minor bulks* which cover the many other commodities that travel in shiploads. The most important of them are steel products, steel scrap, cement, gypsum, non-ferrous metal ores, sugar, salt, sulphur, forest products, wood chips and chemicals.

2.1.2 Principles of Bulk Transports

Sea transport is just one stage in the bulk commodities logistic chain. Like in any other logistic chain, the aim is to transport the cargo as cheaply and efficiently as possible.

The ultimate goal is to develop a system which not only determined by cost in one step of the transport chain, but it will provide the best overall outcome. Of course, since each different commodity and industry has specific transport requirements and no single system is ideal for every situation compromises are inevitable.

Still, there are certain principles which are essential when thinking about the transport systems. (Stopford, Maritime Economics, 2009). There are four basic issues to consider:

1. Gaining maximum economies of scale by using bigger vessels. The unit costs can be reduced by increasing the size of the cargo on the shipping leg. Cargo handling, in the same time, becomes proportionally less important in the unit cost equation as the length of haul increases. Of course it has to be mentioned that very big vessels are less flexible and have fewer trading options due to route/port limitations.
2. Reducing the number of times the cargo is handled since that way the cargo handling cost are reduced as well.
3. Making the cargo-handling operation more efficient by using specialized, more efficient, cargo handling equipment which lower the handling cost per unit of cargo. Another option is to standardize cargo units so it can easily be handled by all stages in the logistic chain
4. Reducing the size of stocks held, taking into consideration that 'just in time' manufacturing systems minimizing the need for stocks thus minimizing the cost for storage. It should be mentioned that this comes in conflict with the first principle and therefore a tradeoff between optimizing stockholding and economies of scale should be found.

2.1.3 Vessels for Dry Bulk Trades

Bulk carriers are vessels specially designed to transport unpackaged bulk cargo in their cargo holds. Bulk carriers are generally designed for low-cost transport and simplicity. Key design features, apart from safety, are cubic capacity, access to the holds, and cargo-handling gear.

The carriage of goods in bulk goes back to ancient times, and possibly the bulk carrier was "invented" by a Phoenician or a Greek naval architect between 2000 B.C. and 3000 B.C as referred in (Clyde, 1983). The first specialized bulk carrier was built in 1852 (Stopford, Maritime Economics, 2009) when the introduction of steel shipbuilding and the use of the properties of steel opened new possibilities for vessel construction. The modern bulk carriers are all single-deck vessels with a double bottom, vertical cargo access through hatches in the weather deck and they are able to maintain speeds generally in the range of 13 – 16 knots (Figure 1).

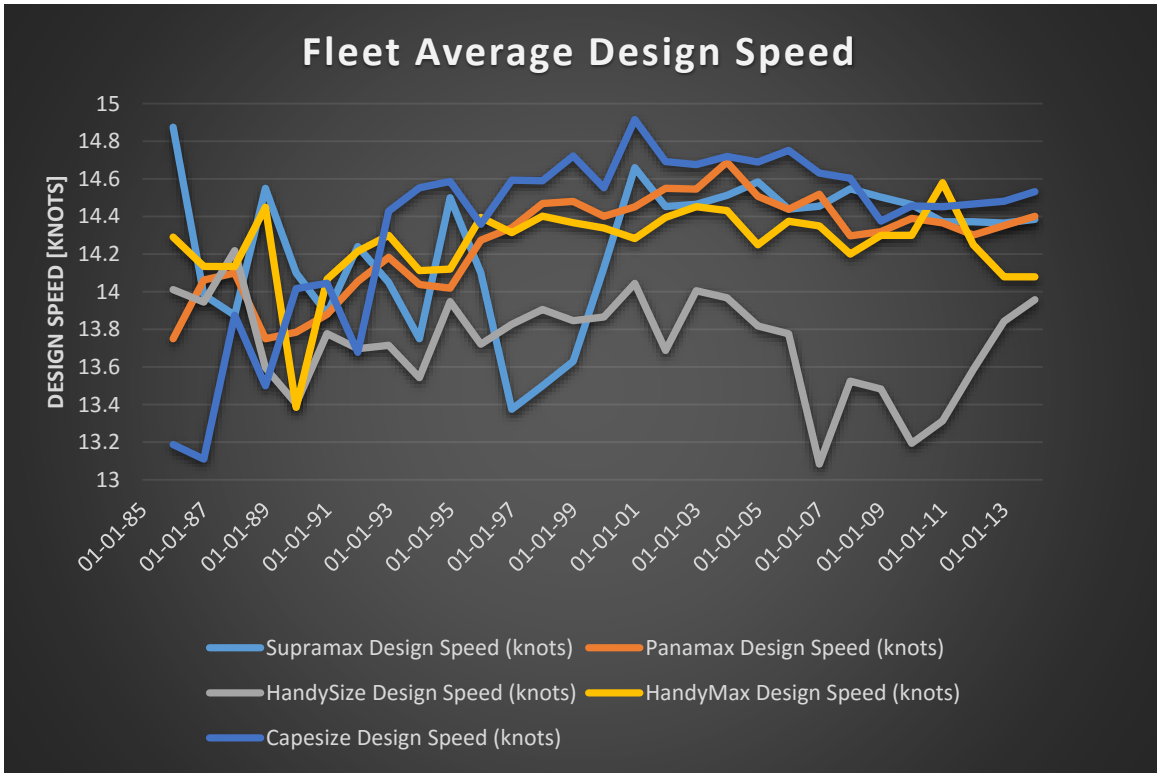


Figure 1 Vessel Design Speed by size Lloyds Fairplay DB

The bulk carrier market has diversified into several different size bands, each focusing on a different sector of the trade, forcing the dry bulk vessels to spread across the size range. The vessels are divided in four main categories based on their DWT capacity. Consequently the bulk carriers are generally referred to as Handy bulk carriers when they are in the range 10,000–39,999 DWT, Handymax bulk carriers when they are in the range 40,000–59,999 DWT, Panamax if they are in the range 60,000–99,999 DWT and finally Capesize if they are over 100,000 DWT. There are some other categories based on on the size of the vessel but rather on the regional trade they serve. Such categories are Kamsarmax, Seawaymax, Setouchmax, Dunkirkmax, and Newcastlemax named after the port or the canal where those vessels can operate. Such categories change every time the capacities of the port or canals they were named from change.

In (Kavussanos & Alizadeh, 2001) α differentiation of the trade pattern based on the vessel size can be found. Handysize vessels are mainly engaged in transportation of grain commodities from North and South America and Australia to Europe and Asia, and minor dry bulk commodities (such as bauxite and alumina, fertilizers, rice and sugar) around the world. Panamax vessels are used primarily in coal and grain and to some extent in iron ore transportation, from North America and Australia to Japan and West Europe. The Capesize fleet is engaged in transportation of iron ore from South America and Australia to Japan, West Europe and North America and to some extent coal from Australia and North America to Japan and West Europe. This differentiation can be seen in Table 1 and the different growth pattern in Figure 3.

Since the mid-1960s there has been a steady upward trend in the fleet size used in most bulk trades. During 2009 the bulk carrier fleet consisted of over 6,000 vessels of 369 million. DWT according to (Stopford, Maritime Economics, 2009). Later in 2014,

according to Lloyd's Fairplay DB the dry bulk fleet consisted of 11.187 vessels with 785 million DWT. This number is close to the Loyds List Intelligence[1] webpage where it claims that the numbers for 2016 are 11041 vessels with 799 million DWT something that is in consistence with the numbers from (UNCTAD, 2015) as it is shown in Figure 2.

Table 1 Dry Bulk carrier fleet by size and hull characteristics 2007 (Stopford, Maritime Economics, 2009)

	Bulk carrier fleet size			Hull characteristics						
Size	No	Av.dwt 000s	Total dwt	Length m.	Beam m.	Draft m.	Speed knots	Cons. t/day	Cubic m^3/tonne	% geared
Handy										
10–19,999	611	15,679	9.6	136	22	8.7	14.1	22.5	1.22	73%
20–24,999	487	23,025	11.2	154	24	9.7	14.3	26.1	1.27	89%
25–29,999	820	27,627	22.7	166	25	9.9	14.3	28.6	1.28	93%
30–39,999	917	35,270	32.3	178	27	10.7	14.4	31.3	1.25	87%
Handymax										
40–49,999	969	44,761	43.4	182	31	11.4	14.4	30.4	1.31	94%
50–59,999	498	53,026	26.4	186	32	12.1	14.5	34.4	1.28	80%
Panamax										
60–79,999	1,292	71,350	92.2	218	32	13.4	14.4	36.7	1.18	7%
80–99,999	121	87,542	10.6	230	37	13.7	14.3	42.0	1.14	2%
Capesize										
100–149,999	173	137,714	23.8	257	43	16.6	14.2	49.8	1.10	2%
150–199,999	468	170,227	79.7	276	45	17.6	14.5	53.9	1.09	0%
199,999+	74	229,096	17.0	303	52	18.9	14.0	60.3	0.87	1%
Grand total	6,430	57,355	368.8	191	30	11.9	14.4	33.4	1.18	60%

[1] http://www.lloydslistintelligence.com/llint/dry-bulk/index.htm

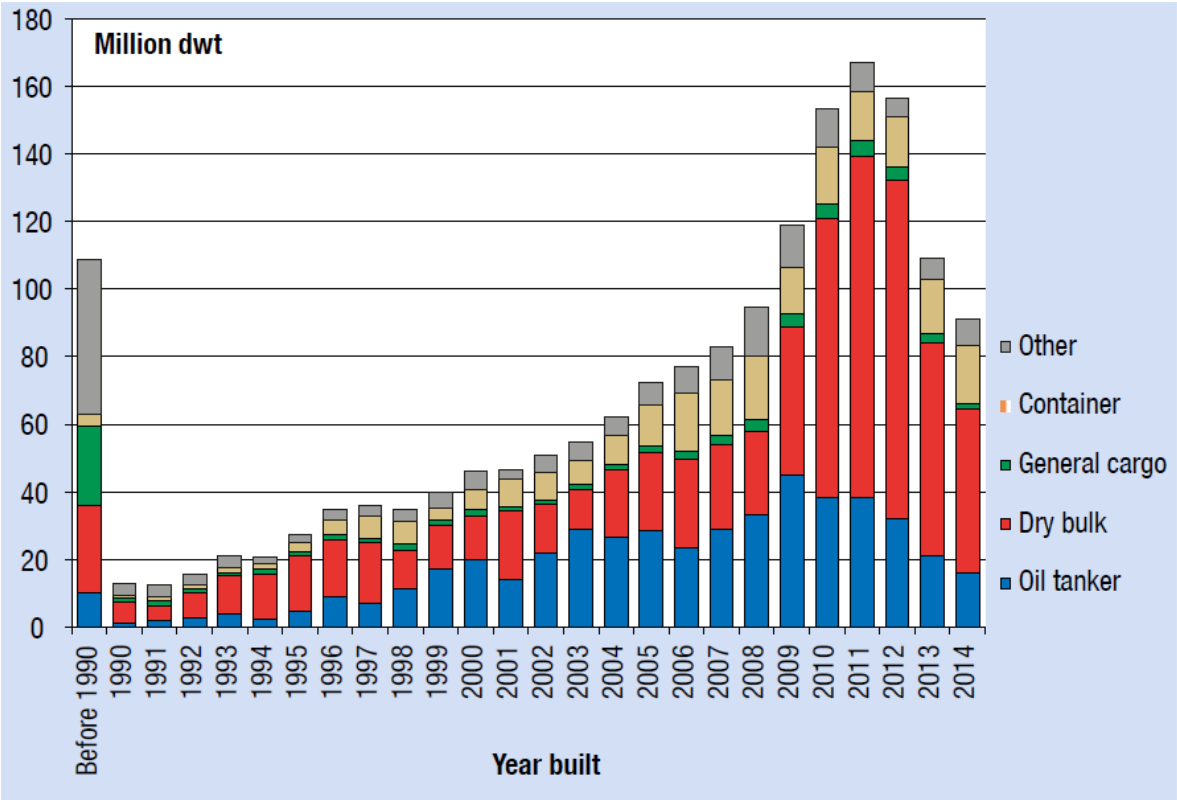


Figure 2 Vessel types of the world fleet, by year of building (dwt as of 1 January 2015) (UNCTAD, 2015)

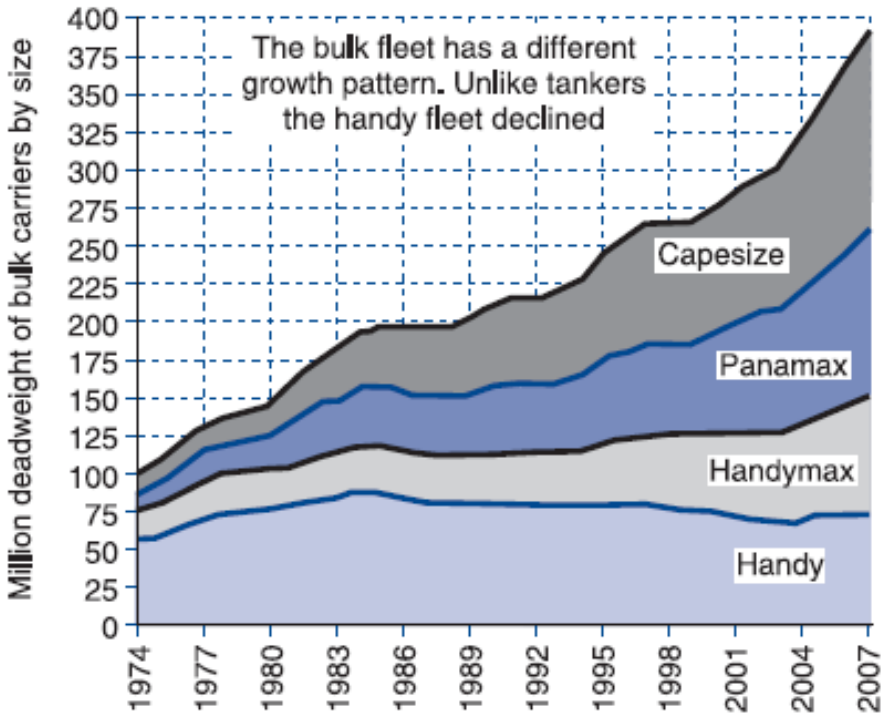


Figure 3 Dry Bulk fleet development per size (Stopford, Maritime Economics, 2009)

2.1.4 Cargoes

Dry Bulk carriers carry a wide spectrum of bulk cargoes ranging from grain, phosphate rock, iron ore and coal, to parcels of chemicals but they can be divided in two distinct categories, major bulks and minor bulks.

Major bulks include iron ore, coal and grain. Because of their volume they are considered as the driving force behind the dry bulk carrier market. They usually shipped in Panamax and Capsize vessels. On the other side minor bulks are fertilizers, steels, sugars, cement etc. In most of the cases they are shipped in smaller more versatile vessels such as Handymax and Handysize.

Iron ore as it can be seen in (Stopford, Maritime Economics, 2009) is the largest of the major bulk commodity trades and the principal raw material of the steel industry with a trade of 590 MT in 2004. The second largest is coal with imports of 665 MT in 2004 principally into Western Europe and Japan. Coal trade separates in two very different markets, ‘coking coal’ used in steel-making, and ‘thermal coal’ used to fuel power stations. The last of the major bulks grain, is an agricultural commodity, seasonal in its trade and irregular in both volume and route. Consequently its trade is more difficult to be optimized, or even plan.

The minor bulks are the most diverse sector of the bulk trades. It is a mix of commodities which generated a billion tons of cargo in 2005, carried mainly by the smaller bulk carriers. It has to be noted that minor bulks are not shipped in bulk carriers exclusively.

Table 2 Bulk cargoes fixed spot 2001-2 (Stopford, World Shipbuilding, 2012, p. 421)

Type of cargo	Number of cargoes	Tonnage of cargo (tonnes)	Average size (tonnes)
Major Bulks			
Iron ore	889	131,397,500	147,804
Coal			
Coking coal	72	3,114,500	43,257
Coal	743	81,021,000	109,046
Grain			
Oats	2	197,000	98,500
Grain	326	16,540,135	50,737
Heavy grain	104	4,639,787	44,613
Barley	15	554,000	36,933
Wheat	64	2,175,960	33,999
Corn	14	444,000	31,714
Maize	13	322,000	24,769
Agribulks			
Canola	3	110,000	36,667
Agriprods	4	69,000	17,250
Rice – bagged	7	55,250	7,893
Sugar			
Sugar – bulk	116	1,981,400	17,230
Sugar – bagged	47	518,575	11,034
Fertilizers			
Fertilizers	18	468,000	26,000
Phosphates	7	168,000	24,000
Phosphate rock	8	171,000	21,375
Urea	16	287,000	17,938
Metals & minerals			
Manganese ore	9	185,000	20,556
Concentrates	2	160,000	80,000
Pig iron	2	75,000	37,500
Cement	4	261,000	65,250
Bauxite	20	1,097,000	54,850
Petcoke	13	600,000	46,154
Coke	7	198,000	28,286
Steel products			
Scrap	16	334,000	20,875
Steel billets	4	98,600	24,650
Steel pipes	4	91,000	22,750
Grand Total	2549	247,333,707	30,119

2.1.5 Trades

It is well known that the demand for shipping services is a derived one based on the world merchandise trade. The UN trade classification system has one hundred major categories of commodities, each of them containing several sub-categories, providing an overwhelmingly detailed picture of what is a very complex international commodity trade system (Talley, 2012).

Maritime trade is dominated by three economic centers (Stopford, Maritime Economics, 2009), North America, Europe and Asia.

The Atlantic, the Pacific and the Indian oceans are the main routes to connect the three centers. Figure 6 Major Dry Bulk seaborne trades shows the main trade routes for Dry Bulk shipping, while in Figure 7 the density of the vessels route can be seen based on

AIS data from vessels in 2012 providing this way a visualization of the maritime trade routes. In Figure 4 Major iron ore exporters and ports 2005 the major ports of iron ore can be seen.

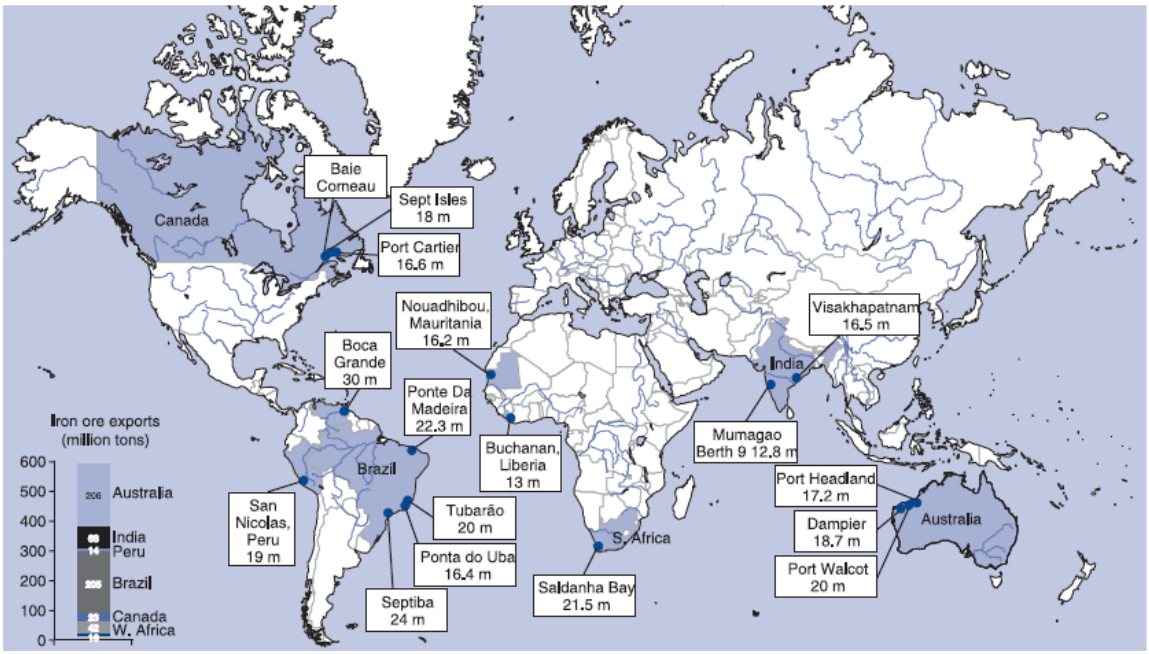


Figure 4 Major iron ore exporters and ports 2005 (Stopford, Maritime Economics, 2009)

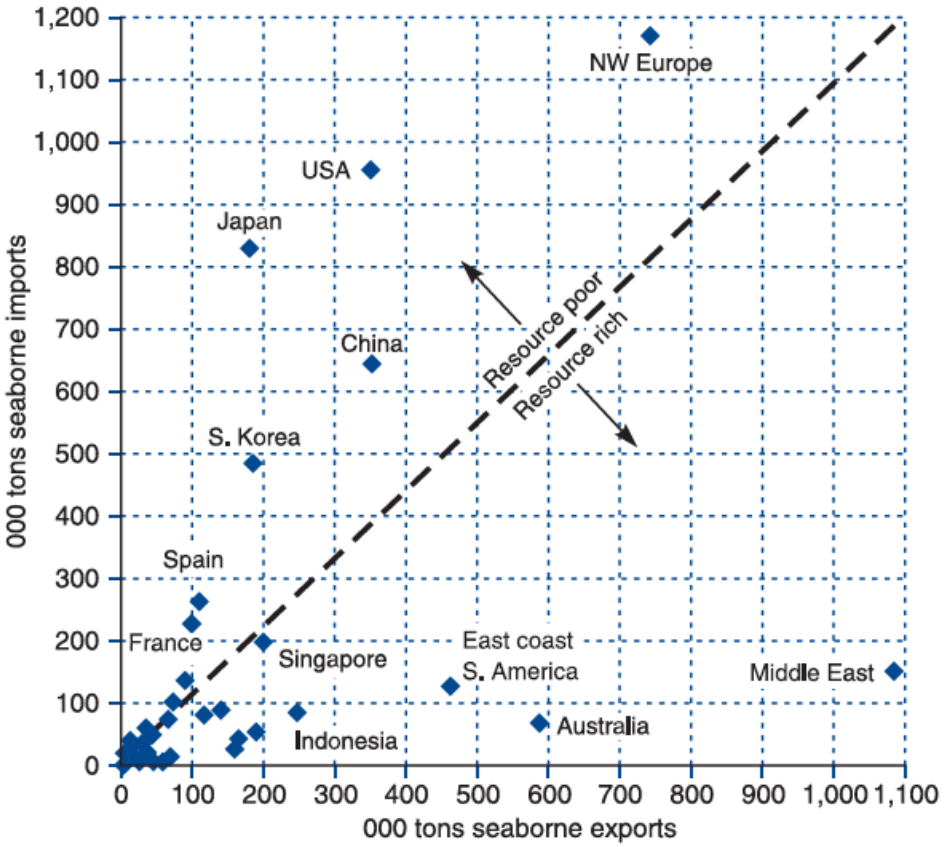


Figure 5 Seaborne imports and exports, 2004 (Stopford, Maritime Economics, 2009)

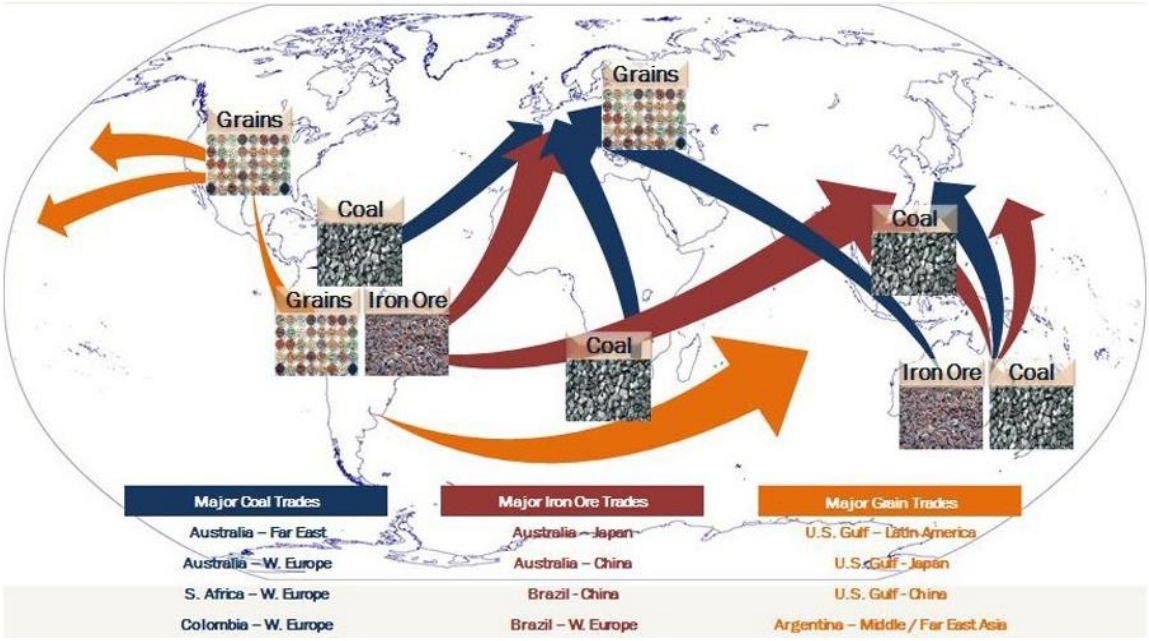


Figure 6 Major Dry Bulk seaborne trades[2]

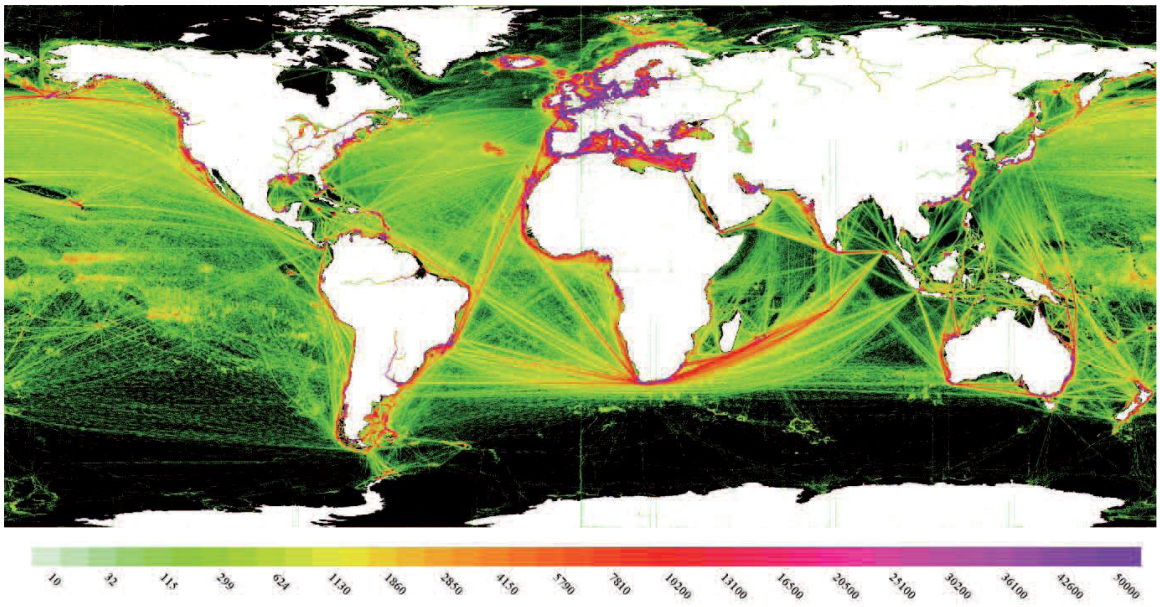


Figure 7 Geographical coverage in 2012, colored according to the intensity of messages received per unit area. This is a composite of both vessel activity and geographical coverage; intensity is not solely indicative of vessel activity (IMO, 2015)

Moreover the basic trades for maritime can be divided in different routes based on the cargo which dominates the route. So according to (Ingpen, 2016) there are 4 major trades. The maps are almost identical to the previous one but they provide some extra routes and they should be mentioned for reason of completeness.

[2] http://www.paragonship.com/dry-bulk.php

The Coal Trade with 5 different routes can be seen below

A: Canada to Europe

B: Venezuela to Europe

C: Brazil to Europe and Asia (China, Japan, Korea)

D: Richards Bay to Europe and Asia (China, Japan, Korea)

E: SE Australia to Europe and Asia (China, Japan, Korea)

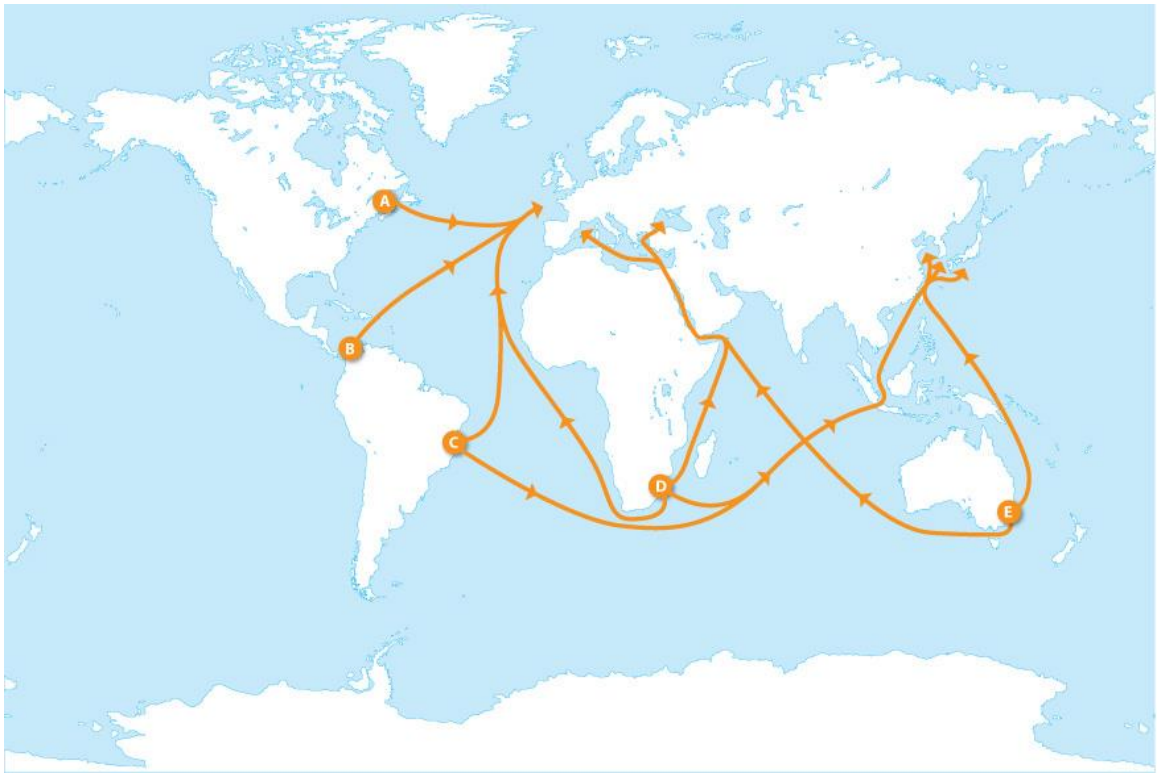


Figure 8 Major Bulk route: Coal (Ingpen, 2016)

The grain trade with 6 different major routes

A: North America (via pacific ports) to Asia

B: North America (via Great Lakes and Atlantic ports) to Europe, Africa, India (via Suez) and Far East (via Panama).

C: North America (via Mississippi ports) to Europe, Africa, India (via Suez) and Far East (via Panama)

D: La Plata to Europe, Africa, Asia and Arabian Gulf

E: Russia and Ukraine (via Black Sea) to Europe, Africa, Asia and Arabian Gulf

F: SE Australia to Asia and East Africa

Figure 9 Major Bulk trade route: Grain (Ingpen, 2016)

The secondary grain routes which are

A: China to Asia, East Africa and Europe

B: SE Asia and India to Asia, East Africa and Europe

Figure 10 Major Bulk route: Secondary grain (Ingpen, 2016)

And last the iron ore routes, which are

A: North America (via Great Lakes and Atlantic ports) to Europe

B: Brazil to Europe and Asia (China, Japan and Korea)

C: Brazil to Europe and Asia (China, Japan and Korea)

D: Saldanha Bay to Europe and Asia (China, Japan and Korea)

E: NW Australia to Europe and Asia (China, Japan and Korea)

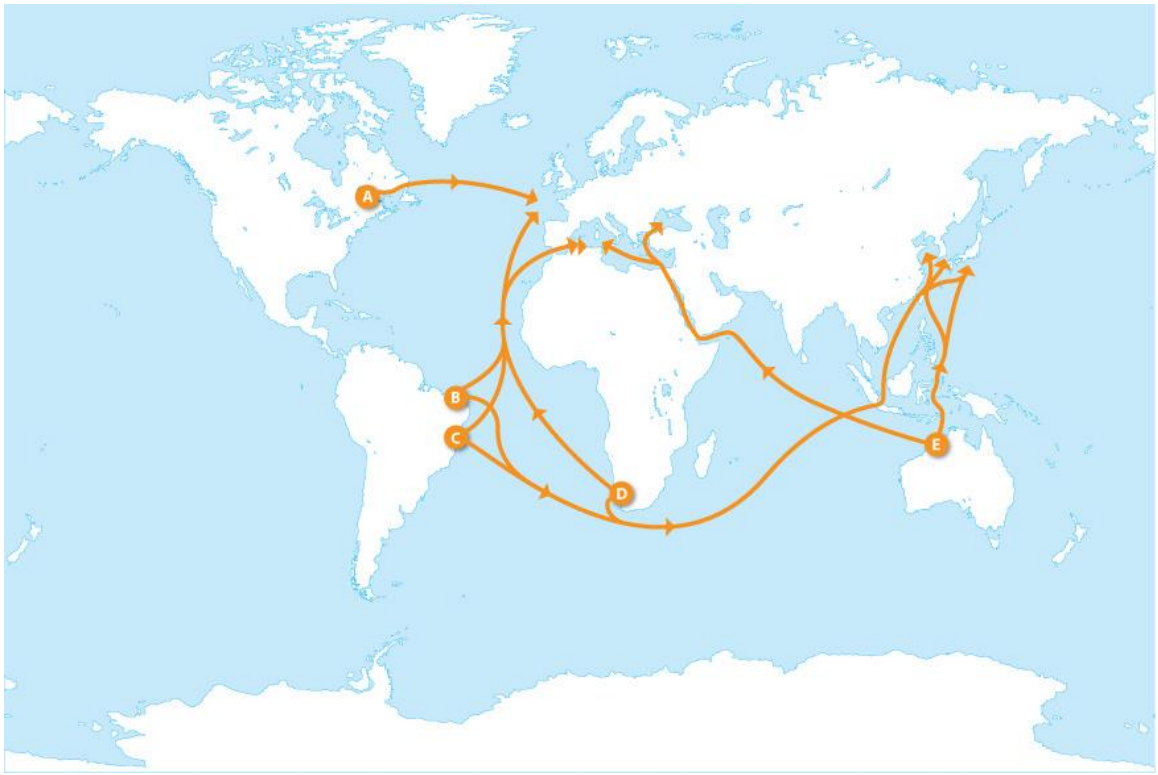


Figure 11 Major Bulk route: Iron ore (Ingpen, 2016)

2.1.6 Parcel Size Distribution

In order to link a certain type of cargo to a certain type of vessel the parcel size distribution (PSD) function is used. PSD is of big importance in shipping operation because in this way certain data for a certain type of cargo act as a signal for a certain type of vessels (and the other way around).

A 'parcel' is an individual consignment of cargo for shipment, so it is the unit used in the daily practice for sending and receiving all kinds of cargo (Stopford, Maritime Economics, 2009). Since the majority of cargoes are transferred by sea, the parcel may have all shapes and sizes and for every cargo is determined by its economic characteristic.

The three factors which effect the PSD are the stock levels held by users, the water depth at the loading and discharging terminals and the economies of scale by using a bigger vessel.

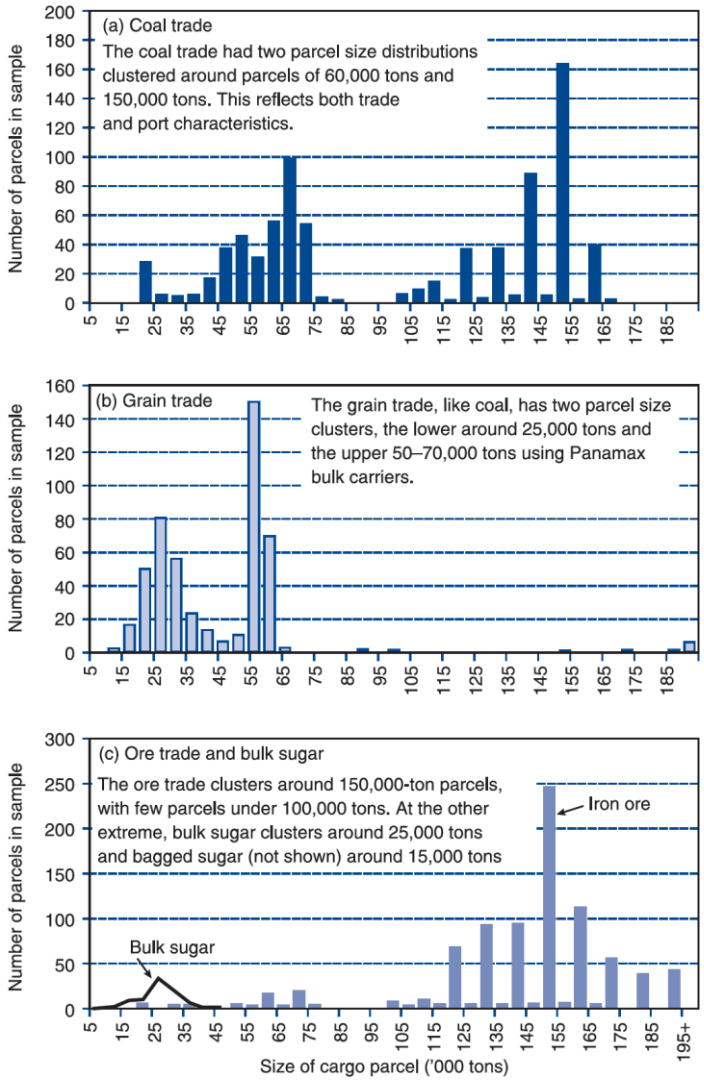


Figure 12 Parcel size distribution for coal, grain, ore and bulk sugar (Stopford, 2009)

2.2 ECONOMIC CYCLES

2.2.1 The components of economic cycles

Cycles are not unique to shipping, they occur in many industries, almost all of them. Economists analyzed these cycles deeply, and found that they often have several components which could be separated statistically using a technique known as 'decomposition' (Nerlove, Grether, & Carvalho, 1995). Cycles are not of only one nature. There are different cycles which last different periods and have different reason for occurring. Cournot, a French economist, thought that 'it is necessary to recognize the *secular* variations which are independent of the *periodic* variations'. (Cournot, 1927). In other words, we should distinguish the long-term trend from the short term cycle as it is shown in Figure 13 where the long-term trend lasts for 60 years and the second component the *short-term cycle*, sometimes referred to as the 'business cycle' lasts from 5 to 10 years. Finally, the regular fluctuations within the year are called seasonal cycles.

Business cycle is the one that corresponds more closely to most people's notion of a shipping cycle according to (Stopford, Maritime Economics, 2009). Despite being termed cycles, these fluctuations in economic activity can prove really unpredictable and may be influenced from a wide variety of factors social, economic, political, and many others.

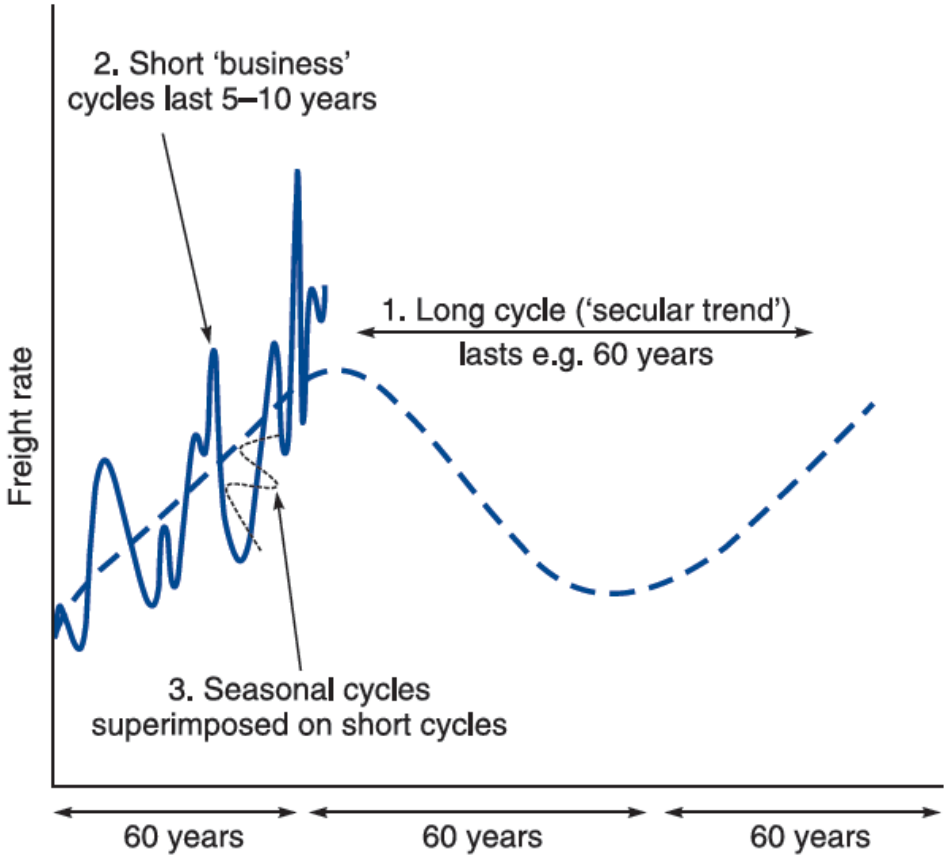


Figure 13 Seasonal, short and long cyclical components (Stopford, Maritime Economics, 2009)

2.2.2 Long shipping cycles (the 'secular trend')

The long-cycle theory of the world economy was developed by the Russian economist, Nikolai Kondratieff in his book *The Major Economic Cycles* (1925). These long-term cycles are driven by technical, economic or regional change, which makes them of great importance and they should be mentioned, even if it is more difficult to define them precisely.

This cycle's main characteristics are its longevity, serenity and unobtrusiveness. Its period ranges from forty to sixty years and the cycles consist of alternating intervals between high sectoral growth and intervals of relatively slow growth based on (Korotayev & Tsirel, 2010)

2.2.3 Short cycles

The first mention of short economic cycles goes back to the early nineteenth century by Jean Charles Léonard de Sismondi. Later observers which were investigating crises in the UK economy came to the conclusion that these 'crises' formed part of a wavelike mechanism and they started to refer to them as cycles (Stopford, Maritime Economics, 2009).

These cycles can be easily identified and also they can be analyzed in stages. The nineteenth-century banker, Lord Overstone, observed that 'the state of trade revolves apparently in an established cycle of quiescence, improvement, prosperity, excitement, overtrading, convulsion, pressure, stagnation and distress' (Schumpeter, 1954). These stages' theory is still valid and used in modern shipping cycles where the short cycle has four main stages: a market trough (stage 1) which is followed by a recovery (stage 2), leading to a market peak (stage 3), followed by a collapse (stage 4).

Of course this periodicity theory does not require cycles to be of equal length neither to be of equal peak heights.

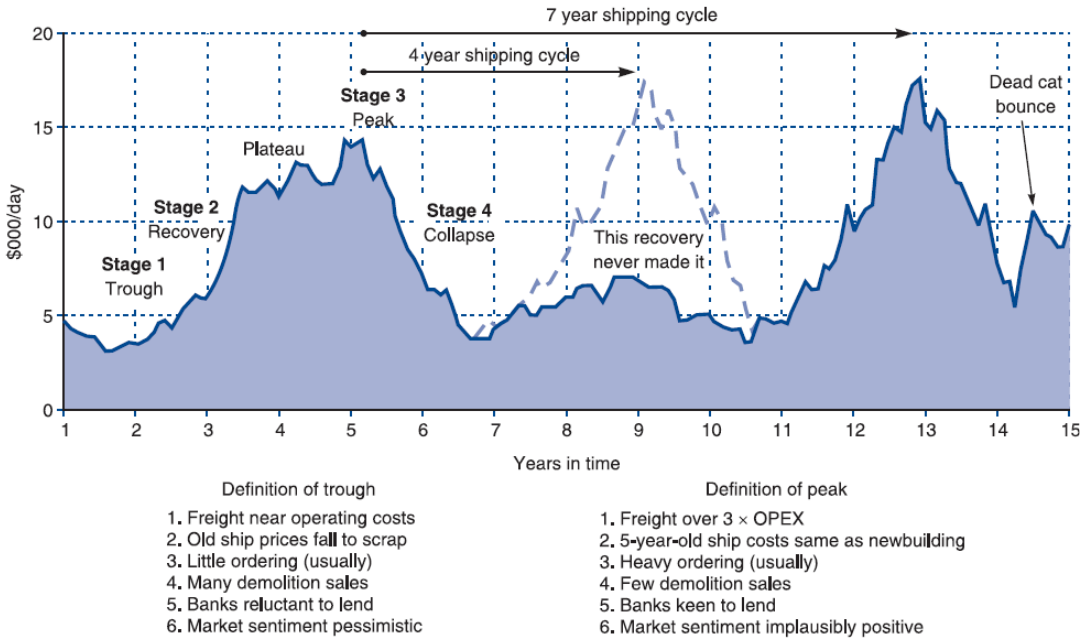


Figure 14 Stages in a typical dry cargo shipping market cycle (Stopford, World Shipbuilding, 2012)

2.2.4 Seasonal cycles

Finally, the seasonal cycles are well-known in many industries. Shipping is not an exception where those cycles can be detected by the fluctuations in freight rates which occur within the year, usually at specific seasons, in response to seasonal patterns of demand for sea transport.

The most notable example, comes from the agricultural trades, where a cycle in freight rates for vessels carrying grain, caused by the timing of harvests.

2.3 FOUR SHIPPING MARKETS

Shipping market, where the sea transport services are provided, is formed by four markets that interact to each other. These markets are closely related but there is no formal structure. This is happening because the same people are trading in all markets but the markets are trading different commodities and not all players are in the same situation at a given time. Actually, this is the reason for the best commercial opportunities which often arise when the markets behave inconsistently according to (Stopford, Maritime Economics, 2009). Below each one of the markets are explained.

2.3.1 Freight

The freight market is the adjustment mechanism linking supply and demand. Shipowners and shippers negotiate to establish a freight rate which reflects the balance of vessels (supply) and cargoes (demand) available in the market. This is the ultimate regulator which the market uses to motivate decision-makers to adjust capacity in the short term, and to find ways of reducing their costs and improving their services in the long term.

Nowadays Baltic Shipping Exchange is the single international freight market with separate sections for different vessels. It is a place where sea transport is bought and sold. Everything started at the Virginia and Baltick Coffee House in Threadneedle Street in 1744 which later became the Baltic Shipping Exchange. Baltic Shipping Exchange first started to trade as a commodity and shipping exchange in the mid-19th century, with leading founding shareholders being Stephen Ralli and Michael Rodocanachi, whose families were from the Chian Diaspora[3] according to (Colli, 2015).

The freight market can be divided in different sectors based on the below criteria (Gkiziakis, Papadopoulos, & Plomaritou, 2010):

- Vessel Types
- Cargo type and nature
- Geographical distribution
- Chartering time duration (spot market or long time chartering)
- Chartering type (voyage chartering, bare boat etc.)

The supply function for an individual vessel, is a J-shaped curve describing the amount of transport the owner provides at each level of freight rates. Provided the market is perfectly competitive, the shipowner maximizes his profit by operating his vessel at the speed at which marginal cost equals the freight rate. Having this in mind the equation for optimum speed can be defined

$$S = \sqrt{\frac{R}{3pkd}} \quad [1]$$

Where:

[3] http://www.christopherlong.co.uk/migrations/index.html

S is the optimum speed in nautical miles per day, R the voyage freight rate, p the price of fuel, k the vessel's fuel constant, and d equals the distance in nautical miles (Evans & Marlow, Quantitative Methods in Maritime Economics, 1990). With equation [1] in mind we can compute the R voyage freight rate (freight analogy) of the bulker fleet if we know the operational speed, the fuel price and the distance.

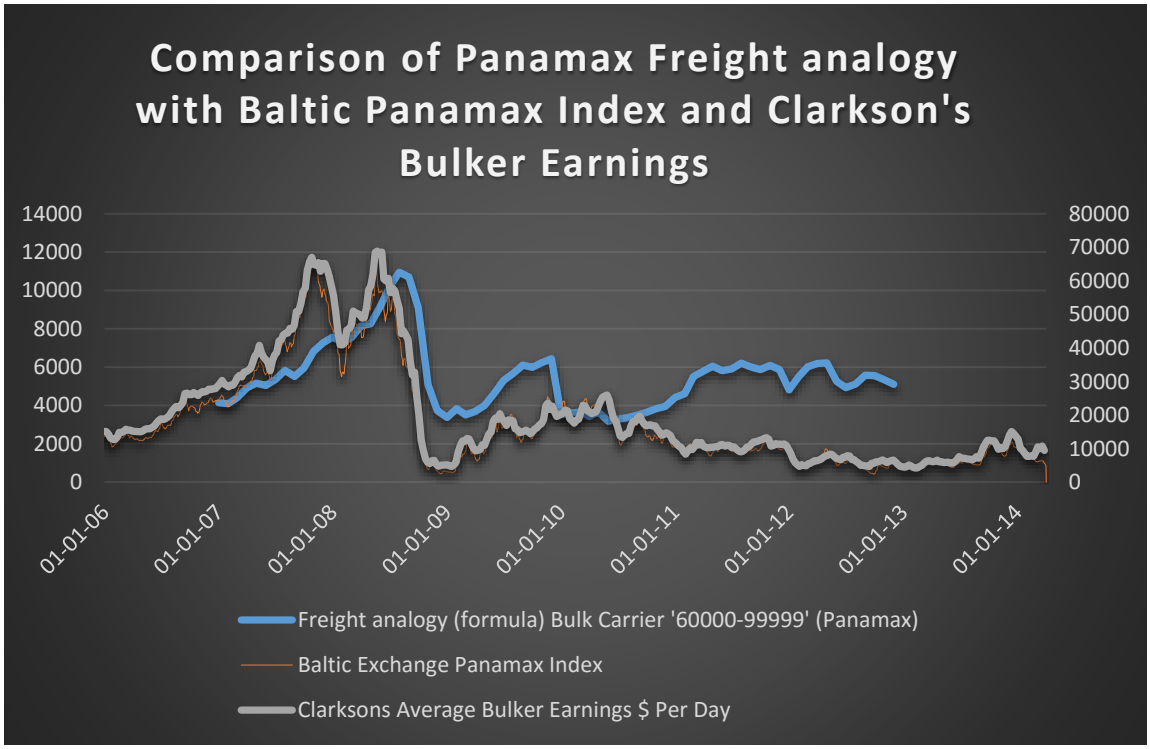


Figure 15 Comparison of Panamax Freight analogy with Baltic Panamax Index and Clarkson's Bulker Earnings by Clarkson's Db and IMO study data

As it is obvious the optimum speed depends on the price of fuel, the efficiency of the vessel and the length of the voyage. But speed is not the only way supply responds to freight rates and in reality the supply function is more complex than the simple speed–freight rates relationship.

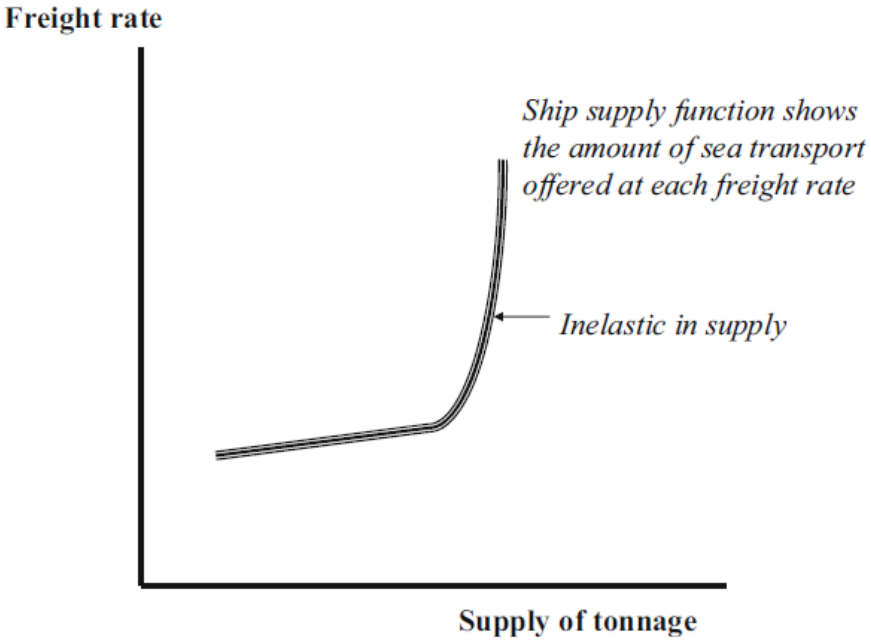


Figure 16 Supply of sea transport (Evans, The elasticity of supply of sea transport., 1988)

Typically the freight rate is being modeled by freight rate indicators and the most typical is Baltic Dry Index (BDI). There are different indicators for every size of vessel. Each indicator is the average of shipping routes measured on a timecharter basis. The routes are meant to be representative for the overall market. These rate assessments are then weighted together to create both the overall BDI and the size specific Supramax, Panamax, and Capesize indices.

Lastly, the freight derivatives market should be mentioned. This market allows charterers and shipowners to hedge their freight risk or speculate by making forward freight agreements (FFAs) which are financial contracts settled against the value of a base index on the date specified in the agreement. (Stopford, Maritime Economics, 2009). Different derivatives markets specialize in different types of risk (e.g. currency, interest rates, commodities, oil prices etc.). The freight derivatives market is used to arrange contracts settled against an agreed future value of a freight market index. This works because cargo owners and shipowners face opposite risks. By contracting to compensate each other when rates move away from an agreed settlement rate shippers and owners can remove this volatility risk. Risk management is extremely important in bulk shipping industry which characterized as highly volatile intensive, cyclical and exposed to international environment. The spot and derivatives markets are correlated, so a comprehensive and detailed survey of the role and the impact of freight derivatives on the spot market is helpful in explaining price fluctuations and in determine which strategies companies should adopt in order to minimize the risk of operations. But as (Gratsos, 2010) pinpoints FFAs represent the perception of anticipated market levels by market practitioners/speculators and not the actual state and those perception may and may not influence others.

2.3.2 NewBuildings

The newbuilding market is trading vessels that are not yet built. Actually that is exactly the largest difference between other markets (their product does not exist yet). It is a heavy engineering business, selling a large and sophisticated product built mainly in facilities located in the industrialized countries of Japan, Europe, South Korea and now China.

Once a vessel is ordered, it will take three to four years to get ready for its sea trials. By this time the entire market conditions may have been changed. It is therefore important to have good prediction of the future before ordering (Stopford, Maritime Economics, 2009). Also that is why shipyards prefer series orders. Vessels of the same design, which often is the shipyards standard design. Those vessel's building procedure is known, with no risk for innovation or complexity, something that if not avoid could increase the cost, in the building process.

Shipbuilding prices (Stopford, Maritime Economics, 2009), like second-hand prices, are determined by supply and demand. But newbuild vessels are not necessarily more expensive than similar second-hand. This is because of the time lag, the time it takes for the vessel to be available and the current fluctuations of offer and demand. As a result shipbuilding prices are just as volatile as second-hand prices and are closely correlated with them. The market mechanism uses the volatility to balance the supply and demand for vessels, whilst at the same time drawing in new low-cost shipbuilders and driving out high-cost capacity.

On the demand side, the key factors are freight rates, the price of modern second-hand vessels, financial liquidity of buyers, the availability of credit and, most importantly, expectations. From the shipyard supply viewpoint the key issues are production costs, the number of berths available and the size of the orderbook.

The supply and demand balancing mechanism in this market is basically unstable due to two characteristics

- the time lag from ordering and delivery of a vessel
- the inflexibility of modern shipyard capacity

According to (Volk, 1994) 'Shipbuilding is characterized by heavy fluctuations of demand over the short-term and by high inertia of supply. This fact leads to brief phases of prosperity and long phases of depression.'

Because the new vessels do not arrive immediately, they are not a precise substitute. Only when second-hand prices increase newbuildings start to look a better deal. Since owners are competing for limited second-hand vessels or newbuilding berths, prices start to rise and vice versa.

Finally the compensated gross ton (CGT) should be mentioned. It is a measure of shipbuilding output which takes account of the work content of the vessel since measurements based on deadweight or gross registered tonnage, were unreliable. A set of standard CGT conversion factors were agreed in 1984, but in 2005 they were replaced by a formula which is used to calculate the compensated gross tonnage of the vessel from the gross tonnage:

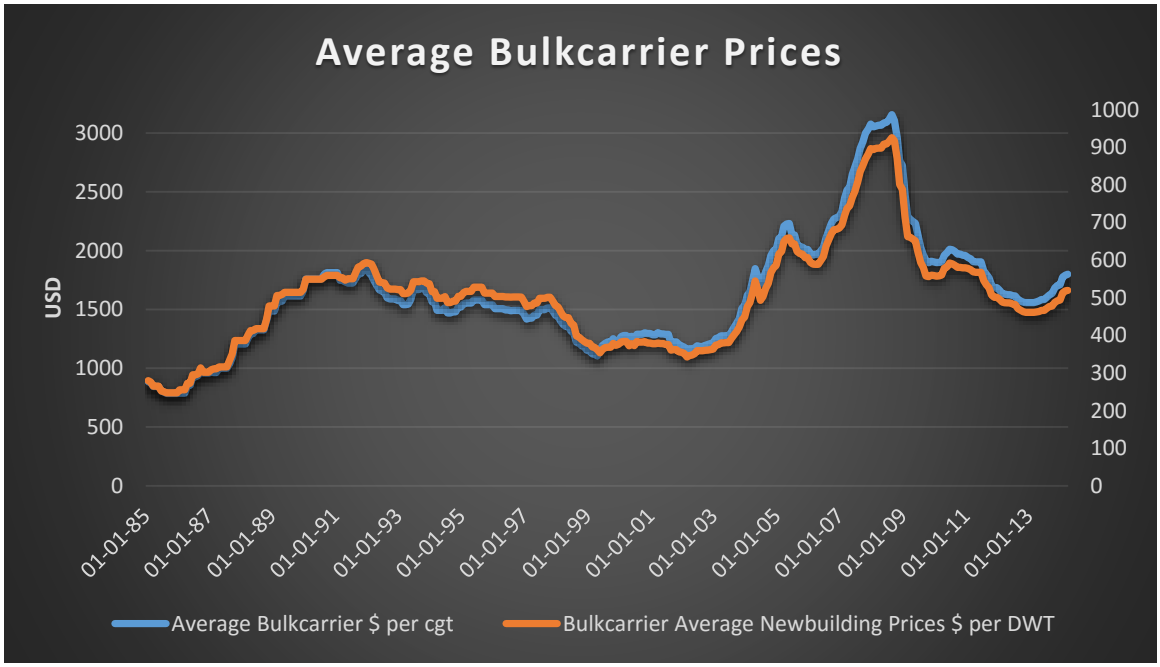


Figure 17 Comparison of Average Bulkcarrier Prices based on CGT and DWT Clarkson's DB

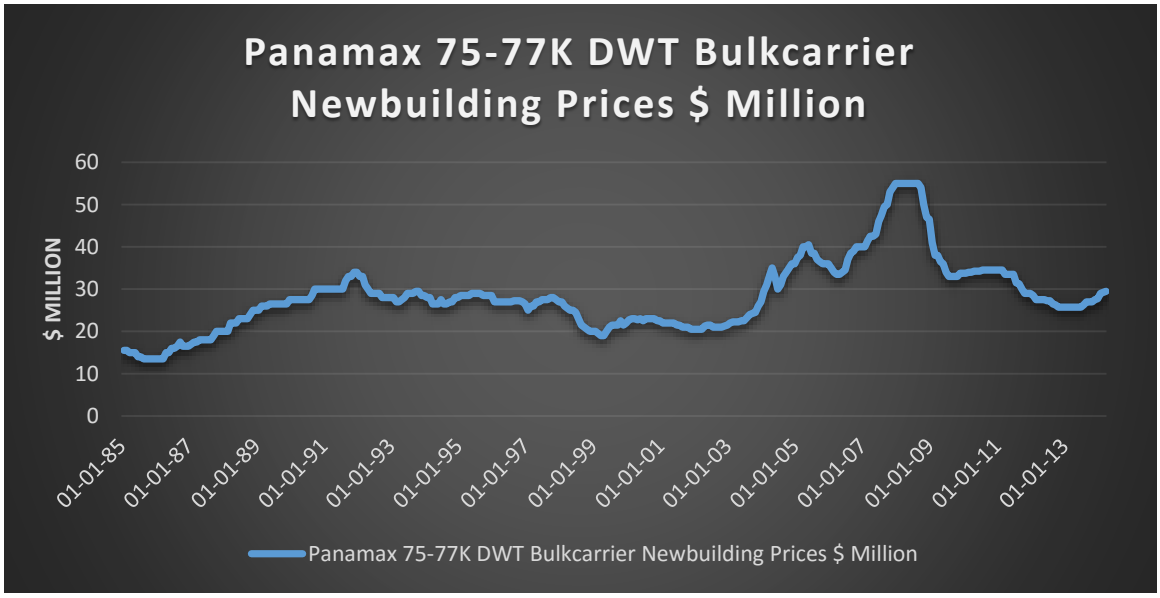


Figure 18 Panamax 75-77K DWT Bulkcarrier Newbuilding Prices $ Million Clarkson's DB

2.3.3 Sale and Purchase

The same players as in the freight market take part in this Sales and Purchase as well.

The most interesting concept of this market, well pictured by (Stopford, Maritime Economics, 2009), is that "ships are traded like sacks of potatoes at a country market". There are many larger commodity markets, but few share the drama of vessel sale and purchase.

Most of the sales and purchases will be carried out by a shipbroker. Typically the vessel will be sold with prompt delivery, after an inspection, for cash, free of any charters, mortgages or maritime liens. The reasons for selling vary from age replacing policy, trade strategy change, lower expectations in a certain trade pattern or even a 'distress sale' in which the owner sells the vessel to cover an immediate cost. In the same way the purchase reasons also may have various reasons. Actually the 'Asset play' profits earned from well-timed buying and selling activity are the major source of income for shipping investors which most of the times surpass the income from operation.

Prices are determined by negotiation between a buyer and a seller. The sale and purchase market thrives on price volatility (Stopford, Maritime Economics, 2009, p. 202) based on the supply and demand of vessels in the market at the certain time. The prices influenced by several factors. Freight rates are the primary influence on vessels prices, making the prices to follow the cycle of the freights. Actually this correlation provides some guidance on valuing vessels using the gross earnings method but still there are no rules about how low or how high prices can go during these cycles. Another major parameter is inflation through time. A third parameter is the price of a similar vessel type. Vessels with "neighboring" sizes influencing the price of one each other since they can be considered as close substitutes. The last and in some ways most important influence on second-hand prices is expectations. The fluctuation of the market are multiplied by the behavior of buyers and sellers.

There are several options to evaluate the price of a vessel. An appropriate measure would be the shipbuilding price, since this determines the replacement cost of the vessel. Another one may be the current annual earnings, based on the one-year time-charter rate. In a good period, market values a five-year old vessel at about four to six times its current annual earnings.

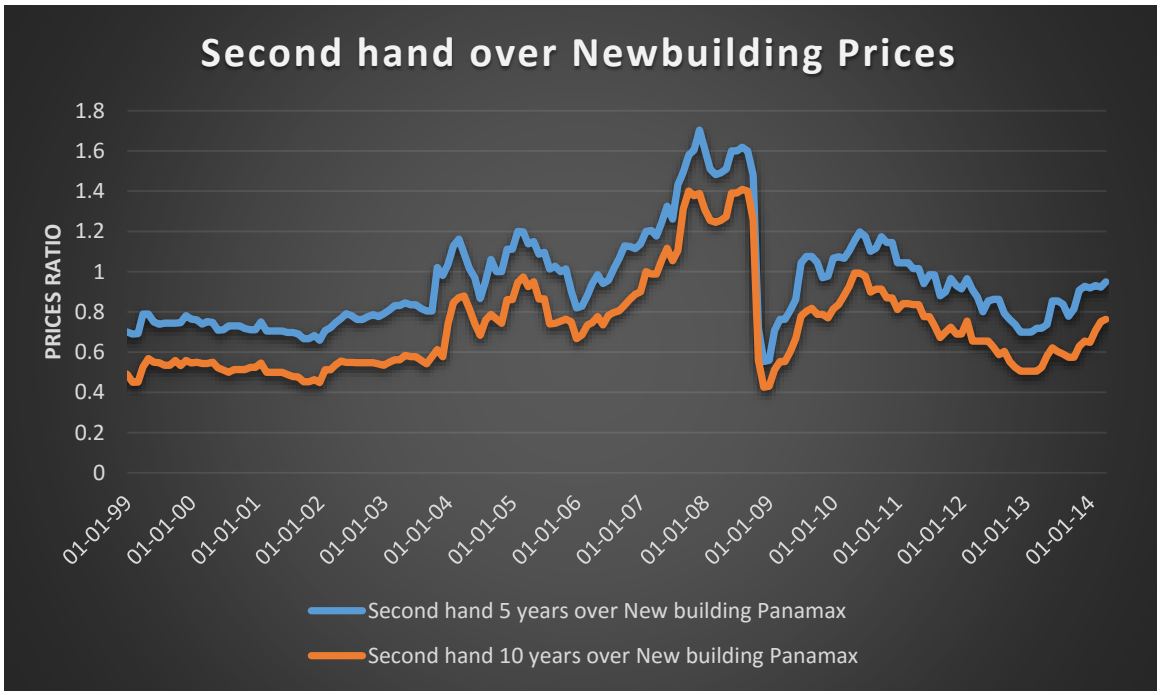


Figure 19 Second Hand over Newbuilding Panamax prices Clarckson's DB

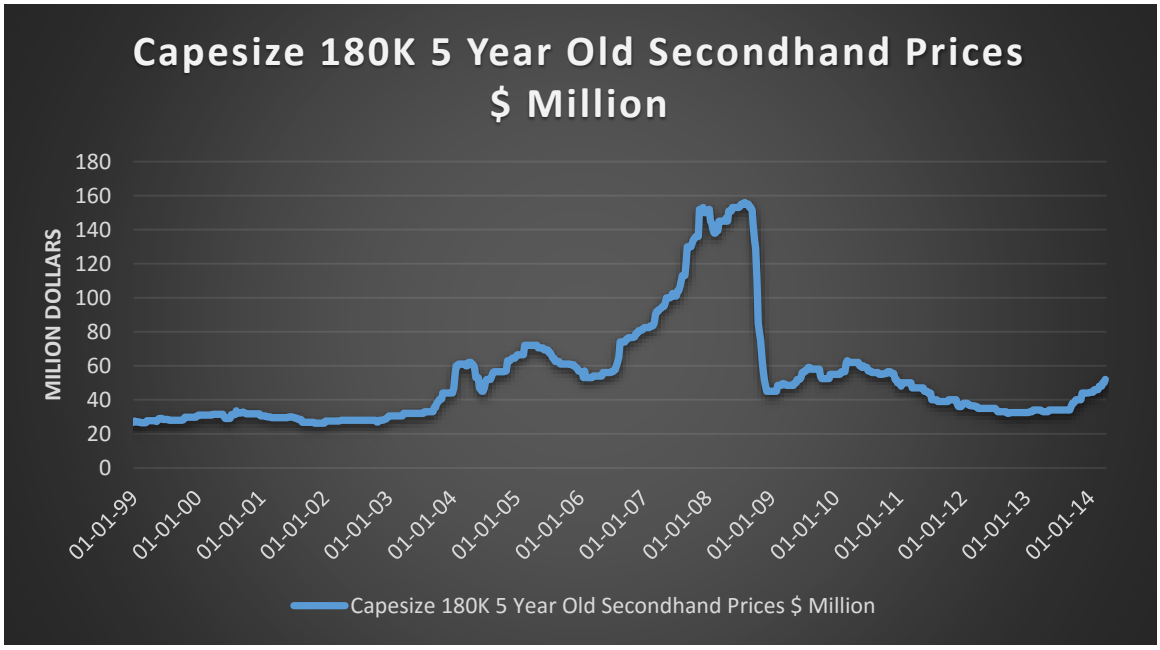


Figure 20 Capesize 180K 5 Year Old Secondhand Prices Clarckson's DB

2.3.4 Demolitions and losses

Demolition is the fourth market and the less prestigious one. Still demolition plays an essential role in shipping industry in keeping the balance between supply and demand in tonnage.

The market is similar with the second-hand market, but here the customers are the scrap yards, which dismantle ships (Stopford, Maritime Economics, 2009). Most of them are located in the Far East (e.g. India, Pakistan, Bangladesh and China) and is one of the world's most labor-intensive industries. Nowadays there is a huge effort to organize the industry in a more environmental friendly structure often referred to as the recycling industry.

The demolition price for a vessel is heavily influenced in scrap metal value but also varies from vessel to vessel, depending on its suitability for scrapping. Thus prices can be very volatile, fluctuating from a trough of $100/dwt in the 1980s to more than $400/dwt in 2007. Usually scrapped tonnage is far less that the newbuilded on which comes into the market. The only exception was 1982 – 1986 period where scrapping had overtaken deliveries for the first time since the Second World War as it is shown in Figure 21.

It is really difficult to predict the average "age" of scrapping for a vessel since it is an extremely complex matter. The reason is that scrapping depends on the balance of a number of factors that can interact in many different ways. The main ones are

- age
- technical obsolescence
- scrap prices
- current earnings

- market expectations

Naturally the oldest vessels will be forced out by the increased operational cost, maintenance cost and the technical disadvantages. But prospect of profitable employment may extend the life of a vessel. Actually scrapping will occur only when the industry's reserves of cash and optimism have been run down. As an alternative to ship breaking, vessels may be sunk to create artificial reefs after being removed of hazardous materials

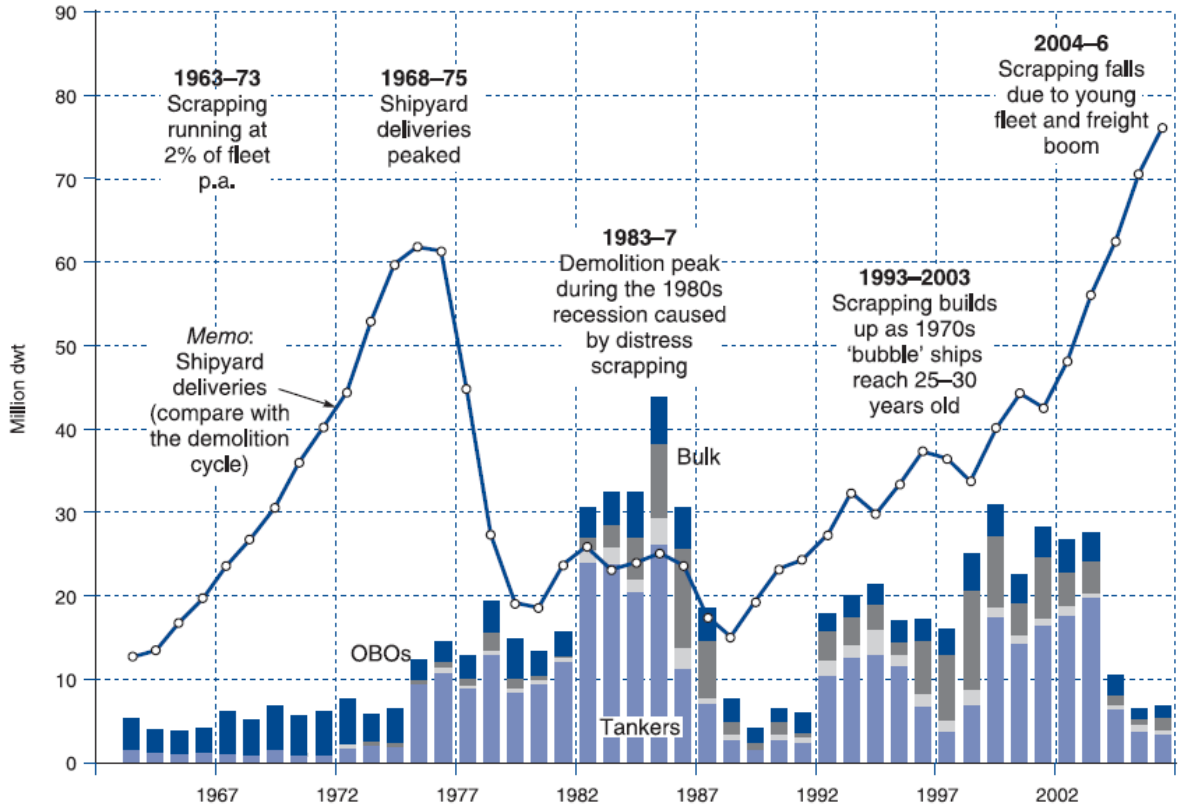


Figure 21 Word vessel demolition sales by type, 1963-2006 (Stopford, Maritime Economics, 2009)

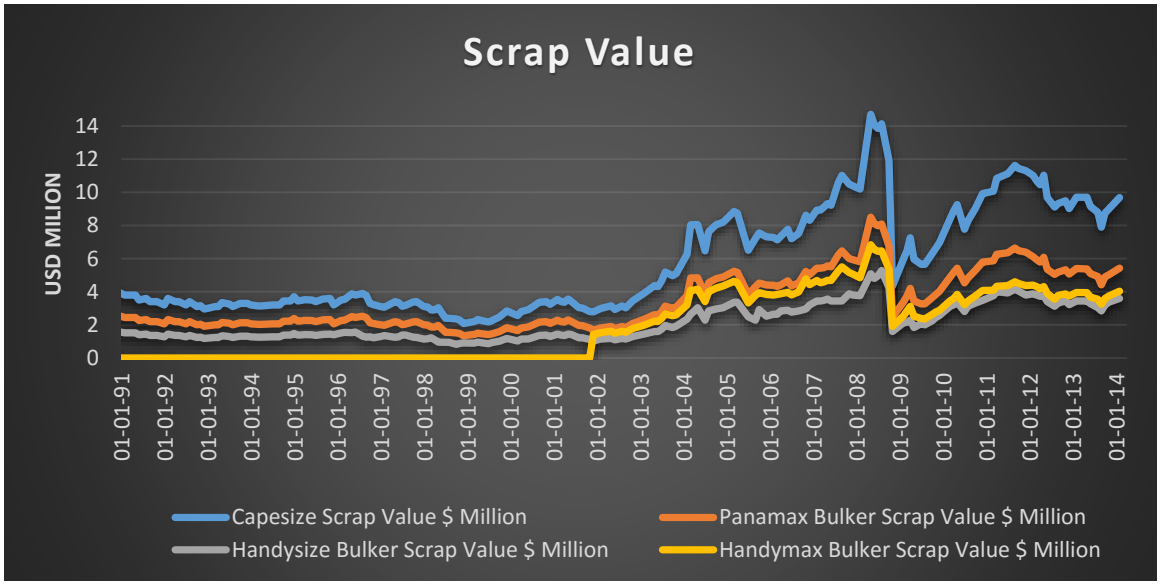


Figure 22 Scrap Value per size of vessel Clarckson's DB

2.4 MARITIME MARKET MODEL

The maritime economy is enormously complex. The demand is so unstable and volatile that can actually fluctuate up to 10% in the same year (Gkiziakis, Papadopoulos, & Plomaritou, 2010) while the supply cannot respond fast enough to those fluctuates. The need for a model is essential. The model should be accurate, reliable and as simply as possible.

In a model there is always a compromise between the accuracy and the simplicity of it. The known proposed model for maritime market is divided in two sectors, supply and demand. Each of the those two sectors are influenced by five major parameters as it is shown in (Stopford, Maritime Economics, 2009)

As far as the demand for sea transport is concerned the five variables are the world economy, seaborne commodity trades, average haul, random shocks and transport costs. On the other side, the supply of shipping services is influenced by the world fleet, fleet productivity, shipbuilding deliveries, scrapping and freight revenues.

One more parameter should be added in the supply part according to (Gkiziakis, Papadopoulos, & Plomaritou, 2010). The "decision makers' group which it is consists of ship owners, charterers, maritime banks and maritime authorities. But the psychology of the decision makers is difficult to foresee and that is the reason for not being part of the general model.

The way in which these variables fit together into a simple model of the shipping market is shown in Figure 23.

Table 3 Variables in the shipping market model

Demand	Supply
1. The world economy	1. World fleet
2. Seaborne commodity trades	2. Fleet productivity
3. Average haul	3. Shipbuilding production
4. Random shocks	4. Scrapping and losses
5. Transport costs	5. Freight revenue

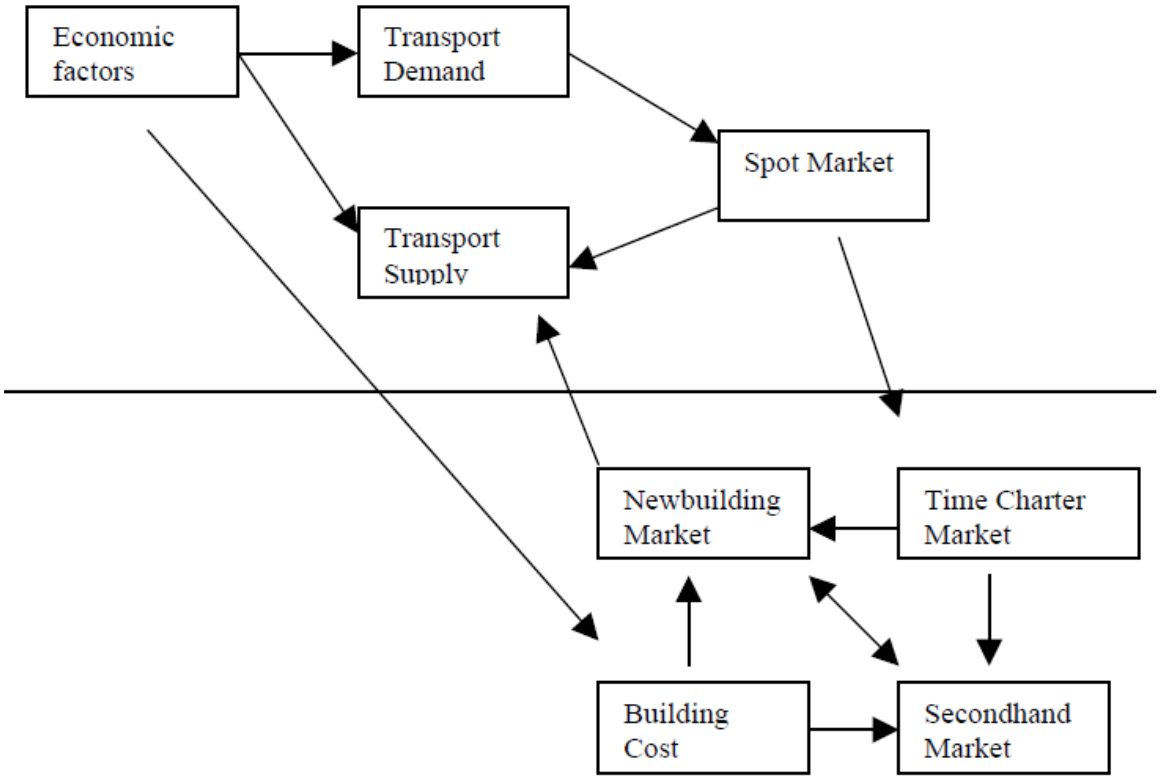


Figure 23 Structure of the maritime market model (Veenstra, 1999)

2.5 ECONOMIC FACTORS

As economic is considered a set of fundamental information that affects a business or an investment's value. They have a huge impact on the market and knowing how to interpret and analyze them is important for all investors.

There are several economic factors that change with the business cycle. They can be categorized by the time of change as[4]

1. Leading Indicators, when they change before an event. Leading indicators are used to predict changes in the economy, but are not always accurate.
2. Lagging Indicators when they change after an event. Lagging indicators confirm long-term trends, but do not predict them.
3. Coincident Indicators, when they vary directly and simultaneously with the event, thus indicating the current state of the explained parameter.

Below the economic factors which are considered to affect the shipping markets will be explained along with some maritime factors.

2.5.1 Gross Domestic Product (GDP)

The most common parameter for the size of the economy of a country is GDP, and as it is obvious bigger economies are likely to generate more trade. Researchers have try to assess this relation. According to (Kenwood, 1971) at normal times there is a ratio of about 1.5 to 2 between the development of the GDP and the international trade. Also (Stopford, Maritime Economics, 2009) examine the relationship between seaborne imports and GDP ending up to a linear model (Figure 24).

Below appear the reasons for explaining the correlation of trade and GDP

1. A larger economy has greater needs in terms of raw materials and manufactured goods which are shipped by sea
2. Mature economies probably consumed their own resources of raw materials, leading to the need for imports.
3. A rich country can afford to purchase imports and has a big production to export in return.

[4] http://www.investopedia.com/exam-guide/finra-series-6/economic-factors/economic-indicators.asp

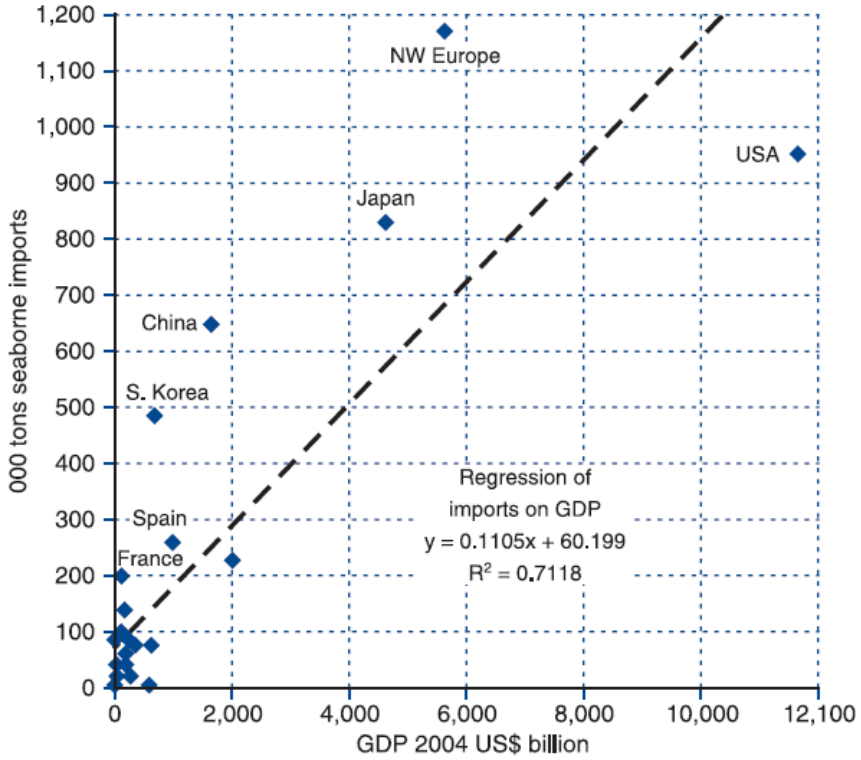


Figure 24 Seaborne imports and GDP, 2004 (Stopford, Maritime Economics, 2009)

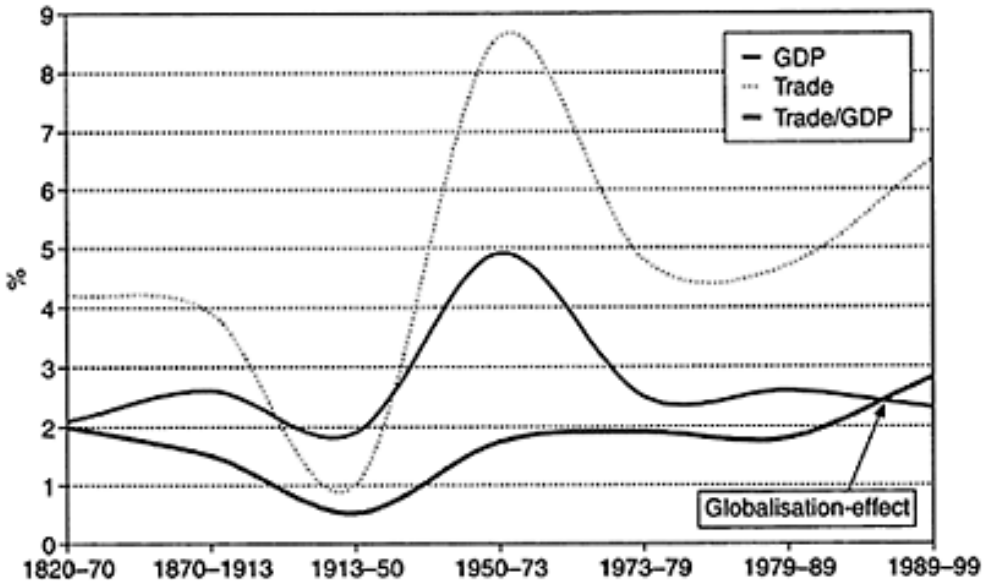


Figure 25 Yearly growth (%) and relationship between GDP and Trade Industrialized World (Leggate, McConville, & Morvillo, 2004)

2.5.2 Population

Population is considered as a parameter for the seaborne trade from the nineteenth-century. The idea is that the more people the greater the trading potential. This idea is still valid today, to some researchers. According to (Elgohary, Seddiek, & Salem, 2015)

the increase in the world population leads to subsequent increase in the development of world economy and sea-borne trade.

On the other hand, a statistical analysis of the relationship between population and trade shows virtually no correlation (correlation coefficient is 0.2) (Stopford, Maritime Economics, 2009).

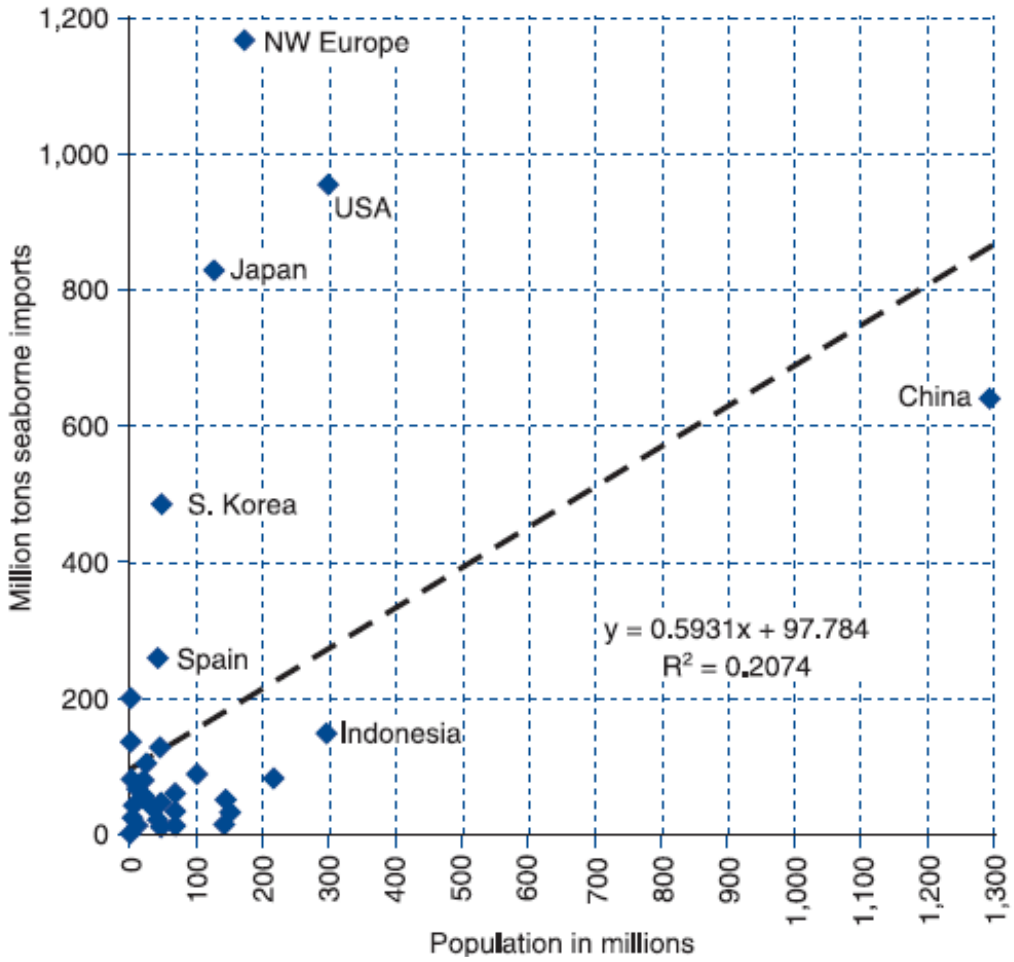


Figure 26 Seaborne trade and population, 2004 (Stopford, Maritime Economics, 2009)

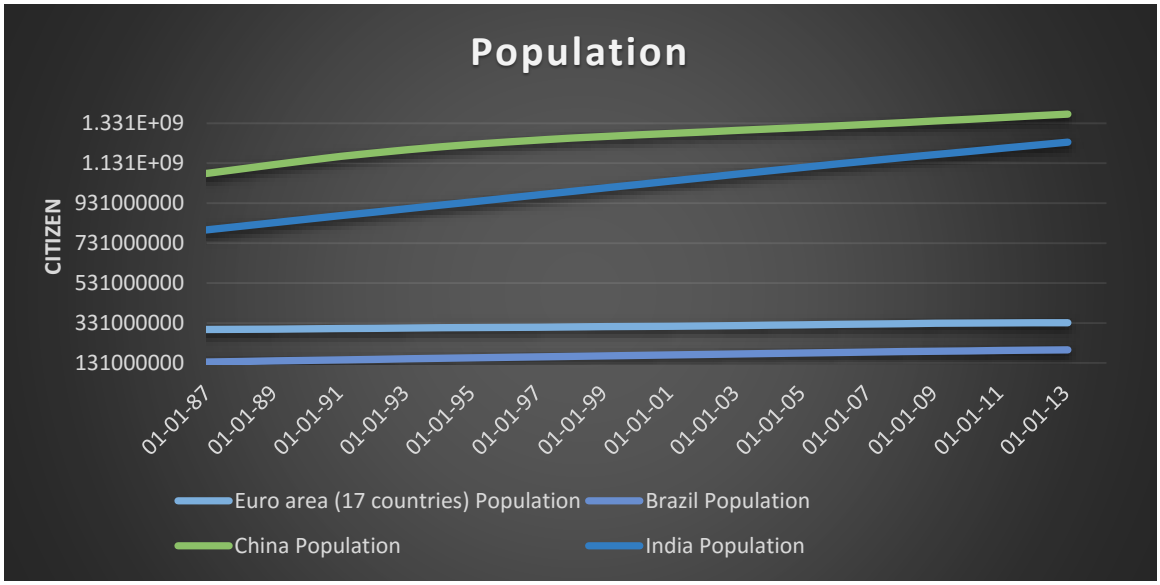


Figure 27 Population increase for OECD database

2.5.3 Current Account

In economics, a country's current account is one of the two components of its balance of payments and is one of two major measures of a country's foreign trade. It consists of the balance of trade, net primary income or factor income and net cash transfers, which have taken place over a given period of time. It could be considered as the difference between a nation’s savings and its investment. The current account is an important indicator about an economy's health.

A current account surplus indicates that the value of a country's net foreign assets (i.e. assets less liabilities) grew over the period in question, and a current account deficit indicates that it shrank. Both government and private payments are included in the calculation. It is called the current account because goods and services are generally consumed in the current period. (Herman & Joshua, 2003)

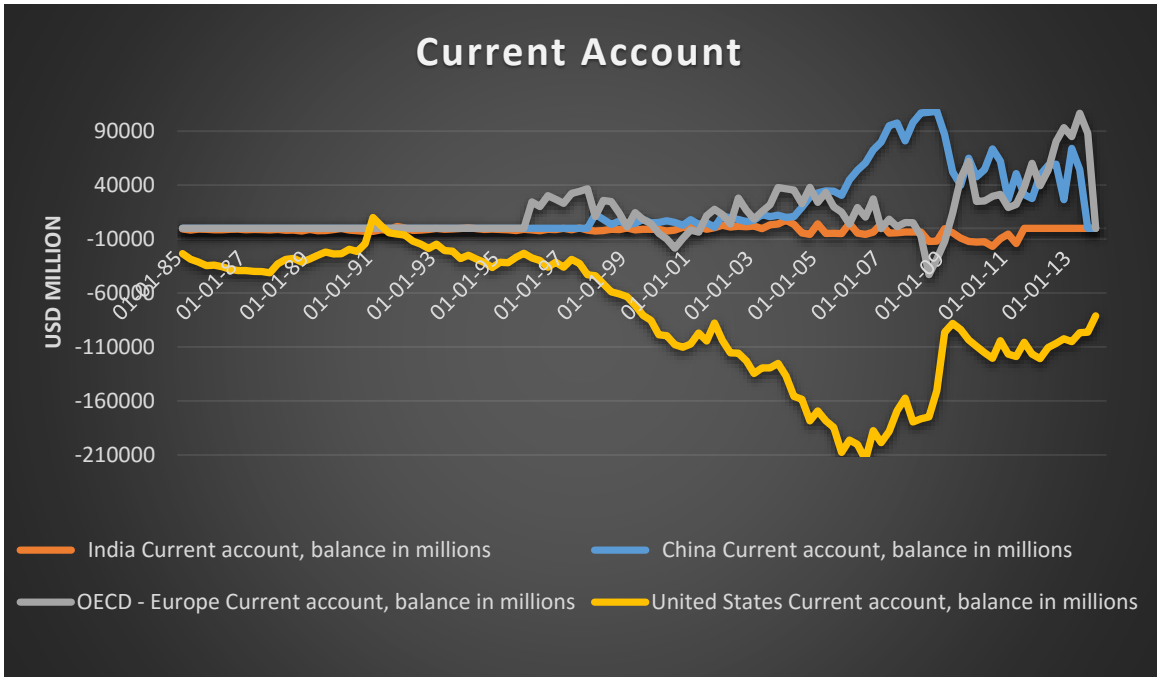


Figure 28 Current Account from OECD database

2.5.4 London Interbank Offered Rate (LIBOR)

The London Interbank Offered Rate (LIBOR) is the average of interest rates estimated by each of the leading banks in London that it would be charged were it to borrow from other banks (ICE Benchmark Administration, 2016). It was formerly known as BBA Libor (for British Bankers' Association Libor or the trademark bbalibor) before the responsibility for the administration was transferred to Intercontinental Exchange and is based on five currencies: U.S. dollar (USD), Euro (EUR), pound sterling (GBP), Japanese yen (JPY) and Swiss franc (CHF), and serves seven different maturities. The Libor is widely used as a reference rate for many financial instruments in both financial markets and commercial fields.

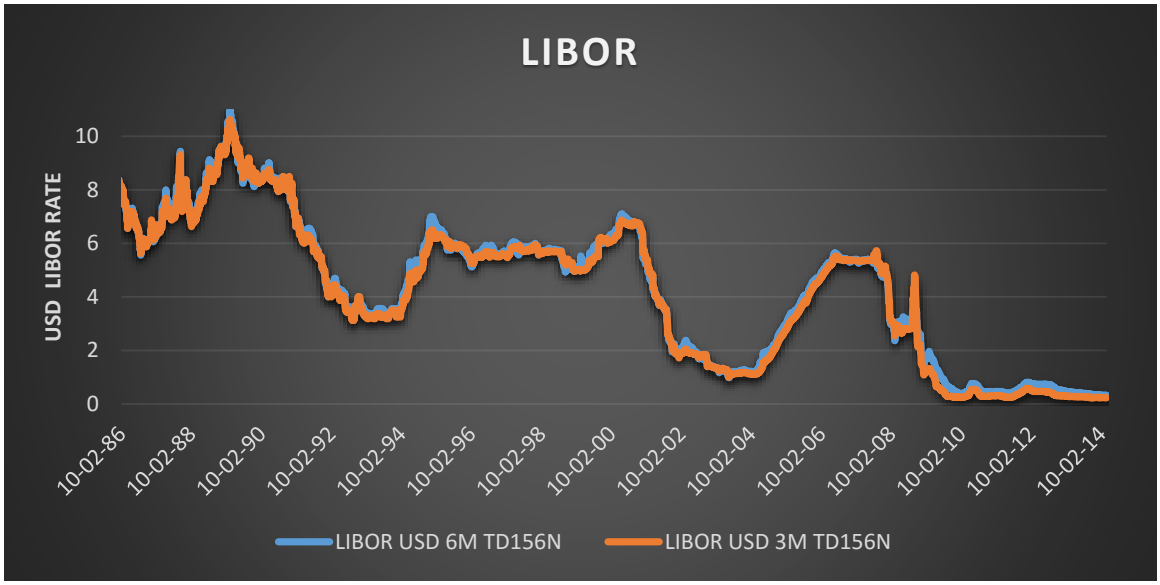


Figure 29 Libor rate in USD by Clarksons database

2.5.5 Fuel Cost

The fluctuation in fuel oil prices force the shipping industry to adapt since fuel oil is the single most important item in voyage costs, accounting for 47% of the total (Stopford, Maritime Economics, 2009).

Although shipping companies cannot control fuel prices, they have some influence on the level of fuel consumption. When the fuel cost is low then the higher power output is preferred over the fuel efficiency of vessels and the other way around when the fuel cost is high.

Vessels do not have a certain speed at which they operate. Their operating speed can vary substantially with the ratio of the freight market level to the bunker price, leading to the fleet tonne mile capability in constant flux (Gratsos, 2010). When a vessel is designed, naval architects optimize the hull and power plant to a prescribed design speed. But in real life, vessel speed varies at any intermediate speed considered appropriate within the envelope described by the vessel's steering ability, critical engine RPM, hull condition, weather condition, design speed and above all the market condition[5]. The possible vessel speed under various Bunker prices and various levels off BDI can be seen in Figure 30 Ship Speed vs Bunker prices for various levels of BDI .

Special note deserves the ability to burn low-quality fuel. In some cases the fuel savings achieved were quite spectacular.

[5] Since the fuel consumption follows the cube rule operation at lower speeds will result to great fuel savings

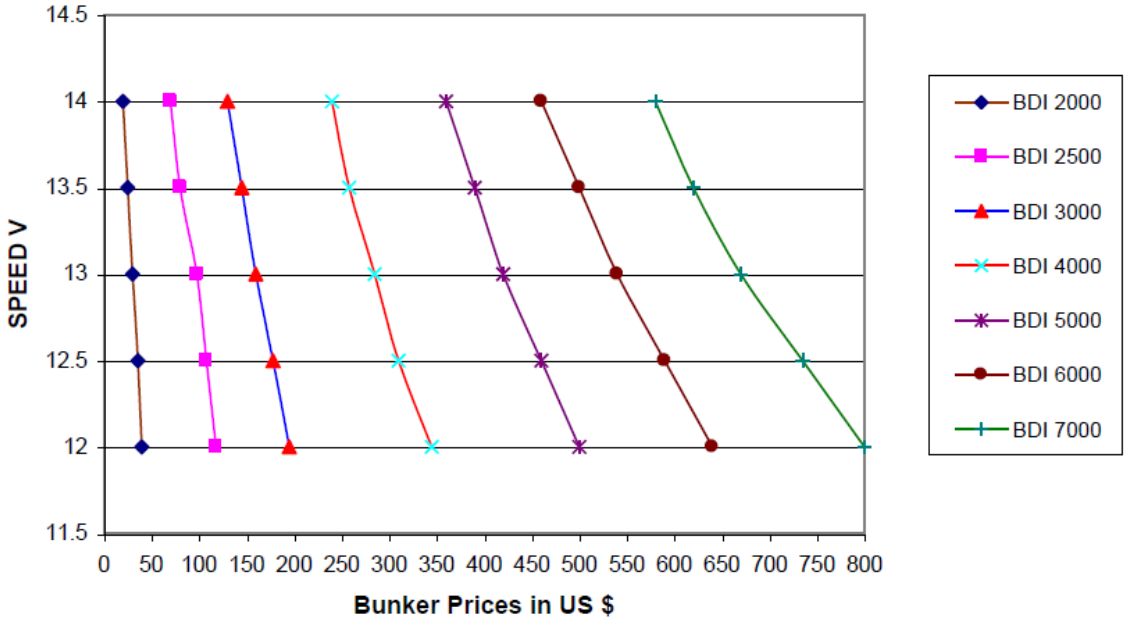


Figure 30 Ship Speed vs Bunker prices for various levels of BDI (Gratsos, 2010)

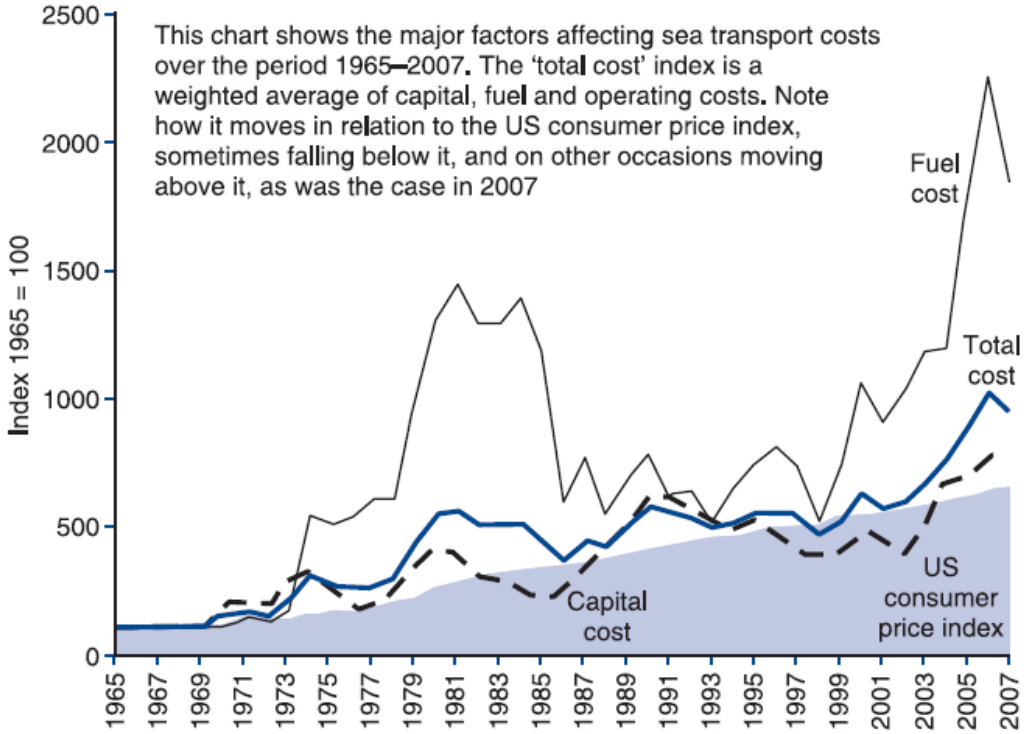


Figure 31 Inflation in shipping costs, 1965-2007 (Stopford, 2009)

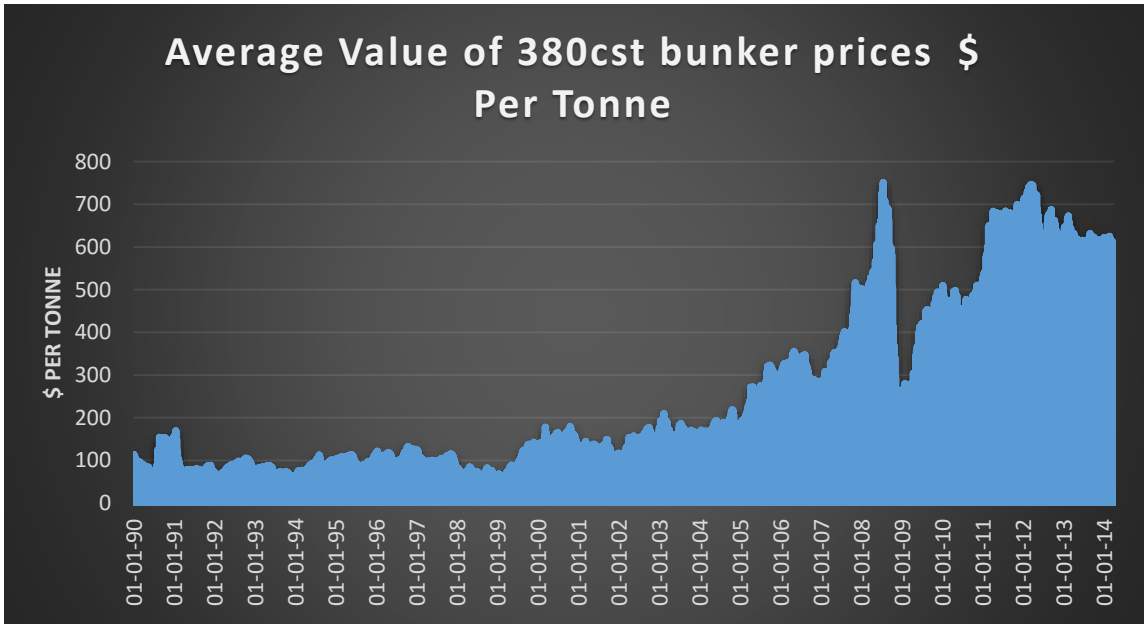


Figure 32 Average value of 380ct bunker prices 1990-2014 by Clarkson's database

2.5.6 Congestion

Congestion appears to have a significant effect at the beginning and the end of a financial cycle but does not appear to have any significant correlation with freight market fluctuations according to (Gratsos, 2010). On the other hand (Stopford, Maritime Economics, 2009) seems to believe that port congestion effect a lot the freight market.

Some of the possible reasons for port congestion are

1. exceptionally bad weather
2. unexpected accident
3. sudden peak in trade
4. seasonal peaks
5. landside congestion
6. lack of berths
7. irrational price policy from the port side

According to (Pardali, 2007) a combination of the above, and many more, reasons should be blamed for port congestions.

If we consider that a bulkcarrier on average call at 14 ports a year, then we can imagine how big is the effect of an additional day of congestion for the shipping industry[6].

[6] According to (Gratsos, 2010) one additional day will cause a 3.8% tonnage increase requirement

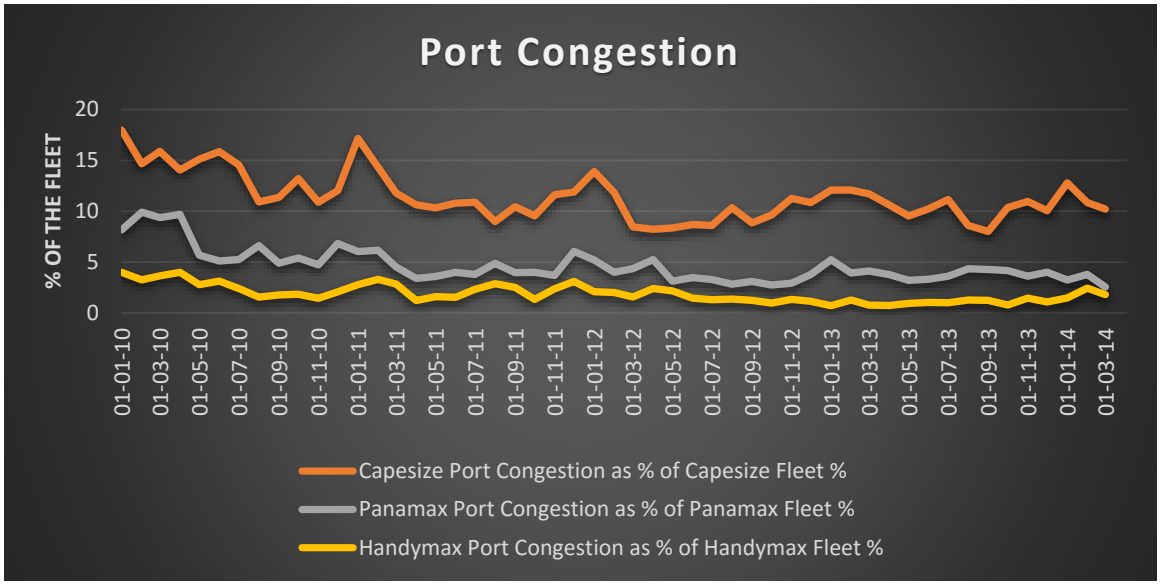


Figure 33 Port Congestion as percent of the fleet by Clarksons DB

2.5.7 Stockpiling

Maintaining adequate stock levels is common practice in all industries. The main reason for maintaining stock levels are (BIMCO, 2016)

1. lack of raw materials
2. price increases anticipation
3. speculation
4. strategic reserves

While adequate stock levels is a "safe" strategy, maintaining high stock levels is not an economically sound policy under normal circumstances, as it entails carrying costs.

According to (Gratsos, 2010) the iron ore stockpiling increase in China in late 2007 lead to an increased demand in shipments which eventually lead to more newbuildings.

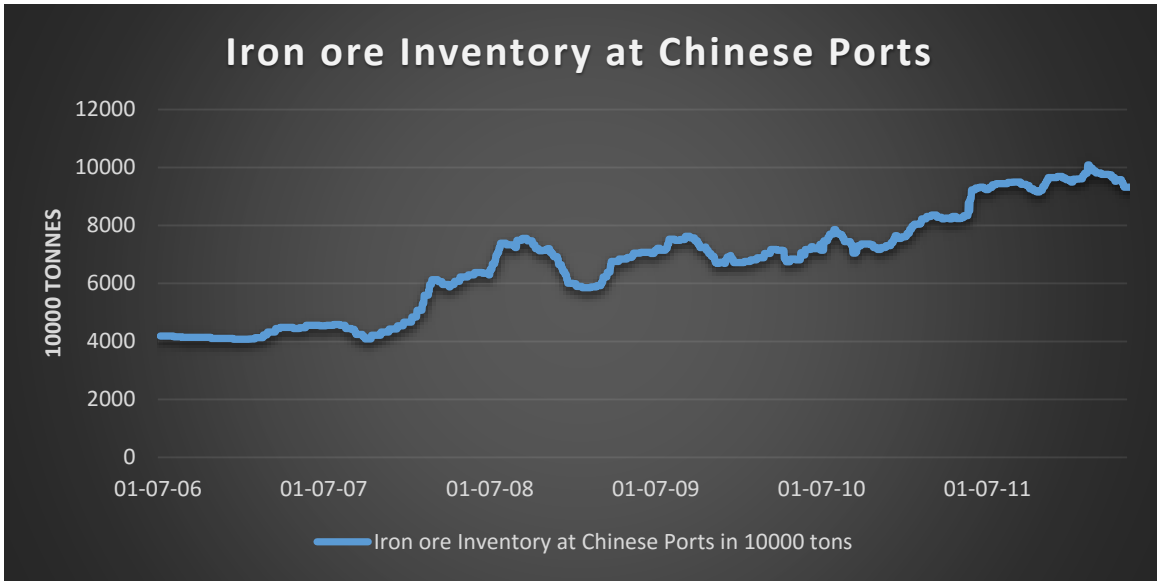


Figure 34 Iron ore inventory at Chinese ports (Dry Bulk Update – March 6, 2013, 2013)

3 TIMESERIES THEORY

A timeserie is a sequence of observations of some quantity taken over time, and a time series plot is a plot of a time series in chronological order according to (Ruppert, 2011). These values are analyzed in order to extract meaningful statistics and other characteristics of the data or to test theories that the current values of one or more independent time series affect the current or future values of another time series.

Time series analyses may be divided into two classes: frequency-domain methods and time-domain methods. The former includes spectral analysis and wavelet analysis; the later includes auto-correlation and cross-correlation analysis. Additionally, time series analysis techniques may be divided into parametric and non-parametric methods regarding the structure of the underlying stationary stochastic process that they represent. Other categories may be linear / non-linear, and univariate / multivariate analysis.

Time series forecasting is the use of a model to predict future values based on previously observed values. Generally there are five stages in developing a forecasting model (Stopford, Maritime Economics, 2009)

1. Design model.
2. Define relationships and collect data.
3. Estimate equations and test parameters
4. Validate model.
5. Prepare forecast.

Given the importance of the investment decisions (due to the high cost of them) it is easy to understand the great need for an accurate and reliable forecast in the shipping industry. The ultimum goal is a forecast of freight rates. Thus far most of the financial forecasting are not so accurate in all industries with the maritime industry being no exception (Stopford, Maritime Economics, 2009) but the forecasting paradox[7] should always be kept in mind.

Goodwin and Fildes divide time-series into a normal period with no unusual events and a special period which includes unusual and sometimes unexpected events. Statistical methods may provide an appropriate solution only for the normal period (Duru & Yoshida, 2009). Another approach of explaining the periods of higher, and of lower, variation within each series is volatility clustering. Volatility clustering refers to the observation that, “large changes tend to be followed by large changes, of either sign, and small changes tend to be followed by small changes” (Mandelbrot, 1963). Volatility clustering does not indicate a lack of stationarity but rather can be viewed as a type of dependence in the conditional variance of each series. (Ruppert, 2011)

Also it must be mentioned the difference between continuous and discrete signals. A discrete signal or discrete-time signal is a time series consisting of a sequence of quantities. Unlike a continuous-time signal, a discrete-time signal is not a function of a continuous argument; however, it may have been obtained by sampling from a continuous-time signal, and then each value in the sequence is called a sample.

[7] Paradoxically, forecasters are only called in when the future is unpredictable

Discrete-time signals can be classified into one of two groups, the one coming from an analog signal with a sampling process and the second which comes from an inherently discrete time process such as the economic indicators (Proakis & Manolakis, 1996).

3.1 Stationarity

A process is said to be strictly stationary according to (Ruppert, 2011) if all aspects of its behavior are unchanged by shifts in time.

Mathematically, stationarity is defined as the requirement that for every m and n, the distributions of $Y_1,\ldots,Y_n$ and $Y_{1+m},\ldots,Y_{n+m}$ are the same that is, the probability distribution of a sequence of n observations does not depend on their time origin.

Strict stationarity is a very strong assumption and it is very difficult to hold in real life time series. For this reason weak stationarity concept has been developed. A time-series process Y_i is said to be weakly stationary (covariance stationary) if its mean and variance are constant and independent of time and the covariances depend only upon the distance between the two time periods (the lag), but not the time periods per se. (Baltagi, 2011). In weakly stationary process other distributional characteristics such as quantiles, skewness, and kurtosis, are not investigated. More precisely, Yi process is a weakly stationary process if

$$\mathrm{E}\left(Y_i\right) = \mu \quad [2]$$

$$Var\left(Y_i\right) = \sigma^2 \quad [3]$$

$$Corr\left(Y_i, Y_j\right) = \rho\left(|i-j|\right) \quad [4]$$

As an example of a non-stationary timeserie in the plot below three types of nonstationarity can be seen. First is the obvious upward trend, second is the seasonal variation, and third is the increase over time in the size of the seasonal oscillations. (Ruppert, 2011)

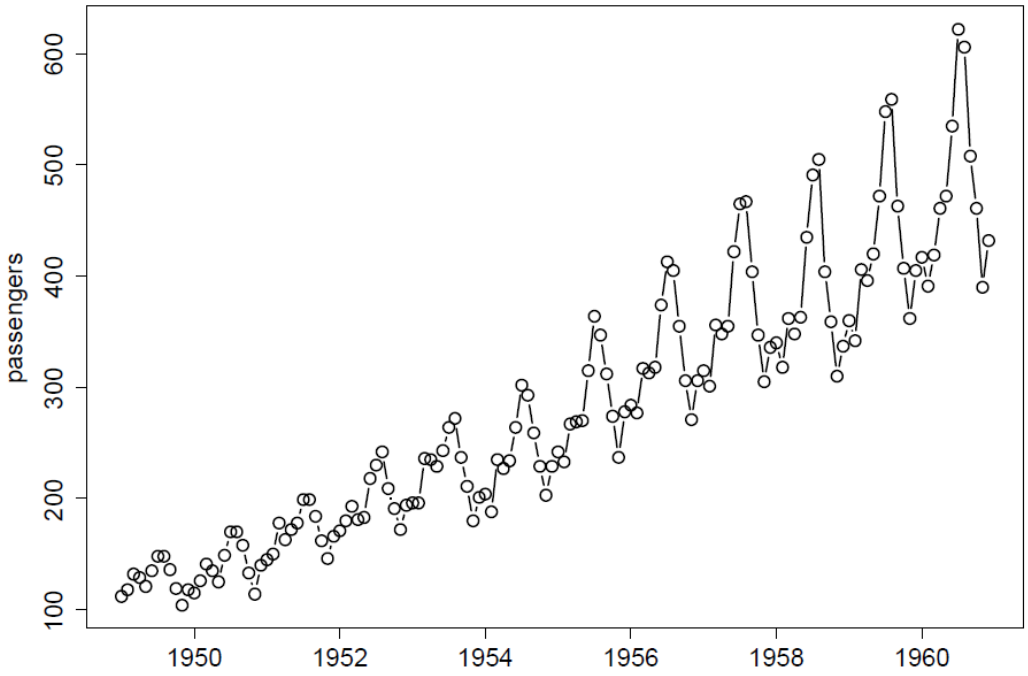


Figure 35 Time series plot of monthly totals of air passengers (in thousands) (Ruppert, 2011)

In order to test a timeserie for stationarity visual inspection of the timeseries and changes in the timeseries can be helpful. Moreover it can be supplemented with other plots, such as the plot of the sample autocorrelation function. Still it is never absolutely certain of the correct answer since for any finite amount of data (sample set) there is a deterministic and stochastic trend that fits the data equally well (Hamilton, 1994) Statistical test of stationarity are tools for assessing the stationarity or not of a timeserie.

3.1.1 Statistical tests for Stationarity

There are a number of statistical tests for testing the stationarity of a timeserie. All of them follow the hypothesis testing and check various types of stationarity. It is mention to note that they all of them are not follow the same structure (the non-stationarity is not the null hypothesis in all of them but it may be the alternative instead) neither the rejection of the hypothesis of a unit root may lead to the conclusion of a stationary timeserie. Below there is a list of some off these statistical tests

1. Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests[8]
2. Augmented Dickey-Fuller test[9]
3. Leybourne-McCabe stationarity test[10]
4. Phillips-Perron test for one unit root[11]

[8] http://www.mathworks.com/help/econ/kpsstest.html
[9] http://www.mathworks.com/help/econ/adftest.html
[10] http://www.mathworks.com/help/econ/lmctest.html
[11] http://www.mathworks.com/help/econ/pptest.html

3.2 Transformations

Using non-stationary time series data in financial models produces unreliable and spurious results and leads to poor understanding and forecasting. The solution to the problem is to transform the time series data so that it becomes stationary. Transformation is the deterministic mathematical function which replaces each point in a data set with the transformed value. Some of the reasons to transform a timeserie may be:

- Isolate temporal components of interest.
- Remove the effect of nuisance components (like seasonality).
- Make a series stationary.
- Reduce spurious regression effects.
- Stabilize variability that grows with the level of the series.
- Make two or more time series more directly comparable.

You can choose among many data transformation to address these (and other) aims. But some of the most common Data Transformations[12] may be seen below

- Detrending
- Differencing
- Log Transformations
- Prices, Returns, and Compounding

After the application of a transformation and the model analysis, the results need to back-transform to return to the original scale.

3.2.1 Detrending

Some nonstationary series can be modeled as the sum of a deterministic trend and a stationary stochastic process, where ε_t is a stationary stochastic process with mean zero and, μ_t a deterministic trend.

$$y_t = \mu_t + \varepsilon_t \quad [5]$$

The deterministic trend, μ_t, can have multiple components, such as nonseasonal and seasonal components and several techniques are available for estimating the trend component. However, estimating trend components can require making additional assumptions, performing extra steps, and estimating additional parameters.

3.2.2 Differencing

Differencing is an alternative transformation for removing a mean trend from a nonstationary series. This approach is advocated in the Box-Jenkins approach to model

[12]http://www.mathworks.com/help/econ/data-transformations.html?requestedDomain=www.mathworks.com#bs8shrz

specification (Box, Gwilym, & Reinsel, 2008). Differencing is appropriate for removing *stochastic* trends and also eliminating seasonality

The first difference is defined as

$$\Delta y_t = y_t - y_{t-1} \quad [6]$$

where Δ is called the *differencing operator*. Similarly, the second difference is defined as

$$\Delta^2 y_t = (y_t - y_{t-1}) - (y_{t-1} - y_{t-2}) = y_t - 2y_{t-1} + y_{t-2} \quad [7]$$

Like taking derivatives, taking a first difference makes a linear trend constant, taking a second difference makes a quadratic trend constant, and so on for higher-degree polynomials. In general taking D differences makes a process with D unit roots stationary. Finally it should be mentioned that differencing can also help to remove spurious regression effects due to cointegration.

3.2.3 Log Transformations

For a series with exponential growth and variance that grows with the level of the series, a log transformation can help linearize and stabilize the series. In some application areas, working with differenced, logged series is the norm. For example, the first differences of a logged time series, are approximately the *rates of change* of the series.

$$\Delta \log y_t = \log y_t - \log y_{t-1} \quad [8]$$

The logarithm transformation is probably the most widely used transformation in data analysis, though the square root is a close second since they can stabilize the variance of a time series. An important note for the log transformation is that when negative values are present in the timeserie, a constant has to be added to make all observations greater than zero before taking the log transformation.

3.2.4 Prices, Returns, and Compounding

The rates of change of a price series are called *returns*. Whereas price series do not typically fluctuate around a constant level, the returns series often looks stationary and that is why returns series are typically used instead of price series in many applications.

The *continuously compounded returns series* is the transformed series

$$r_t = \log y_{t-1} - \log y_t \quad [9]$$

This is the first difference of the log price series, and is sometimes called the *log return*.

An alternative transformation for price series is *simple returns*,

$$r_t = \frac{y_{t-1} - y_t}{y_t} \quad [10]$$

For series with relatively high frequency (e.g., daily or weekly observations), the difference between the two transformations is small.

3.3 Auto Correlation

Autocorrelation is a mathematical tool for finding repeating patterns, such as the presence of a periodic signal obscured by noise, or identifying the missing fundamental frequency in a signal. It is frequently used for time domain signals and describes the dependence between values of the process at different times, as a function of the two times or of the time lag.

In signal processing, the above definition is often used without normalization, when the autocorrelation function is normalized by mean and variance, it is referred to as the autocorrelation coefficient. (Dunn, 2005). However, the normalization is important both because the interpretation of the autocorrelation as a correlation provides a scale-free measure of the strength of statistical dependence, and because the normalization has an effect on the statistical properties of the estimated autocorrelations.

Usually, in statistics, there are three types of correlations

- Pearson (r)
- Kendall's tau (τ)

$$\tau = \frac{n_c - n_d}{\frac{1}{2}n(n-1)} \quad [11]$$

Where:

N_c= number of concordant (ordered in the same way)

N_d= Number of discordant (ordered differently)

- Spearman's rho (ρ)

$$\rho = 1 - \frac{6\sum_{i=1}^{n} d_i^2}{n(n^2-1)} \quad [12]$$

where: d_i is the difference between the ranks of corresponding values X_i and Y_i

For the Pearson r correlation, both variables should be normally distributed. Other assumptions include linearity and homoscedasticity. Kendall's tau and Spearman's (rho) are two accepted measures of non-parametric rank correlations. Non parametric test does not make any assumptions about the distribution. The assumptions of Spearman rho correlation are that data must be at least ordinal and scores on one

variable must be monotonically related to the other variable. In most of the situations, the interpretations of Kendall's tau and Spearman's rank correlation coefficient are very similar and thus invariably lead to the same inferences.

The sample lag-*h* autocorrelation (Pearson) according to (Box, Gwilym, & Reinsel, 2008) is given by

$$\rho_h = \frac{\sum_{t=h+1}^{T} (y_t - y)(y_{t-h} - y)}{\sum_{t=1}^{T} (y_t - y)^2} \quad [13]$$

The standard error for testing the significance of a single lag-*h* autocorrelation is approximately

$$SE_\rho = \sqrt{(1 + 2\sum_{i=1}^{h-1} \hat{\rho}_i^2) / N} \quad [14]$$

The approximate 95% confidence intervals are at ±2SEρ.

3.4 Cross Correlation

Cross-correlation is a measure of similarity of two series as a function of the lag of one relative to the other. It can suggest how the component series might be influencing each other or might be influenced by a common factor. Like all correlations, cross-correlations only show statistical association, not causation. (Ruppert, 2011, p. 264)

For continuous complex functions f and g, the cross-correlation is defined as:

$$(f \star g)(\tau) \overset{def}{=} \int_{-\infty}^{\infty} f^*(t) g(t + \tau) dt \quad [15]$$

where f$\star$ denotes the complex functions of f and $\tau$is the lag.

Similarly, for discrete functions, the cross-correlation is defined as**:**

$$(f \star g)[n] \overset{def}{=} \sum_{m=-\infty}^{\infty} f^*[m] g[m + n] \quad [16]$$

Cross-correlations are useful for determining the time delay between two signals. The absolute maximum of the cross-correlation function indicates the point in time where the signals are best aligned, i.e. the time delay between the two signals is determined by the argument of the maximum, or arg max of the cross-correlation, as in

$$\tau_{delay} = \arg_t \max((f \star g)(t)) \quad [17]$$

Cross correlation analysis must be applied with caution for nonlinear systems since it may be blind to certain nonlinear effects (Billings, 2013) due to the possible small value of some quadratic moments which would suggest little correlation.

Also it must be mentioned that correlation does not imply causality (Aldrich, 1995). Often when two events occur *together* are taken to have a cause-and-effect relationship. This fallacy is also known as "*cum hoc ergo propter hoc*". A similar fallacy, that an event that follows another was necessarily a consequence of the first event, is sometimes described as "*post hoc ergo propter hoc*". In order to prove causality further research required and strong correlation is only a requirement but not adequate enough.

4 IMPLEMENTATION

4.1 Data

4.1.1 Sources

The timeserie used for the analysis in this master Thesis come from the below data sources:

i. Clarksons[13]
ii. Organisation for Economic Co-operation and Development (OECD)[14]
iii. Fairplay[15]
iv. IMO 3rd GHG Study[16]

4.1.1.1 Clarksons

Clarkson PLC is considered as one of the leading providers of shipping services and also one of the most comprehensive and reliable information provider throughout the maritime world. Research services are one of their five business cores, and the foundation for the other four. According to (Clarksons, 2012) their focus is primarily on the collection, validation, analysis and management of data about the merchant shipping and offshore markets.

4.1.1.2 Organization for Economic Co-operation and Development (OECD)

OECD is an international economic organization of 35 member countries, which founded in 1961 to stimulate economic progress and world trade. Their aim is to seek answers to common problems, identify good practices, and co-ordinate domestic and international policies. They publish books, reports, statistics, working papers and reference materials while the database can be accessed via OECD iLibrary. According to their web page[17] "OECD's work is based on continued monitoring of events in member countries as well as outside OECD area, and includes regular projections of short and medium-term economic developments".

[13] http://www.clarksons.net/sin2010/
[14] http://stats.oecd.org/
[15] http://www.ihsfairplay.com/IMO/imo.html
[16] http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Documents/Third%20Greenhouse%20Gas%20Study/GHG3%20Executive%20Summary%20and%20Report.pdf
[17] http://www.oecd.org/about/whatwedoandhow/

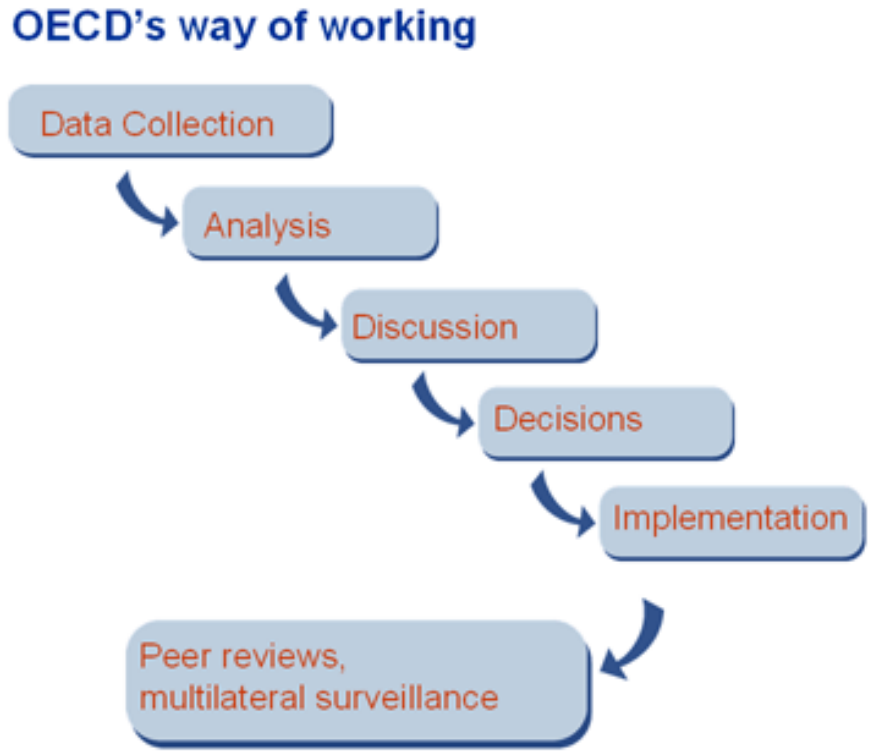


Figure 36 OECD's way of working

4.1.1.3 IHS Fairplay

IHS Inc. (IHS) is a company based in Douglas County, Colorado, United States. IHS provides information and analysis to support the decision-making process of businesses and governments in industries, such as aerospace, defense and security, automotive, chemical, energy; maritime and trade, and technology. IHS is one of the major sources of critical maritime and trade insight, enabling organizations, policy makers and security to navigate today's complex trading environment.

4.1.1.4 IMO 3rd GHG Study

The third study of greenhouse gas emissions from ships (IMO, 2015) was commissioned as an update of the International Maritime Organization's (IMO) Second IMO GHG Study 2009. The updated study has been prepared on behalf of IMO by an international consortium led by the University College London (UCL) Energy Institute.

The basic aim of the study was to provide access to up-to-date information to support working groups and policy decision-making. For this reason the use of vessel-specific activity, technical details and actual vessel speed was required since the fuel consumption is highly correlated with the vessel operational speed.

4.1.2 Matrix with timeseries per category

All the timeseries used in this study, which are more than 300 different time series, have been divided in different categories based on the previous theory of shipping. The four shipping markets and the shipping market model was used as the base for that categorization. In the below Figure 37 the structure of the categorization can be seen.

Figure 37 Data Structure per category

4.2 Implementation Programme Code

The code input is a [M x N] data matrix with M rows, the number of the data entries, and N columns the number of the parameters for assess. The first column must be the

time parameter, which is not included in the analysis but plays an important role in manipulating the timeseries. The rest of the parameters may have any sampling frequency (f_s), as long as it remains constant, and any starting or ending point within the time period.

Firstly, there is a pre-process of the data matrix checking for double date entries, clearing "NaN" and missing values, sorting the matrix in a chronological order, index creation for the starting and ending points of each parameter and assessing the sampling frequency (f_s) for every parameter.

Subsequently the main code assess the statistical values for every parameter starting from the parameter with the lowest sampling frequency and analyzing it against itself and all the other parameters which have a greater sampling frequency following the below procedure:

1. Search for the time period where the two parameters coexist. (overlapping.mat)
2. Check the sampling frequency (f_s) of the two parameters
3. Resample the parameter with the highest sampling frequency (f_s) to the lowest frequency using the matlab function 'resample'[18].
    - This procedure makes the parameters comparable since they are referring to the same time period
    - Also avoids any edge effects issues due to the resampling procedure.
4. The new timeseries are transformed to the below transformations
    a. Normalized timeserie
    b. Differencing the normalized timeserie
    c. Second differencing
    d. Logarithmic differences
    e. Logarithmic ratios
5. Every transformation will be assessed for stationarity and a "flag" will be added in the result matrix. The stationary will be assessed with the statistical tests that appear below
    a. Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests[19]
    b. Leybourne-McCabe stationarity test[20]
    c. Phillips-Perron test for one unit root[21]
    d. Augmented Dickey-Fuller test[22]
6. The new transformed time series will be all checked for cross correlation[23]
7. The cross correlation plot will be created with the upper and lower confidence bounds which correspond to 95% confidence
8. Two final result matrixes are created FIN and FIN_n with the below values
    a. FIN
        i. Transformation of the first parameter
        ii. First parameter title

[18] http://www.mathworks.se/help/ident/ref/resample.html
[19] http://www.mathworks.se/help/econ/kpsstest.html
[20] http://www.mathworks.se/help/econ/lmctest.html
[21] http://www.mathworks.se/help/econ/pptest.html
[22] http://www.mathworks.se/help/econ/adftest.html
[23] http://www.mathworks.com/help/econ/crosscorr.html

iii. Transformation of the second parameter
iv. Second parameter title
v. Flag of stationarity(in case that the statistical test does not provide the same result all of them)

b. FIN_n
i. Cross-correlation absolute highest's value lag in days
ii. Cross-correlation absolute highest value
iii. Percent deviation from the confidence bounds
iv. Index of first parameter
v. Index of second parameter

The analysis took place with 320 initial parameters for a time period spanning from 1/1/1985 to 03/04/2014. In an Intel Core i5 @ 2.67 GHz with 4 GB Ram the script needed 155.68 hours for the complete period and for the half period 73.88 hours

4.3 Super Cycle

During the period 2001 – 2009 there was an anomaly in the shipping cycle. As it is shown in the below figures, Figure 39 and Figure 40, the earnings increased in an enormous amount that period. The BDI index raised from 2000 to 12000! This anomaly was called "Super Cycle" from Dr. Stopford (Stopford, World Shipbuilding, 2012). This kind of anomaly affects the analysis of the timeseries that is why two different analysis had taken place, one with the whole time period (1985 -2014) and a second one, called "half period", from (1985 -2003) leaving outside the anomaly.

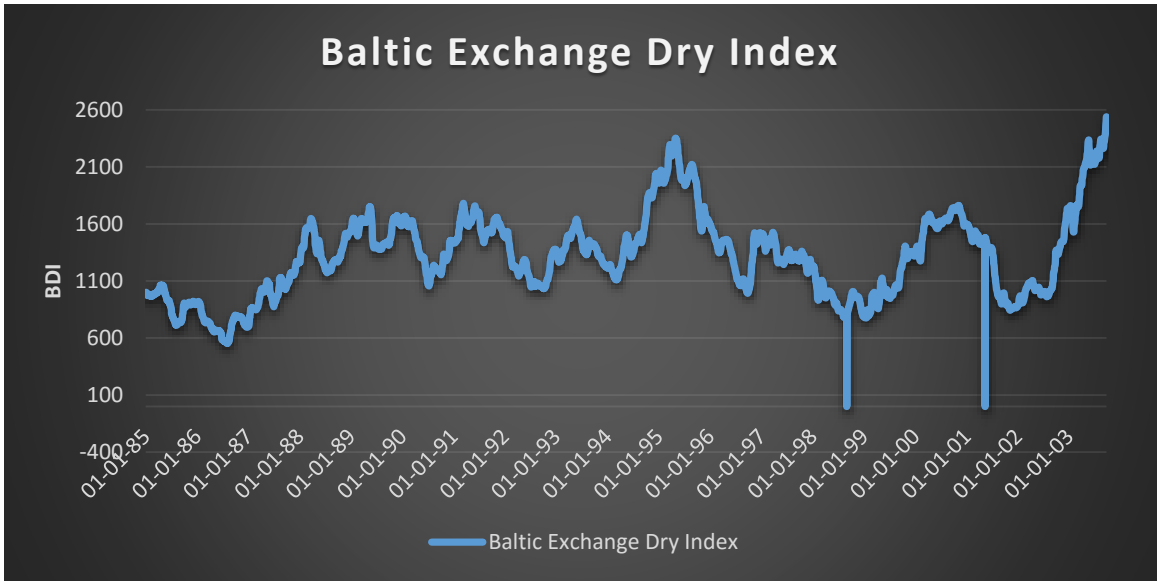


Figure 38 BDI index prior the "Super Cycle" Clarkson's DB

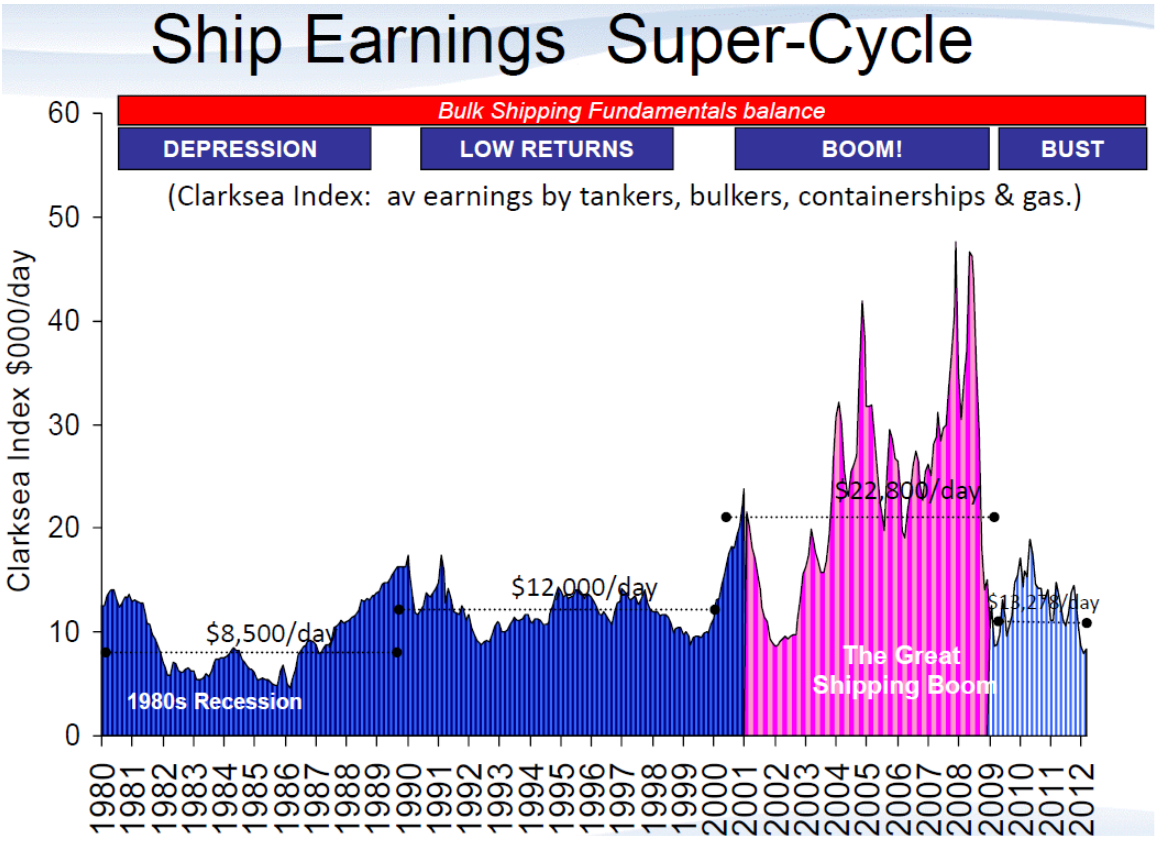


Figure 39 Ship Earnings Super-Cycle Source: Clarkson Research Services Ltd

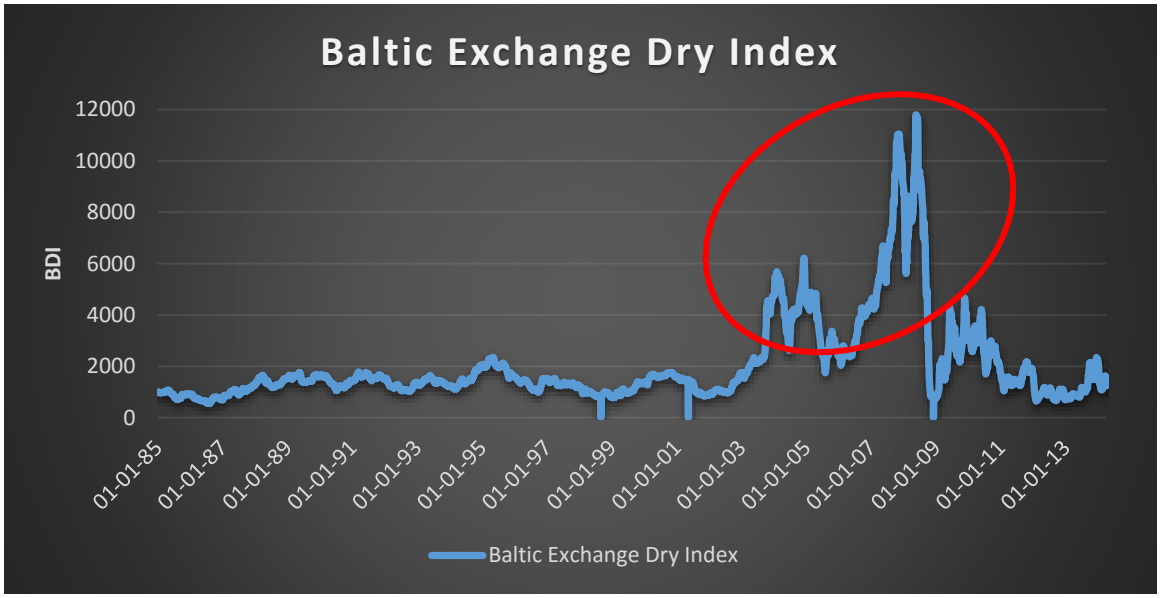


Figure 40 Baltic Exchange Dry Index Clarkson's DB

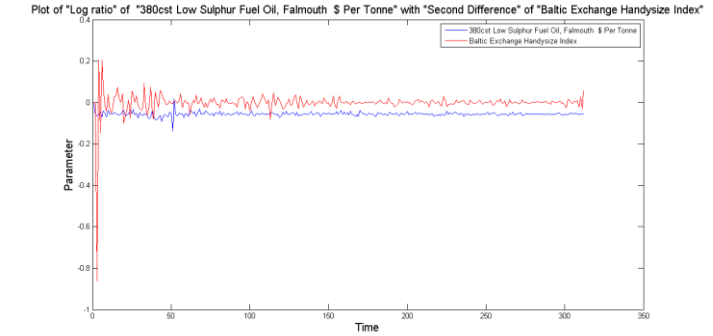
5 RESULTS

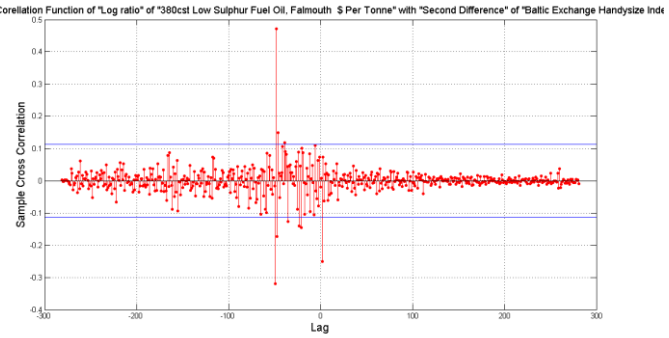
5.1 Baltic Exchange Handysize Index

5.1.1 Complete time period

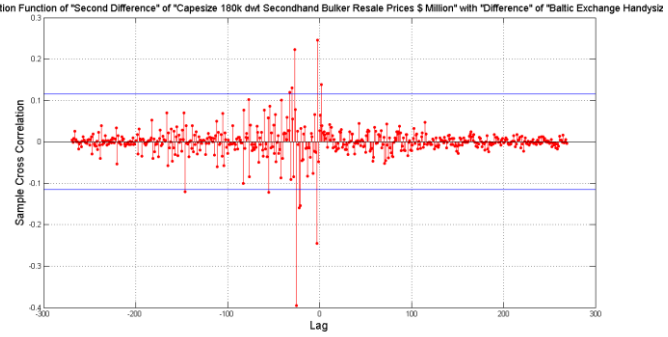
Table 4 Baltic Exchange Handysize Index complete period result table

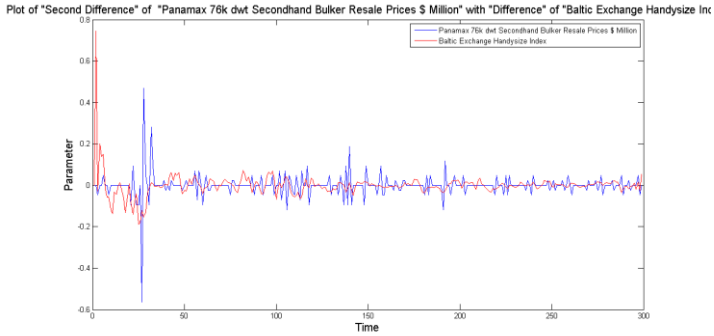
Parameter 1	Transformation 1	Parameter 2	Transformation 2	Lag (days)	Cross Correlation value
'380cst Low Sulphur Fuel Oil, Falmouth $ Per Tonne'	'Log ratio'	'Baltic Exchange Handysize Index'	'Second Difference'	-350,15	0,47
'Capesize 180k dwt Secondhand Bulker Resale Prices $ Million'	'Second Difference'	'Baltic Exchange Handysize Index'	'Difference'	-182,10	-0,39
'Panamax 76k dwt Secondhand Bulker Resale Prices $ Million'	'Second Difference'	'Baltic Exchange Handysize Index'	'Difference'	-182,10	-0,45
'Handymax 61k dwt Secondhand Bulker Resale Prices $ Million'	'Second Difference'	'Baltic Exchange Handysize Index'	'Difference'	-211,24	-0,39
'Bulkcarrier Average Newbuilding Prices'	'Difference'	'Baltic Exchange Handysize Index'	'Second Difference'	-910,34	-0,43
'Handymax 56K 5 Year Old Secondhand Prices $ Million'	'Second Difference'	'Baltic Exchange Handysize Index'	'Second Difference'	-342,22	-0,38
'Bulk Carrier Secondhand Prices Index % Change'	'Log Difference'	'Baltic Exchange Handysize Index'	'Second Difference'	-908,60	-0,33
'380cst Low Sulphur Fuel Oil, Los Angeles $ Per Tonne'	'Second Difference'	'Baltic Exchange Handysize Index'	'Second Difference'	-454,12	-0,42
'Rail goods International transport in million tonne-km Netherlands'	'Second Difference'	'Baltic Exchange Handysize Index'	'Second Difference'	-513,98	-0,20

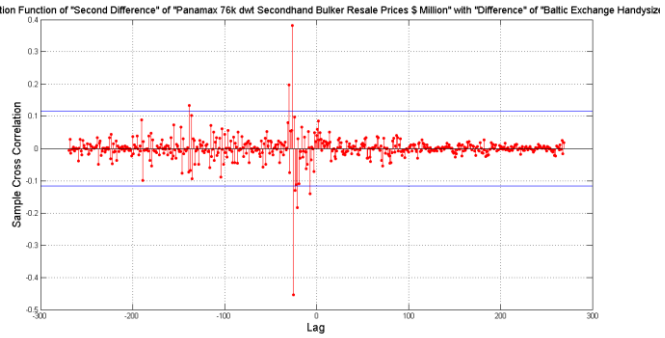

Plot of "Log ratio" of "380cst Low Sulphur Fuel Oil, Falmouth $ Per Tonne" with "Second Difference" of "Baltic Exchange Handysize Index"
380cst Low Sulphur Fuel Oil, Falmouth $ Per Tonne
Baltic Exchange Handysize Index
Parameter
Time


Cross-Corellation Function of "Log ratio" of "380cst Low Sulphur Fuel Oil, Falmouth $ Per Tonne" with "Second Difference" of "Baltic Exchange Handysize Inde
Sample Cross Correlation
Lag

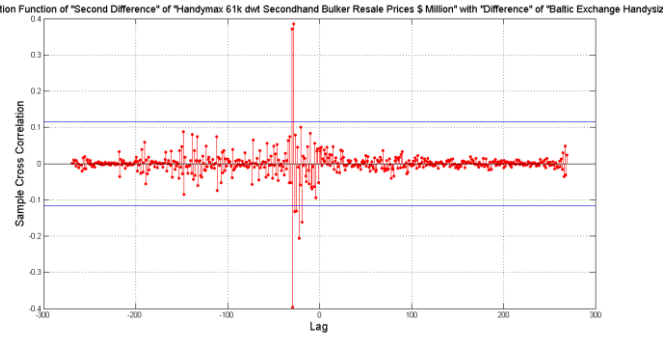

Plot of "Second Difference" of "Capesize 180k dwt Secondhand Bulker Resale Prices $ Million" with "Difference" of "Baltic Exchange Handysize In
Capesize 180k dwt Secondhand Bulker Resale Prices $ Million
Baltic Exchange Handysize Index
Parameter
Time

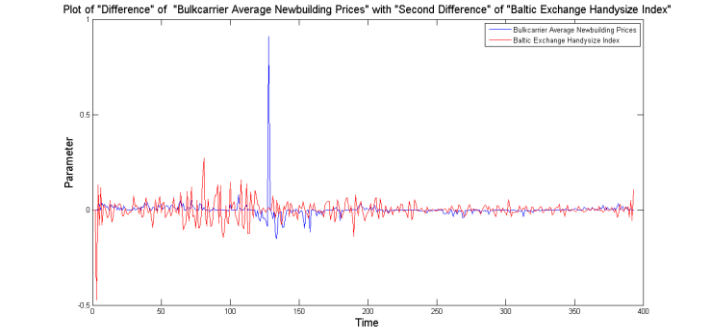

oss-Corellation Function of "Second Difference" of "Capesize 180k dwt Secondhand Bulker Resale Prices $ Million" with "Difference" of "Baltic Exchange Handysiz
Sample Cross Correlation
Lag

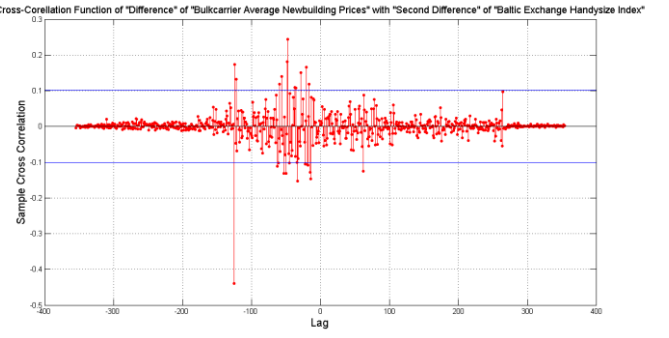

Plot of "Second Difference" of "Panamax 76k dwt Secondhand Bulker Resale Prices $ Million" with "Difference" of "Baltic Exchange Handysize Inc
Panamax 76k dwt Secondhand Bulker Resale Prices $ Million
Baltic Exchange Handysize Index
Parameter
Time


oss-Corellation Function of "Second Difference" of "Panamax 76k dwt Secondhand Bulker Resale Prices $ Million" with "Difference" of "Baltic Exchange Handysiz
Sample Cross Correlation
Lag


Plot of "Second Difference" of "Handymax 61k dwt Secondhand Bulker Resale Prices $ Million" with "Difference" of "Baltic Exchange Handysize In
Handymax 61k dwt Secondhand Bulker Resale Prices $ Million
Baltic Exchange Handysize Index
Parameter
Time


oss-Corellation Function of "Second Difference" of "Handymax 61k dwt Secondhand Bulker Resale Prices $ Million" with "Difference" of "Baltic Exchange Handysiz
Sample Cross Correlation
Lag


Plot of "Difference" of "Bulkcarrier Average Newbuilding Prices" with "Second Difference" of "Baltic Exchange Handysize Index"
Bulkcarrier Average Newbuilding Prices
Baltic Exchange Handysize Index
Parameter
Time


Cross-Corellation Function of "Difference" of "Bulkcarrier Average Newbuilding Prices" with "Second Difference" of "Baltic Exchange Handysize Index"
Sample Cross Correlation
Lag

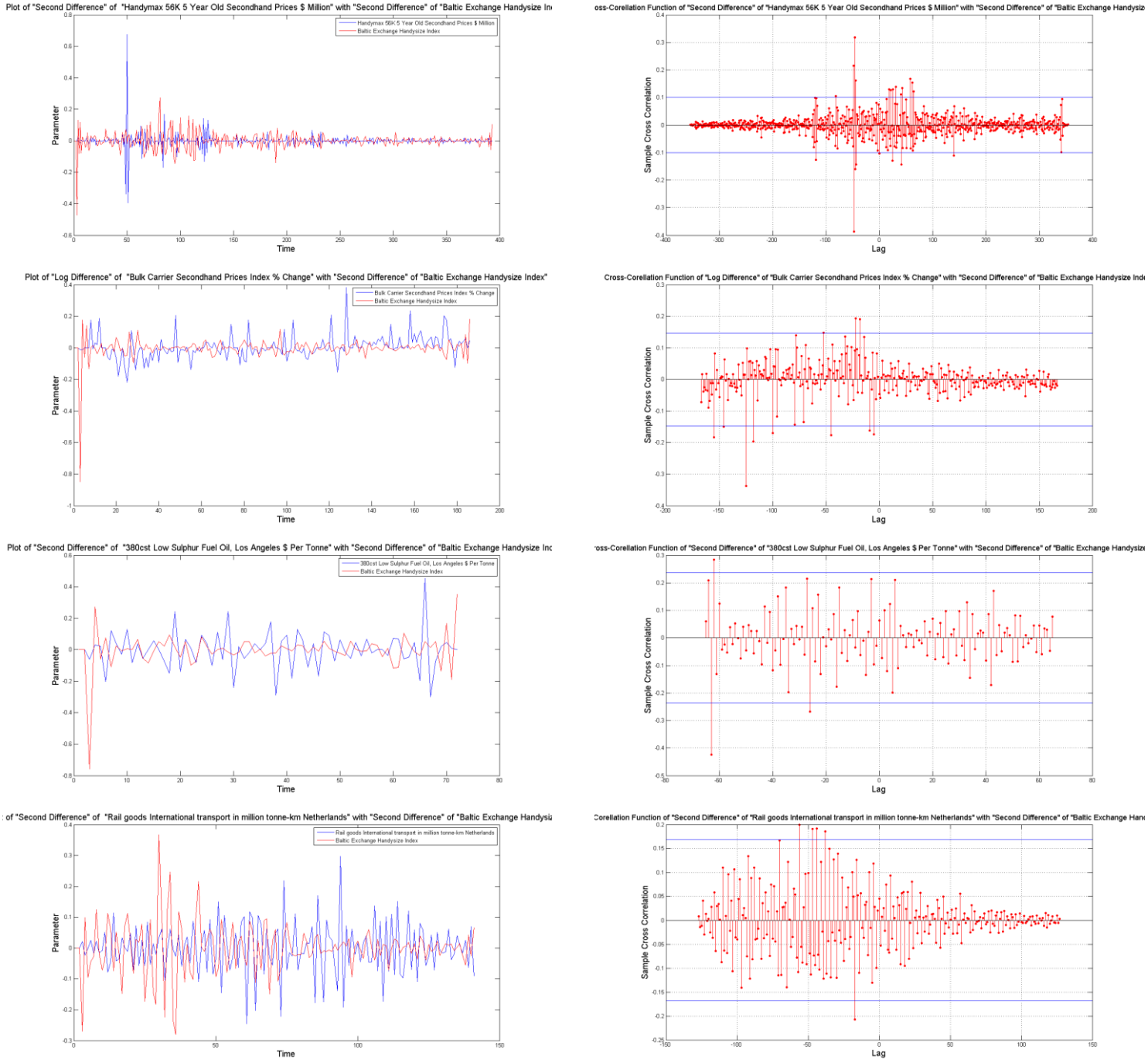


Figure 41 Baltic Exchange Handysize Index complete period correlation graphs

5.1.2 Complete time period Comments

The Baltic Exchange Handysize Index is the first parameter to examine. It represents the freight market of Handy size vessels. The highest correlation is estimated with the value of the Low Sulphur Oil in Falmouth. The price of the oil is leading the freight value with a lag of almost one year, while the strength of the correlation is estimated in 0.47. The next strongest correlation is noted in the Panamax secondhand sales market, but this time the correlation is negative. So when the resales market finds a minimum then after almost 6 months the Handysize freight finds a maximum. Similar correlations

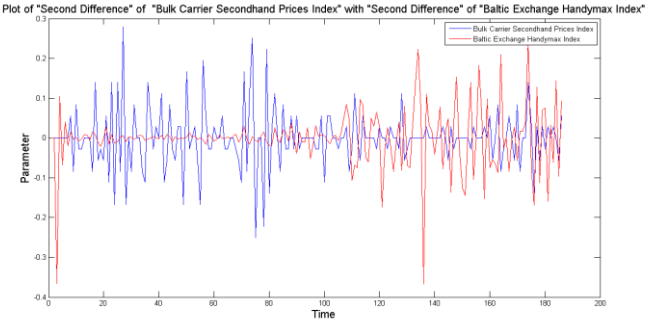
are noted with the Capesizes and the Handymaxes sales markets. All of them are negative correlations of a 0.4 strength (from 0.39 to 0.45) and all of them in the similar lag range of 3 months. One really interesting issue is the negative correlation of 0.2 with the International transport in Netherlands with railway. This correlation has a lag of almost one and a half years. Another one is the negative correlation with the Bulkcarrier Average Newbuilding price with correlation strength of 0.43 and a lag of almost 2.5 years. The Handysize index is leading. It is really strange and may be heavily influenced from the two outlier values. As it is shown in the graph there may be a positive correlation if the outliers were taken outside of the analysis.

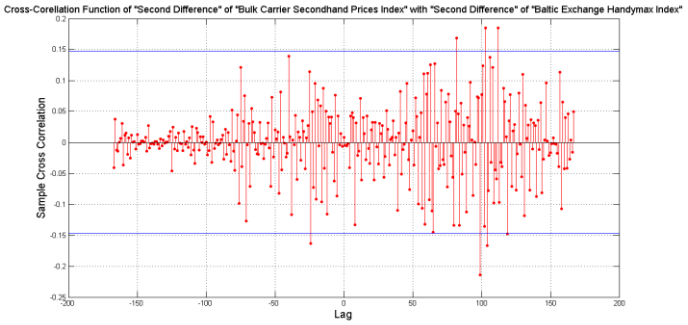
5.2 Baltic Exchange Handymax Index

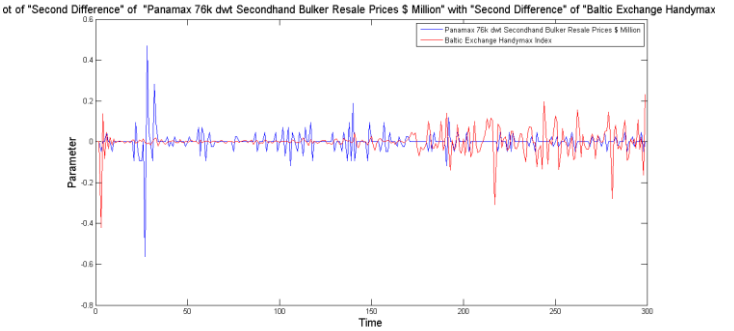
5.2.1 Complete time period

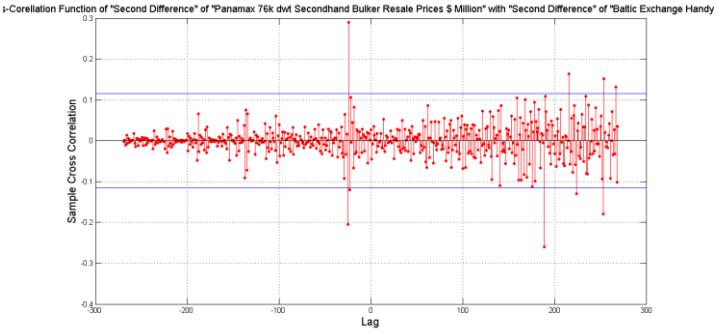
Table 5 Baltic Exchange Handymax Index complete period result table

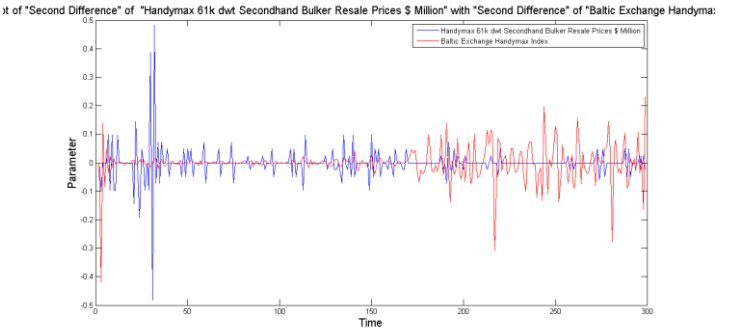
Parameter 1	Transformation 1	Parameter 2	Transformation 2	Lag (days)	Cross Correlation value
'Bulk Carrier Secondhand Prices Index'	'Second Difference'	'Baltic Exchange Handymax Index'	'Second Difference'	719,61	-0,21
'Panamax 76k dwt Secondhand Bulker Resale Prices $ Million'	'Second Difference'	'Baltic Exchange Handymax Index'	'Second Difference'	-174,82	0,29
'Handymax 61k dwt Secondhand Bulker Resale Prices $ Million'	'Second Difference'	'Baltic Exchange Handymax Index'	'Second Difference'	-196,67	-0,28
'Clarksons Average Bulker Earnings $ Per Day'	'Second Difference'	'Baltic Exchange Handymax Index'	'Second Difference'	0	0,42
'Handymax 45-48K DWT 15 Year Old Secondhand Prices $ Million'	'Second Difference'	'Baltic Exchange Handymax Index'	'Second Difference'	-692,36	0,28
'380cst Low Sulphur Fuel Oil, Houston $ Per Tonne'	'Second Difference'	'Baltic Exchange Handymax Index'	'Second Difference'	35,89	-0,30
'Baltic Exchange Supramax Index'	'Second Difference'	'Baltic Exchange Handymax Index'	'Second Difference'	-2,92	0,88
'Baltic Exchange Dry Index'	'Second Difference'	'Baltic Exchange Handymax Index'	'Second Difference'	-1,46	0,30
'Baltic Exchange Freight Index (BFI)'	'Second Difference'	'Baltic Exchange Handymax Index'	'Second Difference'	-1,45	0,30

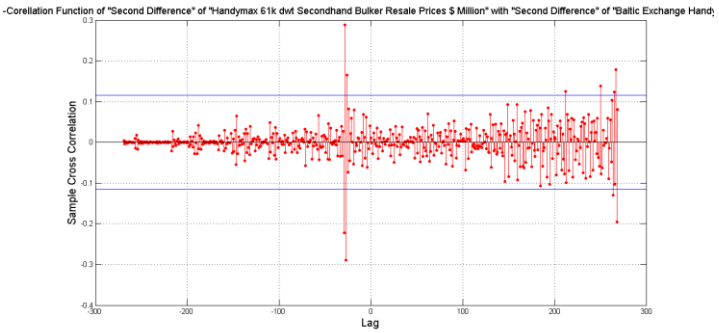

Plot of "Second Difference" of "Bulk Carrier Secondhand Prices Index" with "Second Difference" of "Baltic Exchange Handymax Index"
Bulk Carrier Secondhand Prices Index
Baltic Exchange Handymax Index
Parameter
Time

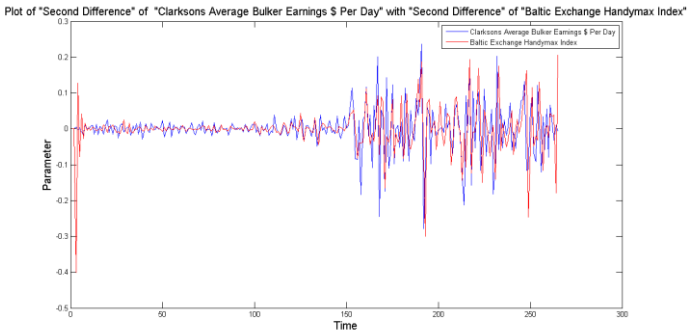

Cross-Corellation Function of "Second Difference" of "Bulk Carrier Secondhand Prices Index" with "Second Difference" of "Baltic Exchange Handymax Index"
Sample Cross Correlation
Lag

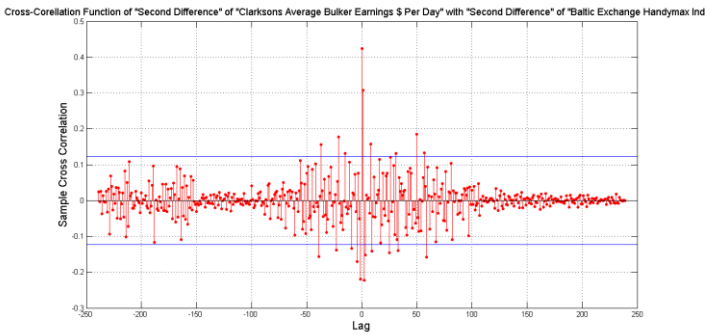

ot of "Second Difference" of "Panamax 76k dwt Secondhand Bulker Resale Prices $ Million" with "Second Difference" of "Baltic Exchange Handymax
Panamax 76k dwt Secondhand Bulker Resale Prices $ Million
Baltic Exchange Handymax Index
Parameter
Time

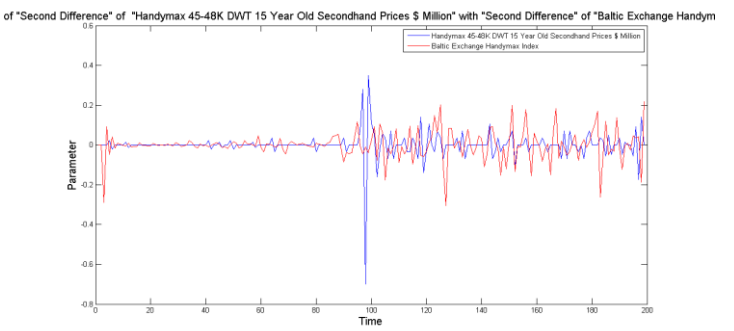

ı-Corellation Function of "Second Difference" of "Panamax 76k dwt Secondhand Bulker Resale Prices $ Million" with "Second Difference" of "Baltic Exchange Handy
Sample Cross Correlation
Lag

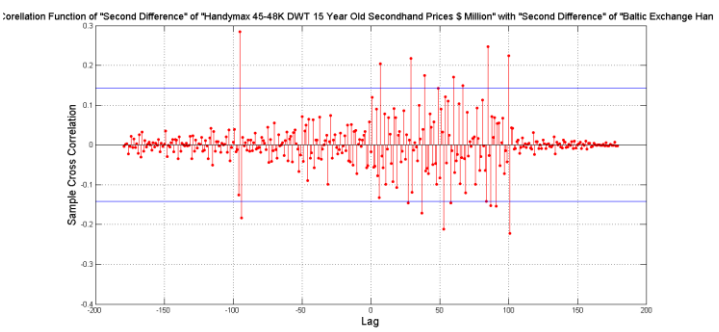

ɪt of "Second Difference" of "Handymax 61k dwt Secondhand Bulker Resale Prices $ Million" with "Second Difference" of "Baltic Exchange Handyma
Handymax 61k dwt Secondhand Bulker Resale Prices $ Million
Baltic Exchange Handymax Index
Parameter
Time


-Corellation Function of "Second Difference" of "Handymax 61k dwt Secondhand Bulker Resale Prices $ Million" with "Second Difference" of "Baltic Exchange Handy
Sample Cross Correlation
Lag


Plot of "Second Difference" of "Clarksons Average Bulker Earnings $ Per Day" with "Second Difference" of "Baltic Exchange Handymax Index"
Clarksons Average Bulker Earnings $ Per Day
Baltic Exchange Handymax Index
Parameter
Time


Cross-Corellation Function of "Second Difference" of "Clarksons Average Bulker Earnings $ Per Day" with "Second Difference" of "Baltic Exchange Handymax Ind
Sample Cross Correlation
Lag


of "Second Difference" of "Handymax 45-48K DWT 15 Year Old Secondhand Prices $ Million" with "Second Difference" of "Baltic Exchange Handym
Handymax 45-48K DWT 15 Year Old Secondhand Prices $ Million
Baltic Exchange Handymax Index
Parameter
Time


:orellation Function of "Second Difference" of "Handymax 45-48K DWT 15 Year Old Secondhand Prices $ Million" with "Second Difference" of "Baltic Exchange Han
Sample Cross Correlation
Lag

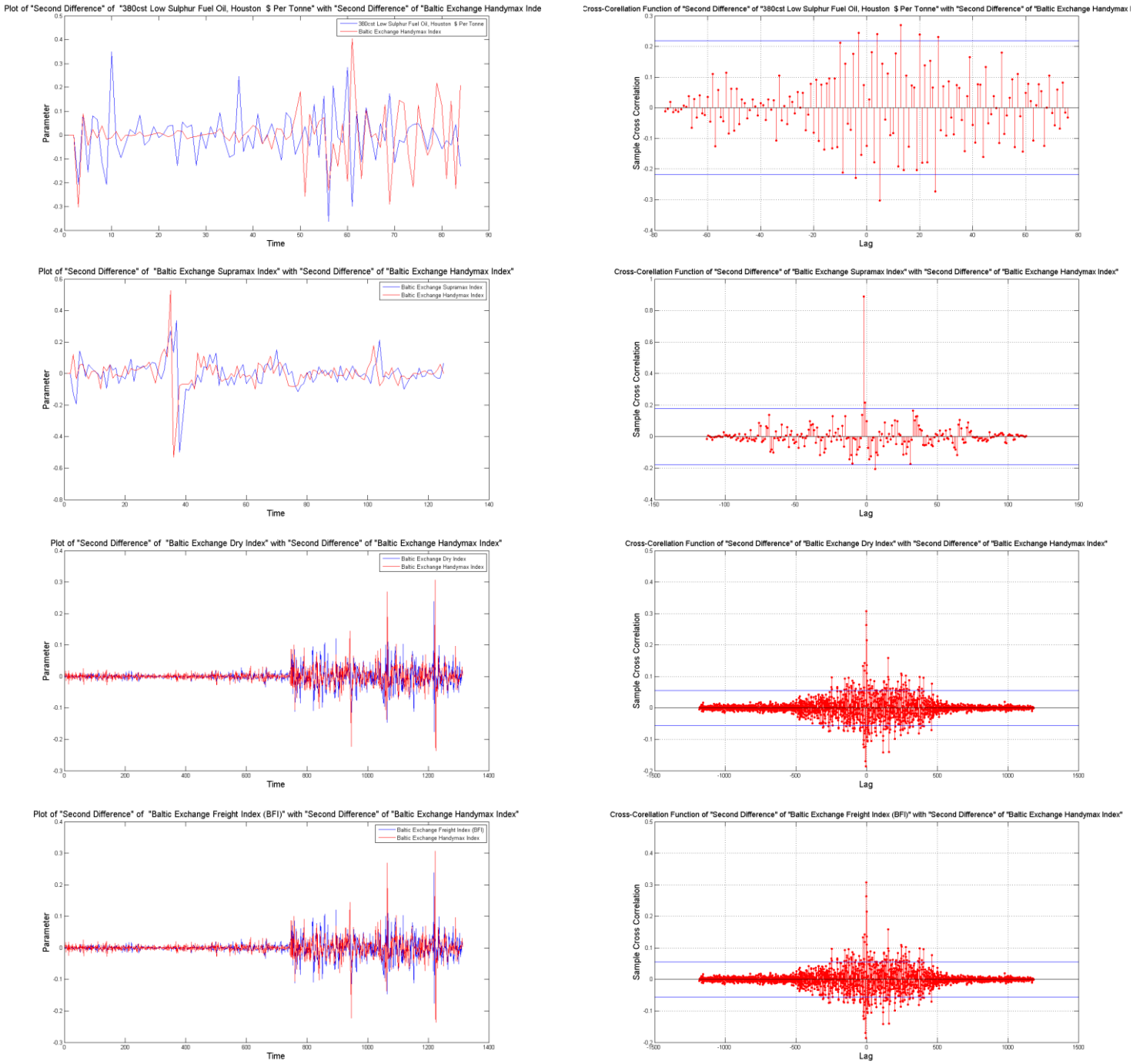


Figure 42 Baltic Exchange Handymax Index complete period correlation graphs

5.2.2 Complete time period Comments

The Baltic Exchange Handymax Index represents the freight market for Handymax vessels. In this case, the most notable correlation is the 0.88 correlation of Baltic Exchange Supramax Index with the Handymax Index. The Supramax follows the Handymax after 3 days. Actually the correlation graph is clean as a school book example. The next strong relation is with the Clarksons Average Bulker Earnings. The correlation value is 0.42 and it seems that there is no lag. This issue of zero lag needs further explanation.

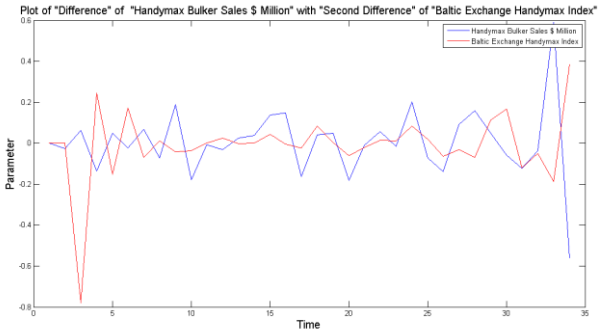
Zero lag in this analysis does not imply that there is no lag time between the changes of the real parameters. Since the parameters are discrete economic timeseries they have a sampling frequency (f_s). If the real time required for the timeseries to adjust is less than the time which corresponds to the sampling frequency then it cannot be assessed. Therefore, zero lag means that there is no lag between the two samples, not that there is no time. Actually it could logical be assumed that the real time is maximum the sampling frequency of the parameter with the lowest sampling frequency, which can be found in the appropriate matrix in annex.

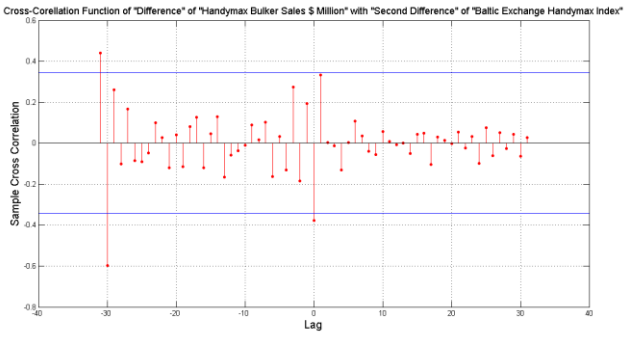
Then comes the Baltic Exchange Dry Index (and the older same index BFI) with a positive correlation of 0.3 with a lag of 1.45 days meaning that Handymax is leading the change. For the sales market it is not easy to reach a conclusion since there are 2 examples with a negative correlation and two examples with positive correlation all of them with a correlation close to 0.28. The interesting point is that there is also a relation with the lag time. A possible explanation may be that the correlation function is not working well with “no changing signals” and due to the data structure and the transformation used there are some periods in those timeseries with no change which may be the reason for the irrational results.

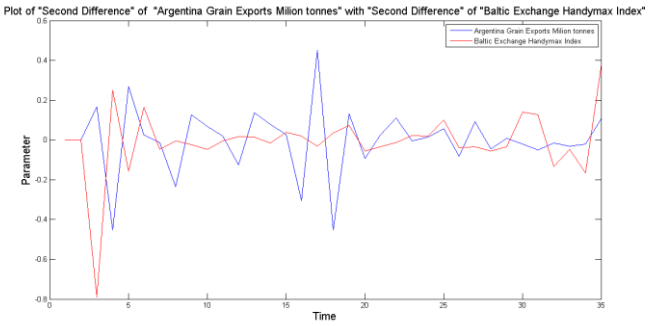
5.2.3 Half time period

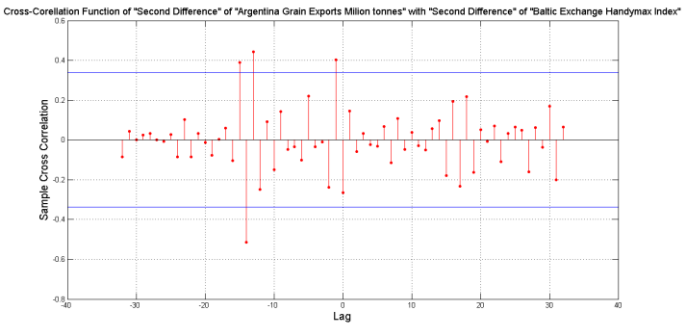
Table 6 Baltic Exchange Handymax Index half period result table

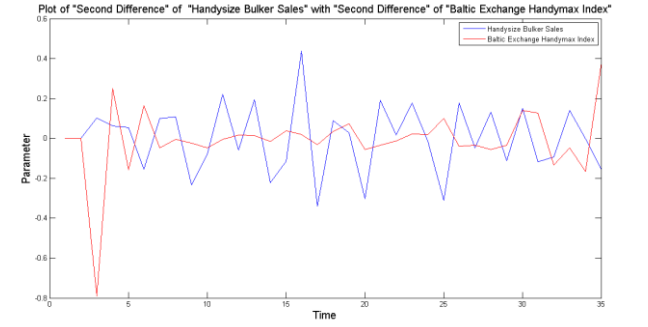
Parameter 1	Transformation 1	Parameter 2	Transformation 2	Lag (days)	Cross Correlation value
'Handymax Bulker Sales $ Million'	'Difference'	'Baltic Exchange Handymax Index'	'Second Difference'	-931,17	-0,59
'Argentina Grain Exports Milion tonnes'	'Second Difference'	'Baltic Exchange Handymax Index'	'Second Difference'	-423,38	-0,51
'Handysize Bulker Sales'	'Second Difference'	'Baltic Exchange Handymax Index'	'Second Difference'	-391,98	-0,46
'Capesize 120k $ per cgt'	'Difference'	'Baltic Exchange Handymax Index'	'Second Difference'	-242,39	0,62
'Capesize 150 155k $ per cgt'	'Difference'	'Baltic Exchange Handymax Index'	'Second Difference'	-242,37	0,62
'Capesize 176-180K DWT Newbuilding Prices $ Million'	'Difference'	'Baltic Exchange Handymax Index'	'Second Difference'	-242,35	0,62
'Second hand 10 years over New building Panamax'	'Second Difference'	'Baltic Exchange Handymax Index'	'Second Difference'	-389,11	-0,53
'Average Bulkcarrier $ per cgt'	'Second Difference'	'Baltic Exchange Handymax Index'	'Second Difference'	-242,40	0,53

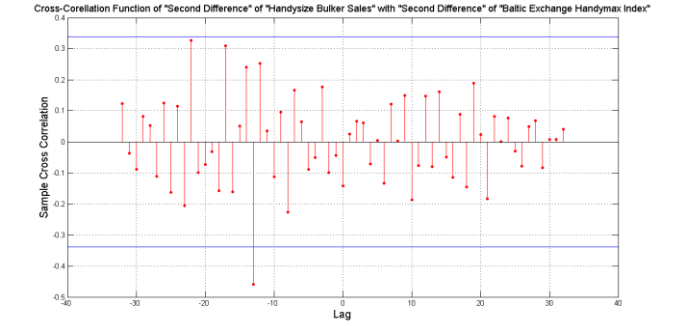


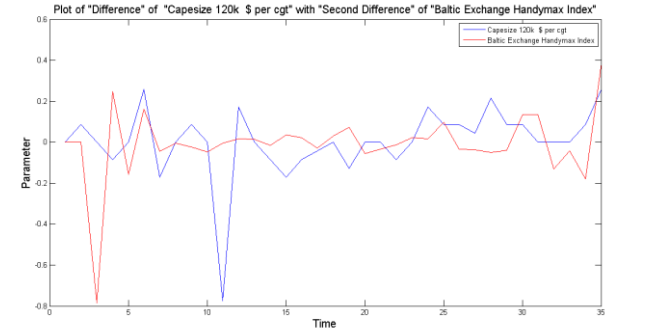


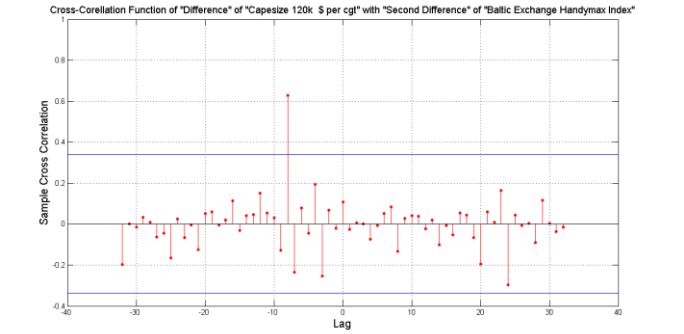

Plot of "Second Difference" of "Argentina Grain Exports Milion tonnes" with "Second Difference" of "Baltic Exchange Handymax Index"
Argentina Grain Exports Milion tonnes
Baltic Exchange Handymax Index
Parameter
Time

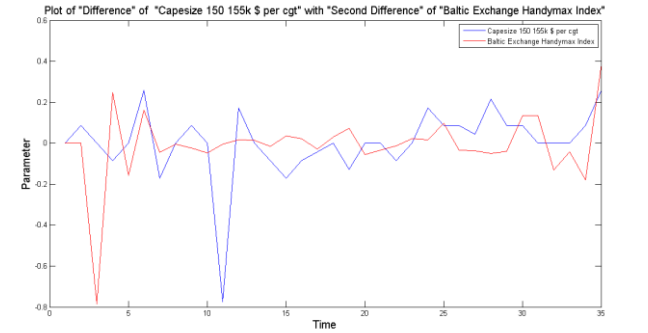

Cross-Corellation Function of "Second Difference" of "Argentina Grain Exports Milion tonnes" with "Second Difference" of "Baltic Exchange Handymax Index"
Sample Cross Correlation
Lag

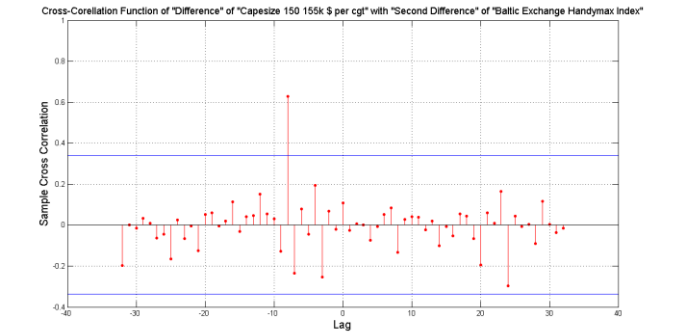

Plot of "Second Difference" of "Handysize Bulker Sales" with "Second Difference" of "Baltic Exchange Handymax Index"
Handysize Bulker Sales
Baltic Exchange Handymax Index
Parameter
Time

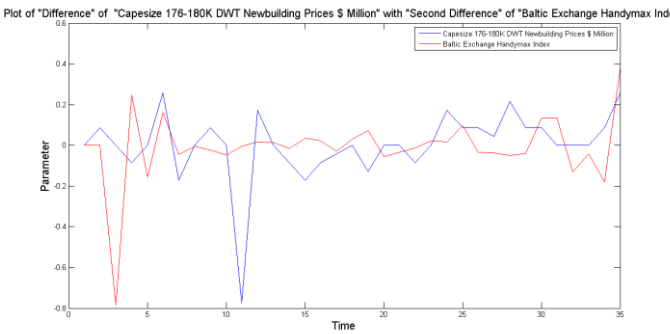

Cross-Corellation Function of "Second Difference" of "Handysize Bulker Sales" with "Second Difference" of "Baltic Exchange Handymax Index"
Sample Cross Correlation
Lag

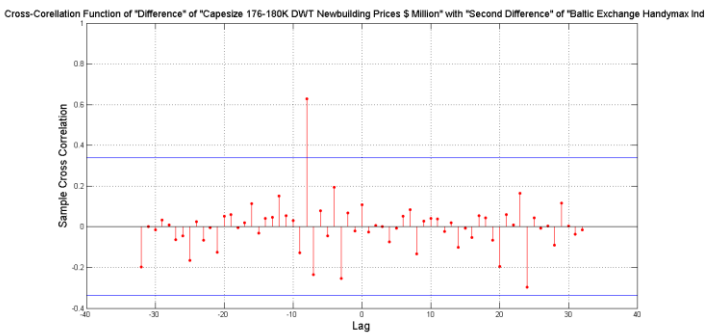

Plot of "Difference" of "Capesize 120k $ per cgt" with "Second Difference" of "Baltic Exchange Handymax Index"
Capesize 120k $ per cgt
Baltic Exchange Handymax Index
Parameter
Time


Cross-Corellation Function of "Difference" of "Capesize 120k $ per cgt" with "Second Difference" of "Baltic Exchange Handymax Index"
Sample Cross Correlation
Lag


Plot of "Difference" of "Capesize 150 155k $ per cgt" with "Second Difference" of "Baltic Exchange Handymax Index"
Capesize 150 155k $ per cgt
Baltic Exchange Handymax Index
Parameter
Time


Cross-Corellation Function of "Difference" of "Capesize 150 155k $ per cgt" with "Second Difference" of "Baltic Exchange Handymax Index"
Sample Cross Correlation
Lag


Plot of "Difference" of "Capesize 176-180K DWT Newbuilding Prices $ Million" with "Second Difference" of "Baltic Exchange Handymax Index"
Capesize 176-180K DWT Newbuilding Prices $ Million
Baltic Exchange Handymax Index
Parameter
Time


Cross-Corellation Function of "Difference" of "Capesize 176-180K DWT Newbuilding Prices $ Million" with "Second Difference" of "Baltic Exchange Handymax Ind
Sample Cross Correlation
Lag

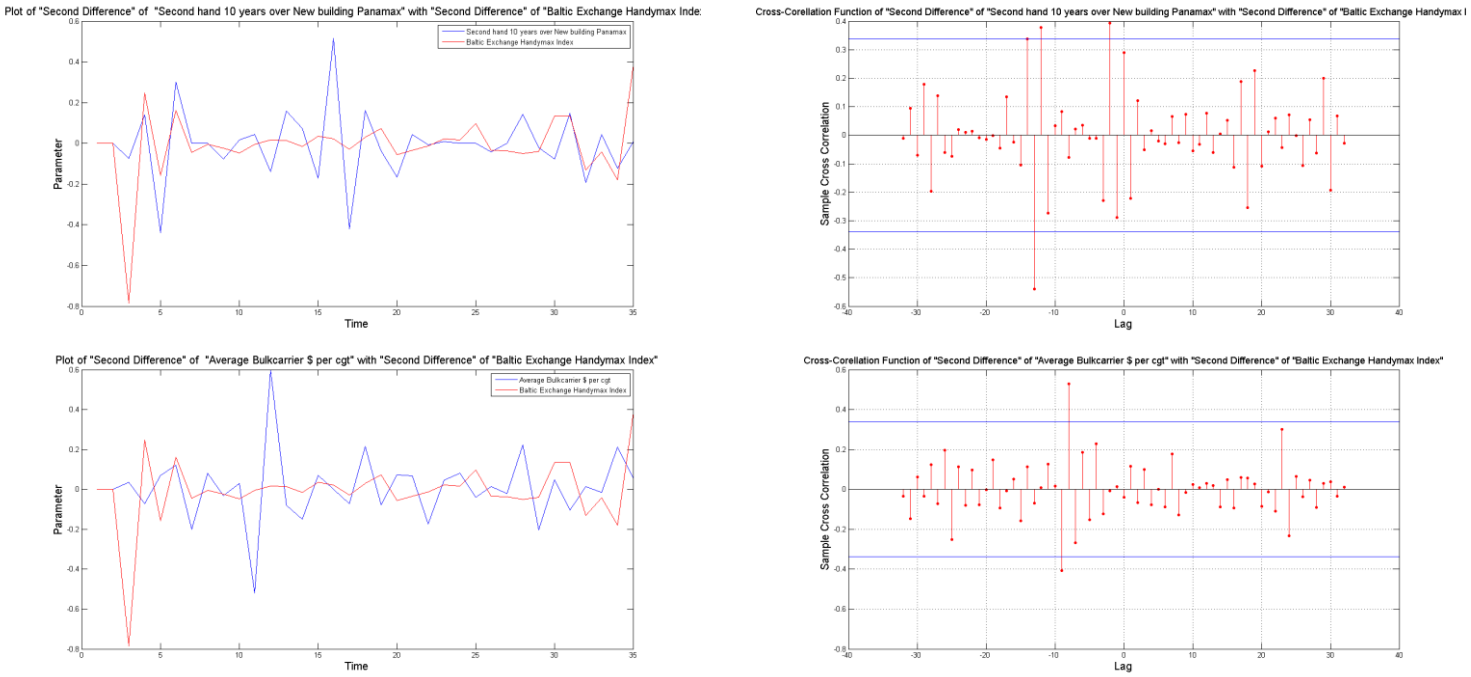


Figure 43 Baltic Exchange Handymax Index half period correlation graphs

5.2.4 Half time period Comments

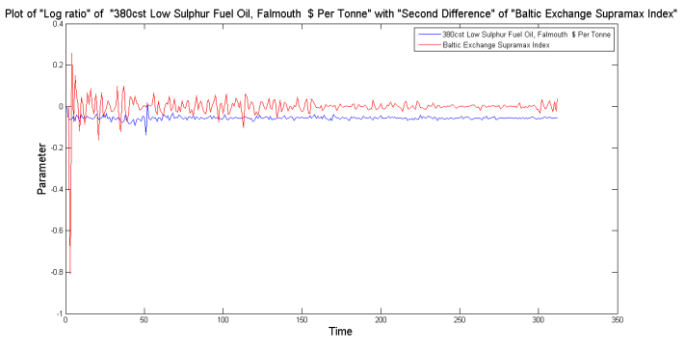
For the half period the strongest correlation increased to 0.62 for the Newbuilding market of the Capesizes. For all of the timeseries the Handymax is positive correlated and it is leading the Capesize newbuilding with a lag of almost 250 days. The same phenomenon is observed in the cost of the newbuilding of the Average Bulkcarrier with the same lag but with a strength of 0.53 this time. The second strongest correlation is estimated with the sales market of Handymax vessels, negative at 0.59. The lag is 2.5 years with the Handymax index leading and the sales following. The problem in this case is that the highest correlation is observed at the end of the timeserie which is not the most valid case. In the Handysize sales market observed again a negative correlation of 0.46 but this time with a lag close to one year. The last observation is a negative correlation of 0.51 strength with the Argentina Grain Exports at 400 days lag.

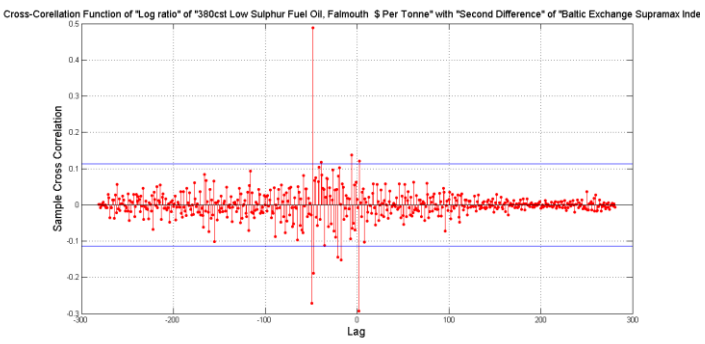
5.3 Baltic Exchange Supramax Index

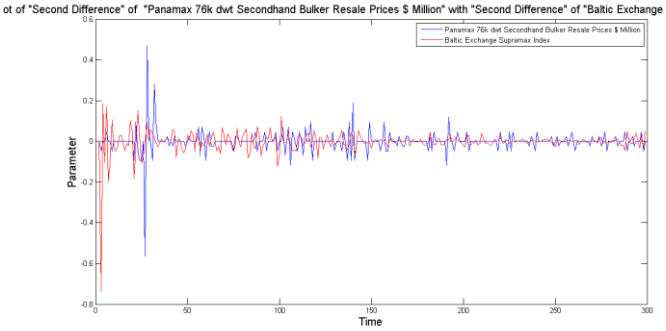
5.3.1 Complete time period

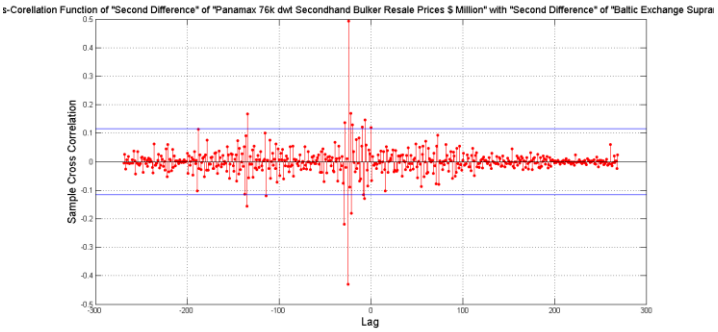
Table 7 Baltic Exchange Supramax Index complete period result table

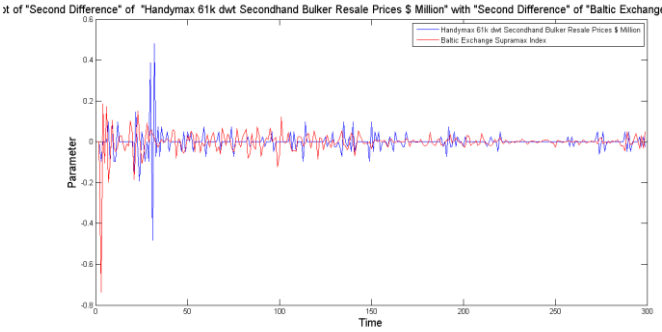
Parameter 1	Transformation 1	Parameter 2	Transformation 2	Lag (days)	Cross Correlation value
'380cst Low Sulphur Fuel Oil, Falmouth $ Per Tonne'	'Log ratio'	'Baltic Exchange Supramax Index'	'Second Difference'	-350,15	0,48
'Panamax 76k dwt Secondhand Bulker Resale Prices $ Million'	'Second Difference'	'Baltic Exchange Supramax Index'	'Second Difference'	-174,82	0,49
'Handymax 61k dwt Secondhand Bulker Resale Prices $ Million'	'Second Difference'	'Baltic Exchange Supramax Index'	'Second Difference'	-203,95	0,48
'Handysize 33k dwt Secondhand Bulker Resale Prices $ Million'	'Second Difference'	'Baltic Exchange Supramax Index'	'Second Difference'	-182,10	-0,36
'Bulkcarrier Average Newbuilding Prices'	'Second Difference'	'Baltic Exchange Supramax Index'	'Second Difference'	-1238	-0,39
'Clarksons Average Bulker Earnings $ Per Day'	'Second Difference'	'Baltic Exchange Supramax Index'	'Second Difference'	0	0,41
'Panamax 75K Bulkcarrier 10 Year Old Secondhand Prices $ Million'	'Second Difference'	'Baltic Exchange Supramax Index'	'Second Difference'	-1186,85	0,29
'Baltic Exchange Supramax Index'	'Second Difference'	'Baltic Exchange Handymax Index'	'Second Difference'	-2,92	0,88

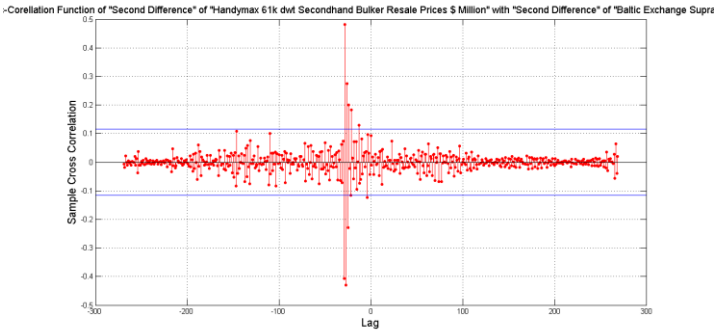


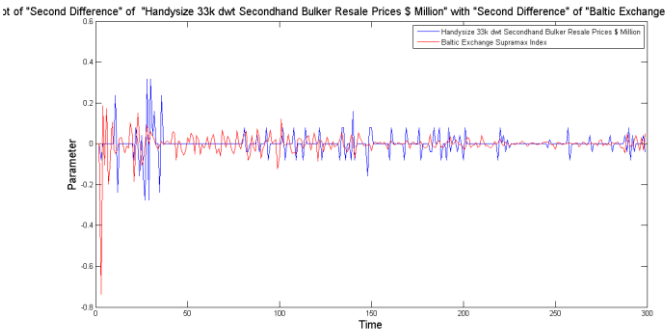


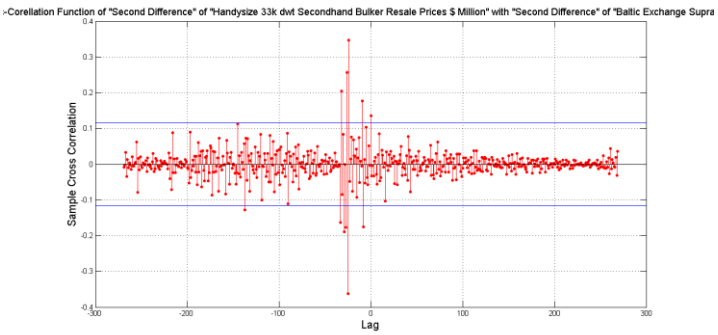

ot of "Second Difference" of "Panamax 76k dwt Secondhand Bulker Resale Prices $ Million" with "Second Difference" of "Baltic Exchange Supramax
Panamax 76k dwt Secondhand Bulker Resale Prices $ Million
Baltic Exchange Supramax Index
Parameter
Time

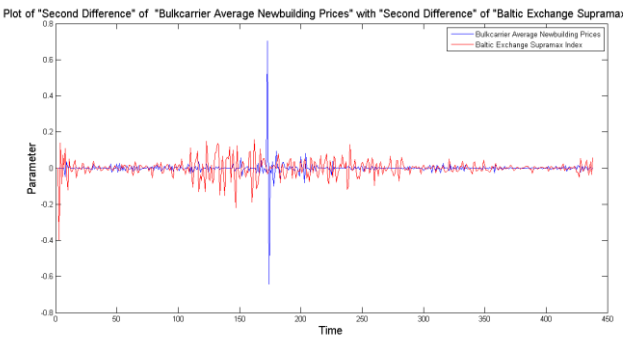

s-Corellation Function of "Second Difference" of "Panamax 76k dwt Secondhand Bulker Resale Prices $ Million" with "Second Difference" of "Baltic Exchange Supra
Sample Cross Correlation
Lag

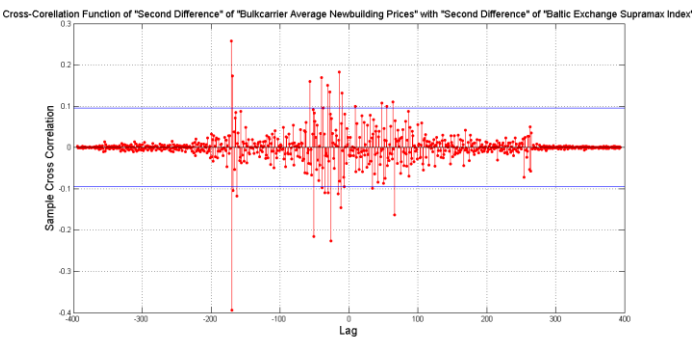

ot of "Second Difference" of "Handymax 61k dwt Secondhand Bulker Resale Prices $ Million" with "Second Difference" of "Baltic Exchange Supramax
Handymax 61k dwt Secondhand Bulker Resale Prices $ Million
Baltic Exchange Supramax Index
Parameter
Time

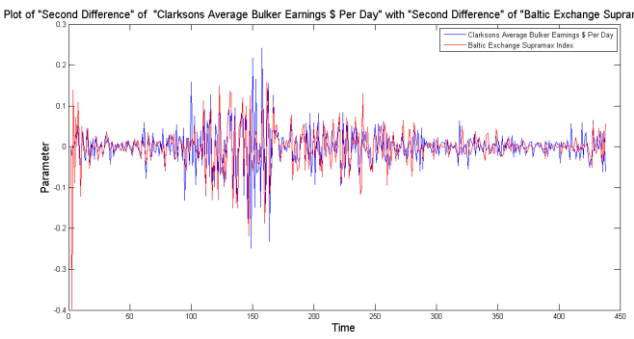

s-Corellation Function of "Second Difference" of "Handymax 61k dwt Secondhand Bulker Resale Prices $ Million" with "Second Difference" of "Baltic Exchange Supra
Sample Cross Correlation
Lag

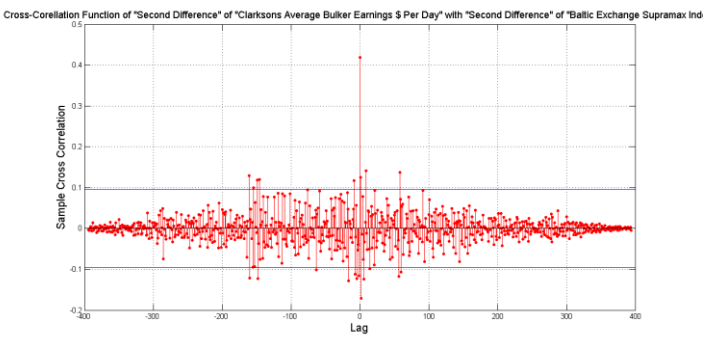

ot of "Second Difference" of "Handysize 33k dwt Secondhand Bulker Resale Prices $ Million" with "Second Difference" of "Baltic Exchange Supramax
Handysize 33k dwt Secondhand Bulker Resale Prices $ Million
Baltic Exchange Supramax Index
Parameter
Time


s-Corellation Function of "Second Difference" of "Handysize 33k dwt Secondhand Bulker Resale Prices $ Million" with "Second Difference" of "Baltic Exchange Supra
Sample Cross Correlation
Lag


Plot of "Second Difference" of "Bulkcarrier Average Newbuilding Prices" with "Second Difference" of "Baltic Exchange Supramax Index"
Bulkcarrier Average Newbuilding Prices
Baltic Exchange Supramax Index
Parameter
Time


Cross-Corellation Function of "Second Difference" of "Bulkcarrier Average Newbuilding Prices" with "Second Difference" of "Baltic Exchange Supramax Index"
Sample Cross Correlation
Lag


Plot of "Second Difference" of "Clarksons Average Bulker Earnings $ Per Day" with "Second Difference" of "Baltic Exchange Supramax Index"
Clarksons Average Bulker Earnings $ Per Day
Baltic Exchange Supramax Index
Parameter
Time


Cross-Corellation Function of "Second Difference" of "Clarksons Average Bulker Earnings $ Per Day" with "Second Difference" of "Baltic Exchange Supramax Ind
Sample Cross Correlation
Lag

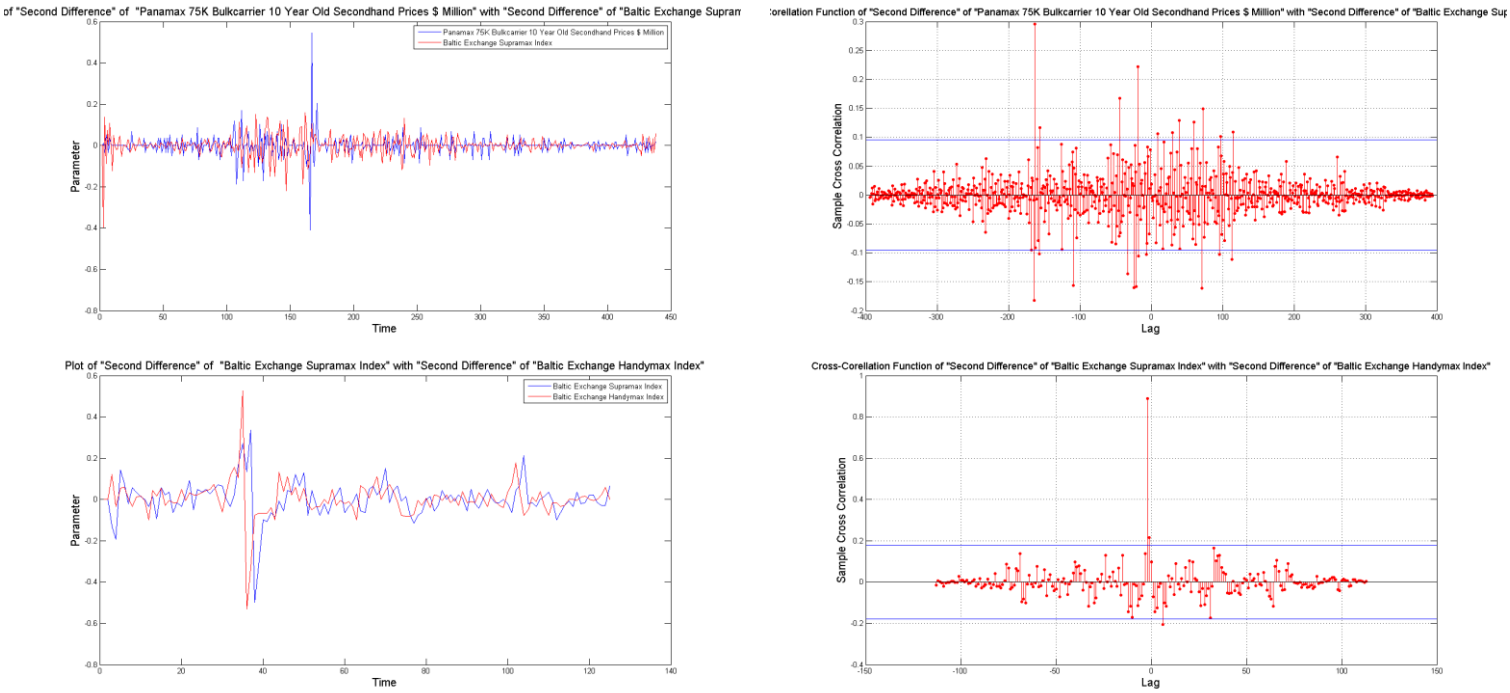


Figure 44 Baltic Exchange Supramax Index complete period correlation graphs

5.3.2 Baltic Exchange Supramax Index complete period comments

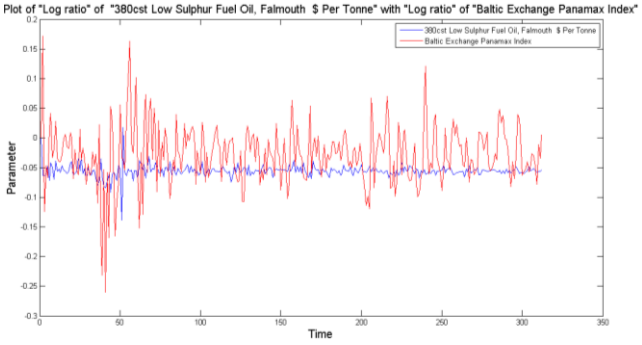
The strongest correlations is observed with the Handymax Index as it has been already explained. The correlation with the sales market is present with the Panamax, Handymax and Handysise vessels. All of them have a lag of almost 200 days with the Supramax index leading. For the Panamax and the Handymax the correlation is positive while for the Handysize is negative. Howevert the plots and the correlation graphs have a similar pattern and there is a possibility that the negative value is a random effect due to “no changing signals” effect. The next bigger correlation is positive 0.48 with the Low Sulphur Fuel oil cost at Falmouth with a lag of almost a year leading the Supramax index. Then there is a clear correlation of 0.41 with Clarksons Average Earnings at zero lag. The newbuilding market is represented by the Bulkcarrier Average Newbuilding Prices which are negative correlated 0.39 with the Supramax index leading for almost 3.4 years.

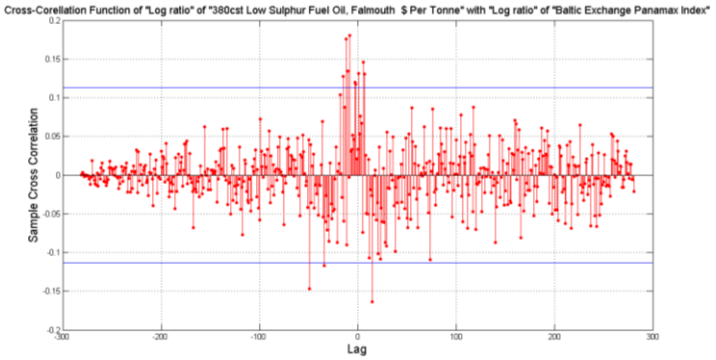
5.4 Baltic Exchange Panamax Index

5.4.1 Complete time period

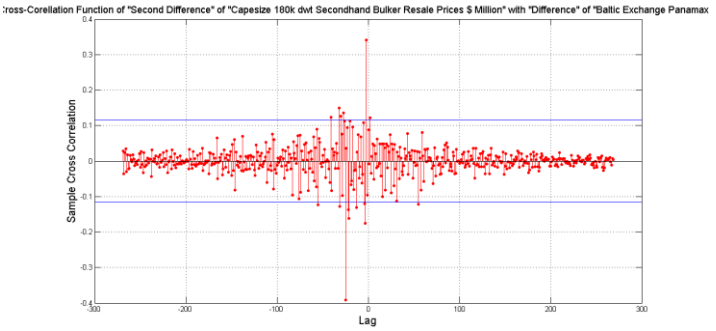
Table 8 Baltic Exchange Panamax Index complete period result table

Parameter 1	Transformation 1	Parameter 2	Transformation 2	Lag (days)	Cross Correlation value
'380cst Low Sulphur Fuel Oil, Falmouth $ Per Tonne'	'Log ratio'	'Baltic Exchange Panamax Index'	'Second Difference'	-350,15	0,33
'Capesize 180k dwt Secondhand Bulker Resale Prices $ Million'	'Second Difference'	'Baltic Exchange Panamax Index'	'Difference'	-182,10	-0,39
'Panamax 76k dwt Secondhand Bulker Resale Prices $ Million'	'Second Difference'	'Baltic Exchange Panamax Index'	'Difference'	-182,10	-0,47
'Handymax 61k dwt Secondhand Bulker Resale Prices $ Million'	'Second Difference'	'Baltic Exchange Panamax Index'	'Second Difference'	-203,95	0,38
'Bulkcarrier Average Newbuilding Prices'	'Second Difference'	'Baltic Exchange Panamax Index'	'Second Difference'	-65,54	-0,33
'Clarksons Average Bulker Earnings $ Per Day'	'Second Difference'	'Baltic Exchange Panamax Index'	'Second Difference'	0	0,49
'Baltic Exchange Supramax Index'	'Second Difference'	'Baltic Exchange Panamax Index'	'Second Difference'	-1,46	0,31
'Baltic Exchange Dry Index'	'Second Difference'	'Baltic Exchange Panamax Index'	'Second Difference'	0	0,51
'Baltic Exchange Capesize Index'	'Second Difference'	'Baltic Exchange Panamax Index'	'Second Difference'	0	0,34
'Baltic Exchange Panamax Index'	'Second Difference'	'Baltic Exchange Freight Index (BFI)'	'Second Difference'	1,46	0,49

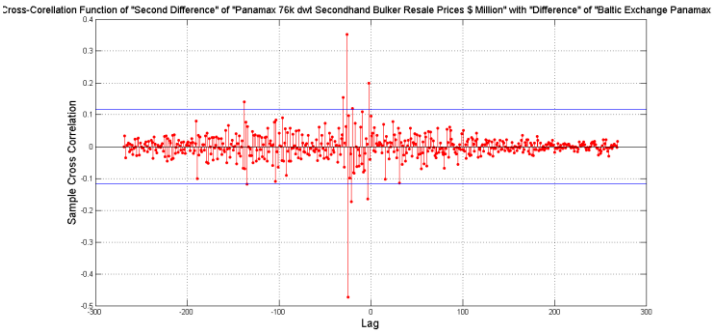

Plot of "Log ratio" of "380cst Low Sulphur Fuel Oil, Falmouth $ Per Tonne" with "Log ratio" of "Baltic Exchange Panamax Index"
380cst Low Sulphur Fuel Oil, Falmouth $ Per Tonne
Baltic Exchange Panamax Index
Parameter
Time

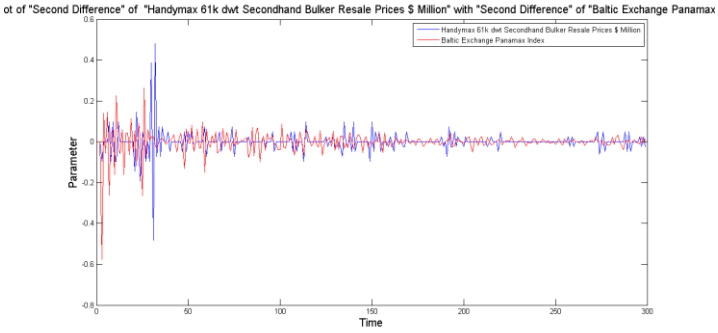

Cross-Corellation Function of "Log ratio" of "380cst Low Sulphur Fuel Oil, Falmouth $ Per Tonne" with "Log ratio" of "Baltic Exchange Panamax Index"
Sample Cross Correlation
Lag

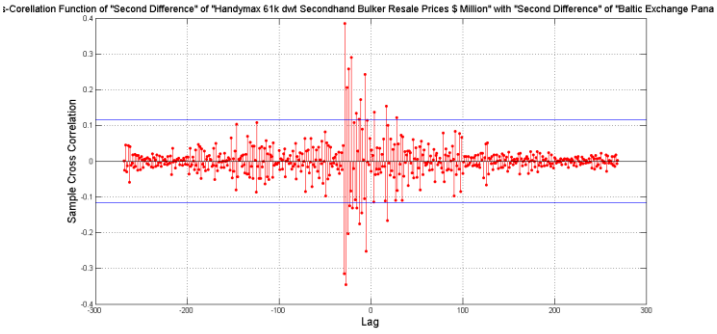

Plot of "Second Difference" of "Capesize 180k dwt Secondhand Bulker Resale Prices $ Million" with "Difference" of "Baltic Exchange Panamax Ind
Capesize 180k dwt Secondhand Bulker Resale Prices $ Million
Baltic Exchange Panamax Index
Parameter
Time

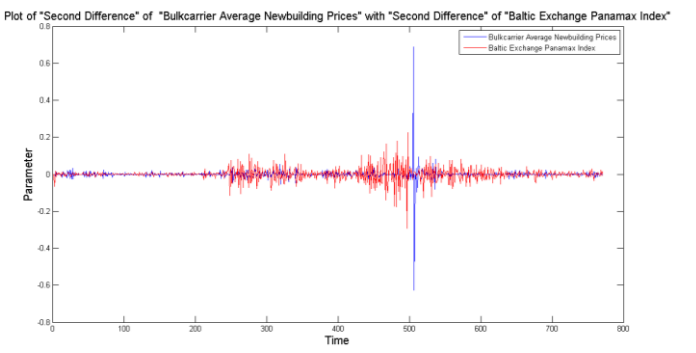

ross-Corellation Function of "Second Difference" of "Capesize 180k dwt Secondhand Bulker Resale Prices $ Million" with "Difference" of "Baltic Exchange Panamax
Sample Cross Correlation
Lag

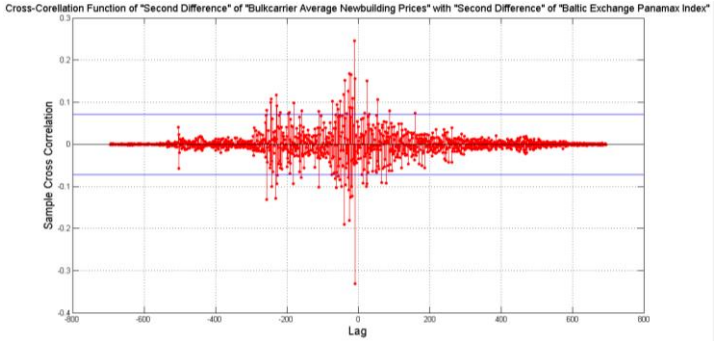

Plot of "Second Difference" of "Panamax 76k dwt Secondhand Bulker Resale Prices $ Million" with "Difference" of "Baltic Exchange Panamax Inde
Panamax 76k dwt Secondhand Bulker Resale Prices $ Million
Baltic Exchange Panamax Index
Parameter
Time


Cross-Corellation Function of "Second Difference" of "Panamax 76k dwt Secondhand Bulker Resale Prices $ Million" with "Difference" of "Baltic Exchange Panamax
Sample Cross Correlation
Lag


ot of "Second Difference" of "Handymax 61k dwt Secondhand Bulker Resale Prices $ Million" with "Second Difference" of "Baltic Exchange Panamax
Handymax 61k dwt Secondhand Bulker Resale Prices $ Million
Baltic Exchange Panamax Index
Parameter
Time


-Corellation Function of "Second Difference" of "Handymax 61k dwt Secondhand Bulker Resale Prices $ Million" with "Second Difference" of "Baltic Exchange Pana
Sample Cross Correlation
Lag


Plot of "Second Difference" of "Bulkcarrier Average Newbuilding Prices" with "Second Difference" of "Baltic Exchange Panamax Index"
Bulkcarrier Average Newbuilding Prices
Baltic Exchange Panamax Index
Parameter
Time


Cross-Corellation Function of "Second Difference" of "Bulkcarrier Average Newbuilding Prices" with "Second Difference" of "Baltic Exchange Panamax Index"
Sample Cross Correlation
Lag

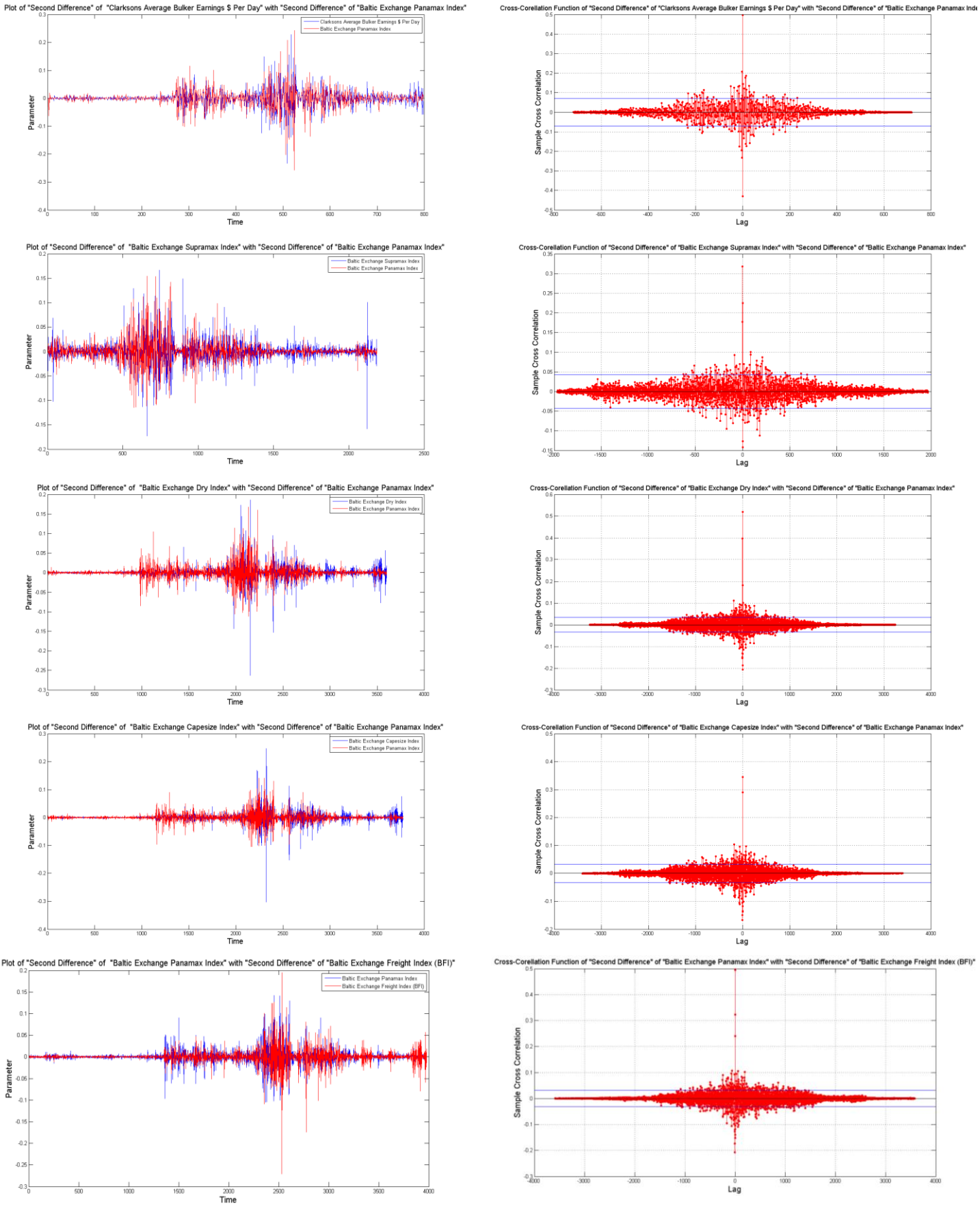


Figure 45 Baltic Exchange Panamax Index complete period correlation graphs

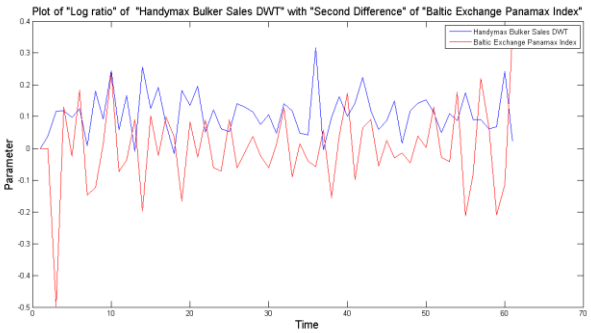
5.4.2 Baltic Exchange Panamax Index complete period comments

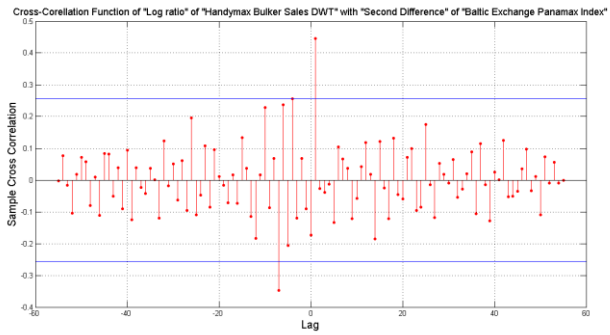
The Panamax index is the first index which correlates with the most Baltic Exchange indices. So there is correlation with BDI, BFI, BCI and BSI all of them positive correlated with strength from 0.51 to 0.31. The lag varies from 1.5 days (leading or following) to zero lag. The same phenomenon is observed with the Clarksons Average Bulker Earnings. Next is the sales market. The resales prices with Capesize, Panamax and Handymax are correlated with a strength from 0.47 to 0.39 just like they were correlated at the complete period of the Supramax Index. The correlation with the Fuel oil in Falmouth is still valid with the same lag but with lowest strength at 0.33.

5.4.3 Half time period

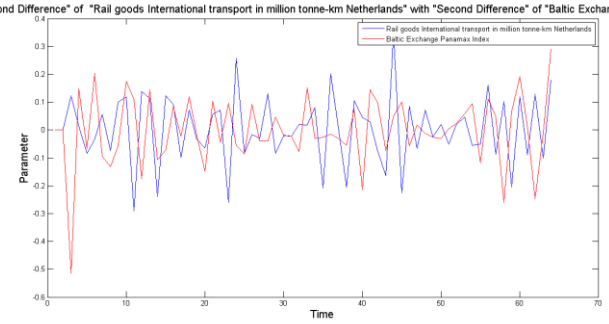
Table 9 Baltic Exchange Panamax Index half period result table

Parameter 1	Transformation 1	Parameter 2	Transformation 2	Lag (days)	Cross Correlation value
'Handymax Bulker Sales DWT'	'Log ratio'	'Baltic Exchange Panamax Index'	'Second Difference'	31,03	0,44
'Rail goods International transport in million tonne-km Netherlands'	'Second Difference'	'Baltic Exchange Panamax Index'	'Second Difference'	-332,02	0,35
'Dry Cargo Average Newbuilding Prices $ Per DWT'	'Second Difference'	'Baltic Exchange Panamax Index'	'Second Difference'	-90,89	0,44
'Second hand 5 years over New building Panamax'	'Second Difference'	'Baltic Exchange Panamax Index'	'Second Difference'	-89,79	-0,45
'EU-28 Grain Exports Milion tonnes'	'Log ratio'	'Baltic Exchange Panamax Index'	'Second Difference'	90,72	0,27
'Australia Grain Exports Milion tonnes'	'Log ratio'	'Baltic Exchange Panamax Index'	'Second Difference'	90,72	0,37
'Baltic Exchange Dry Index'	'Second Difference'	'Baltic Exchange Panamax Index'	'Second Difference'	0	0,62

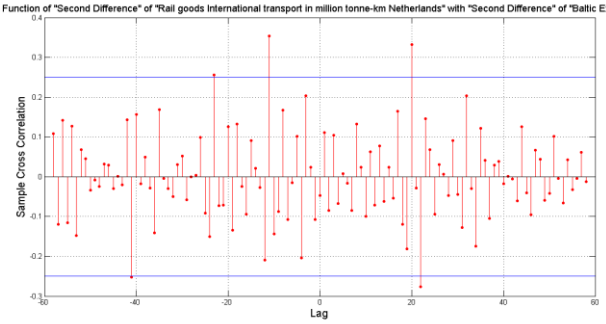




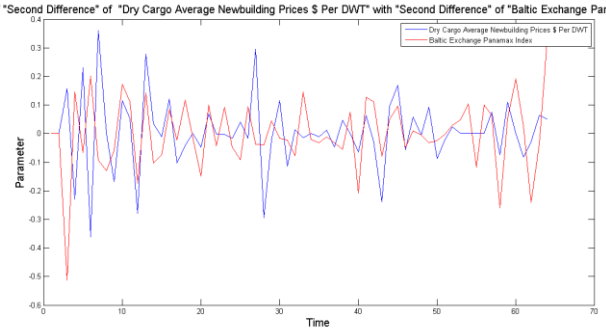
t of "Second Difference" of "Rail goods International transport in million tonne-km Netherlands" with "Second Difference" of "Baltic Exchange Panama



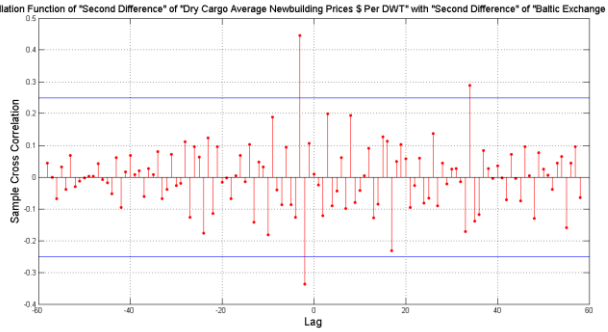
Corellation Function of "Second Difference" of "Rail goods International transport in million tonne-km Netherlands" with "Second Difference" of "Baltic Exchange Pan



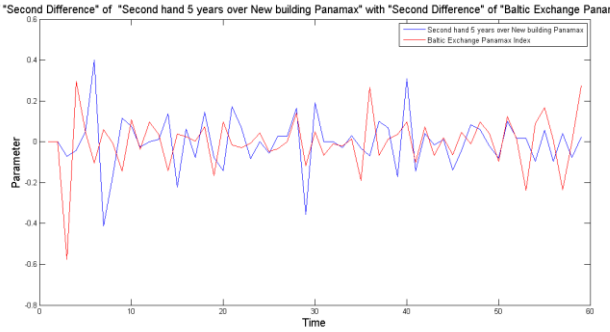
Plot of "Second Difference" of "Dry Cargo Average Newbuilding Prices $ Per DWT" with "Second Difference" of "Baltic Exchange Panamax Index



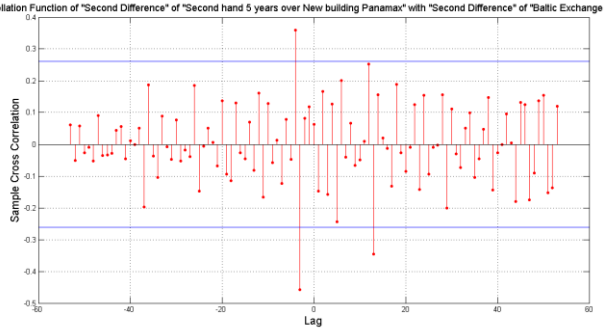
Cross-Corellation Function of "Second Difference" of "Dry Cargo Average Newbuilding Prices $ Per DWT" with "Second Difference" of "Baltic Exchange Panamax Ir



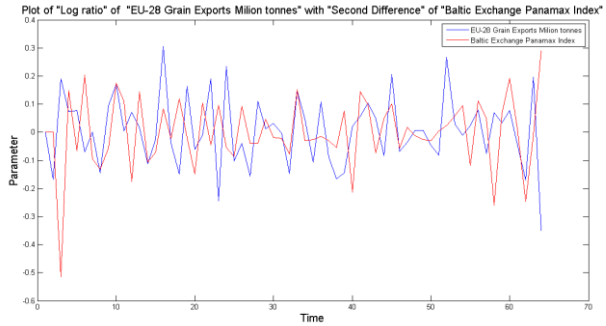
Plot of "Second Difference" of "Second hand 5 years over New building Panamax" with "Second Difference" of "Baltic Exchange Panamax Index'



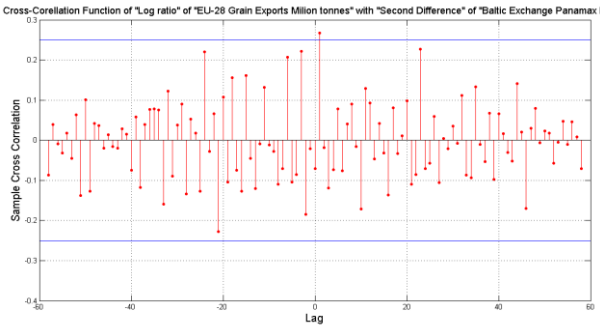
Cross-Corellation Function of "Second Difference" of "Second hand 5 years over New building Panamax" with "Second Difference" of "Baltic Exchange Panamax In



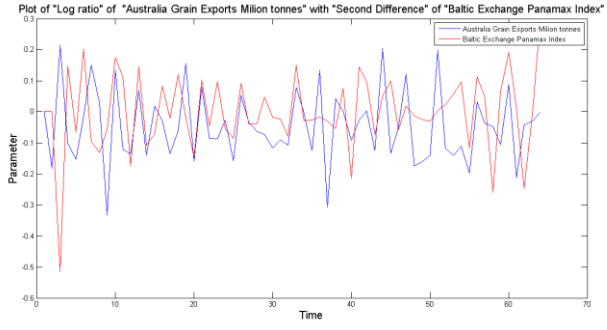
Plot of "Log ratio" of "EU-28 Grain Exports Milion tonnes" with "Second Difference" of "Baltic Exchange Panamax Index"



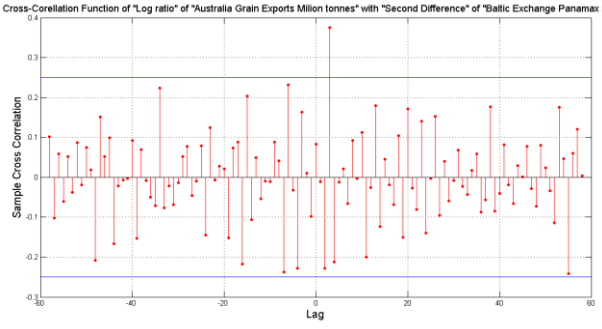
Cross-Corellation Function of "Log ratio" of "EU-28 Grain Exports Milion tonnes" with "Second Difference" of "Baltic Exchange Panamax Index"



Plot of "Log ratio" of "Australia Grain Exports Milion tonnes" with "Second Difference" of "Baltic Exchange Panamax Index"



Cross-Corellation Function of "Log ratio" of "Australia Grain Exports Milion tonnes" with "Second Difference" of "Baltic Exchange Panamax Index"



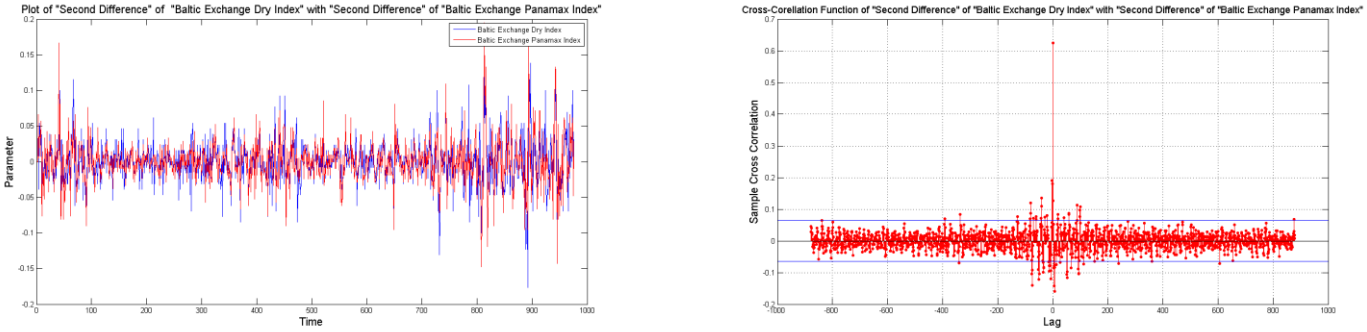


Figure 46 Baltic Exchange Panamax Index half period correlation graphs

5.4.4 Baltic Exchange Panamax Index half period comments

The correlation with the BDI increased to 0.62 in half period. This time the newbuilding market represented by the Average Newbuilding price with a 0.44 positive correlation and the BDI is leading by 3 months. The sales market is represented by Handymax sales with 0.44 positive but this time BDI is follows the sales by one month. A possible explanation may be that the sales market in general has a frequency sample of one month. One month is a great time period for the freight market and the values may fluctuate a lot. So one lag period for this case is a total different period for each one of the parameters. The noticeable correlation is the positive correlation of the Grain Exports of both Australia and EU, both of them in a lag of one month and with a power of 0.37 and 0.27 respectively. Also the relation between the Rail goods International transport of Netherlands and the Panamax Index is of power of 0.35 but this seems to be a random correlation.

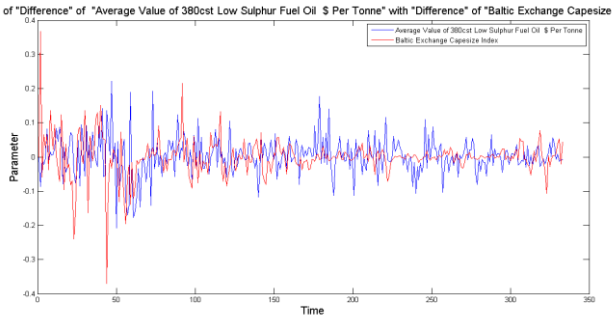
5.5 Baltic Exchange Capesize Index

5.5.1 Complete time period

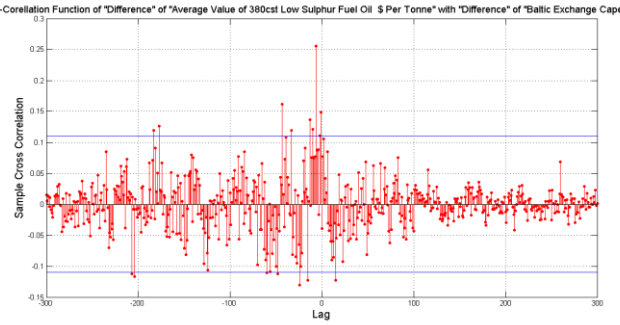
Table 10 Baltic Exchange Capesize Index complete period result table

Parameter 1	Transformation 1	Parameter 2	Transformation 2	Lag (days)	Cross Correlation value
'Average Value of 380cst Low Sulphur Fuel Oil $ Per Tonne'	'Difference'	'Baltic Exchange Capesize Index'	'Difference'	-43,78	0,26
'Panamax 76k dwt Secondhand Bulker Resale Prices $ Million'	'Second Difference'	'Baltic Exchange Capesize Index'	'Second Difference'	-174,82	0,31
'Handymax 61k dwt Secondhand Bulker Resale Prices $ Million'	'Second Difference'	'Baltic Exchange Capesize Index'	'Second Difference'	-196,67	0,31
'Clarksons Average Bulker Earnings $ Per Day'	'Log Difference'	'Baltic Exchange Capesize Index'	'Log Difference'	-7,2	0.58
'380cst Low Sulphur Fuel Oil, Los Angeles $ Per Tonne'	'Second Difference'	'Baltic Exchange Capesize Index'	'Second Difference'	-21,62	0,40
'Baltic Exchange Dry Index'	'Second Difference'	'Baltic Exchange Capesize Index'	'Second Difference'	0	0,66
'Bulkcarrier Average Newbuilding Prices'	'Log Difference'	'Baltic Exchange Capesize Index'	'Second Difference'	-174,78	0,28
'Baltic Exchange Capesize Index'	'Second Difference'	'Baltic Exchange Panamax Index'	'Second Difference'	0	0,34
'Baltic Exchange Capesize Index'	'Second Difference'	'Baltic Exchange Freight Index (BFI)'	'Second Difference'	0	0,65

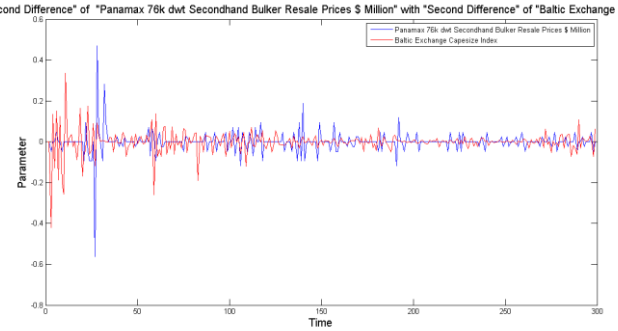
Plot of "Difference" of "Average Value of 380cst Low Sulphur Fuel Oil $ Per Tonne" with "Difference" of "Baltic Exchange Capesize Index"



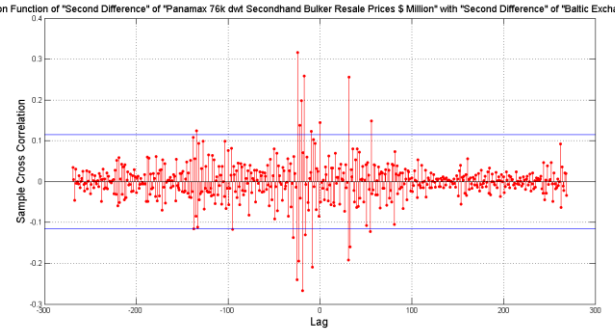
Cross-Corellation Function of "Difference" of "Average Value of 380cst Low Sulphur Fuel Oil $ Per Tonne" with "Difference" of "Baltic Exchange Capesize Index



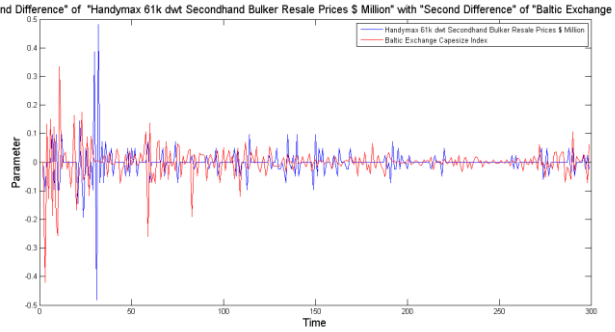
lot of "Second Difference" of "Panamax 76k dwt Secondhand Bulker Resale Prices $ Million" with "Second Difference" of "Baltic Exchange Capesize



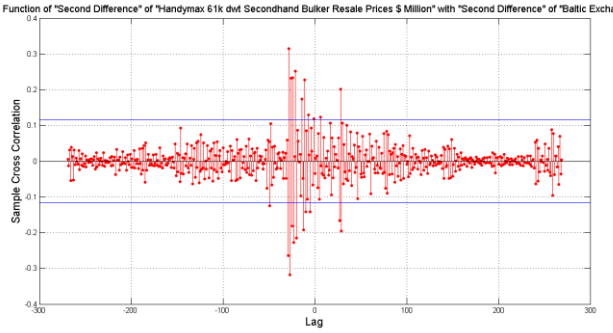
s-Corellation Function of "Second Difference" of "Panamax 76k dwt Secondhand Bulker Resale Prices $ Million" with "Second Difference" of "Baltic Exchange Capes



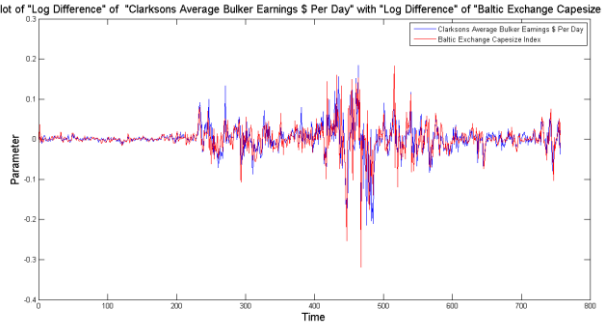
ot of "Second Difference" of "Handymax 61k dwt Secondhand Bulker Resale Prices $ Million" with "Second Difference" of "Baltic Exchange Capesize



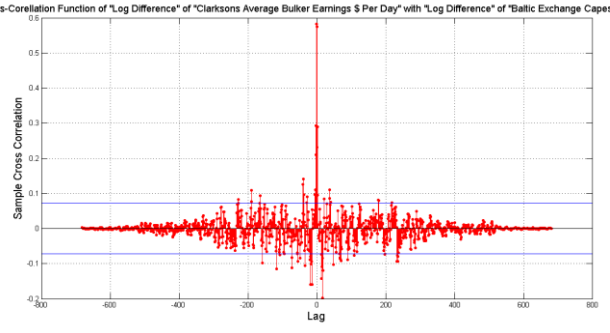
ı-Corellation Function of "Second Difference" of "Handymax 61k dwt Secondhand Bulker Resale Prices $ Million" with "Second Difference" of "Baltic Exchange Cape



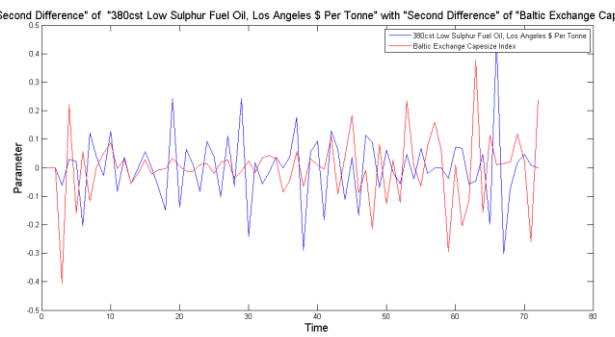
Plot of "Log Difference" of "Clarksons Average Bulker Earnings $ Per Day" with "Log Difference" of "Baltic Exchange Capesize Index"



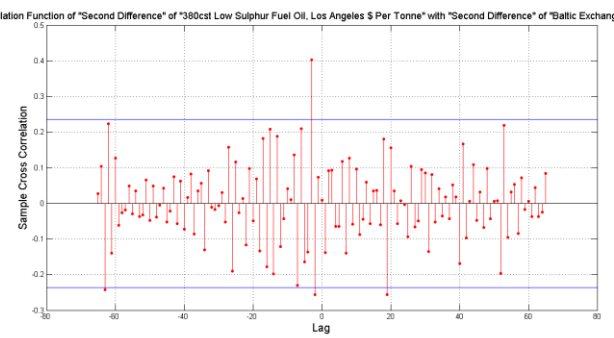
Cross-Corellation Function of "Log Difference" of "Clarksons Average Bulker Earnings $ Per Day" with "Log Difference" of "Baltic Exchange Capesize Index"



Plot of "Second Difference" of "380cst Low Sulphur Fuel Oil, Los Angeles $ Per Tonne" with "Second Difference" of "Baltic Exchange Capesize Ind



ross-Corellation Function of "Second Difference" of "380cst Low Sulphur Fuel Oil, Los Angeles $ Per Tonne" with "Second Difference" of "Baltic Exchange Capesize



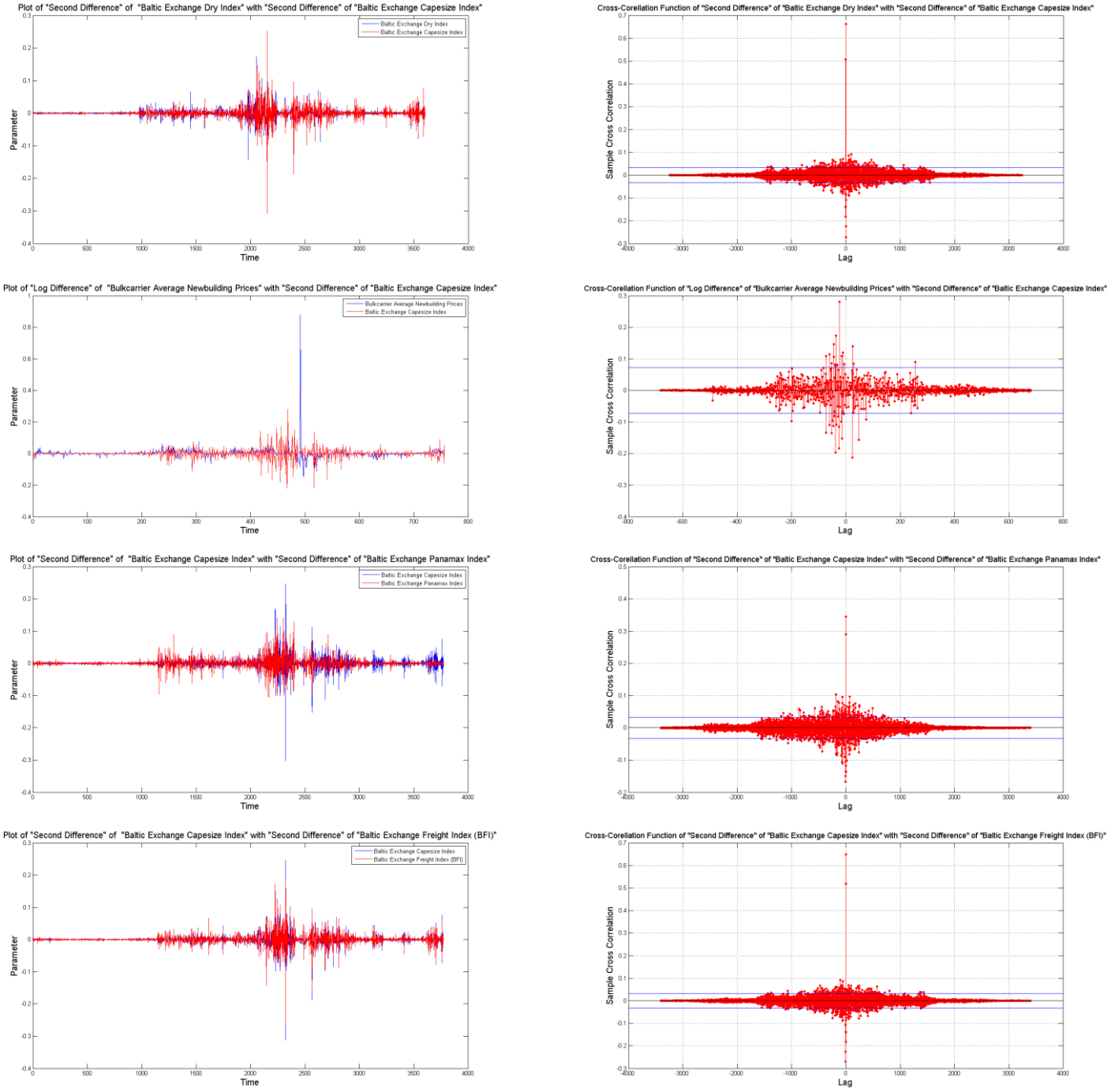


Figure 47Baltic Exchange Capesize Index complete period correlation graphs

5.5.2 Baltic Exchange Capesize Index complete period comments

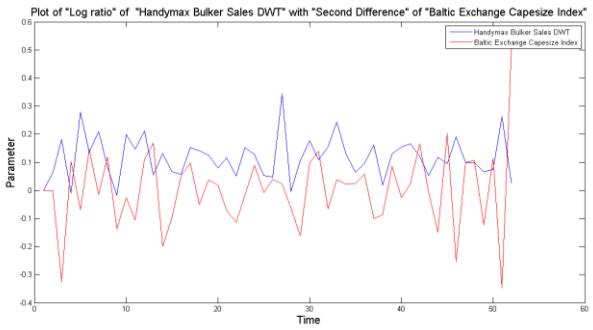
The BCI is highly positive correlated with BDI, BFI and BPI at 0.66, 0.65 and 0.34 respectively. Also the BCI is positive correlated with Clarksons Average Earnings with strength 0.58 and the BCI leading for 7 days. The sales market is represented with Panamax and Handymax Secondhand prices both of them positive correlated at 0.31 with a lag of 6 months after the leading of BCI (the Handymax has also high negative correlation values but the structure of the signal is the same as the Panamax). A really interesting finding is the positive correlation of the BCI (0.26) with the Average Value

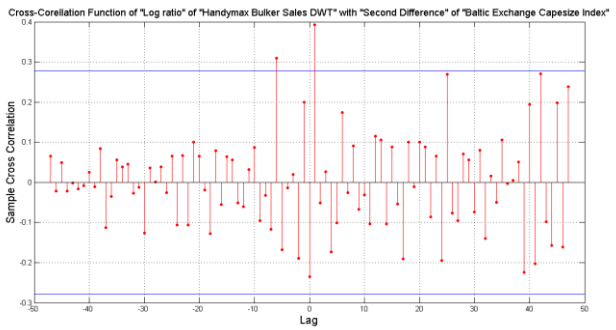
of 380cst Low Sulphur Fuel Oil with a lag of 43 days and leading parameter the BCI. The price of fuel oil in Los Angeles is also positive correlated at a strength of 0.40 and with a lag of 21 days where the BCI is again the leading parameter. Finally, the newbuilding market is represented by Bulkcarrier Average Newbuilding Prices which is correlated with BCI at a strength of 0.28 and a lag of 174 days and the BDI as the leading parameter.

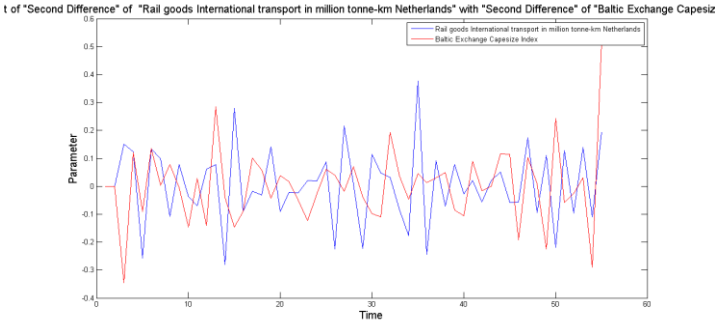
5.5.3 Half time period

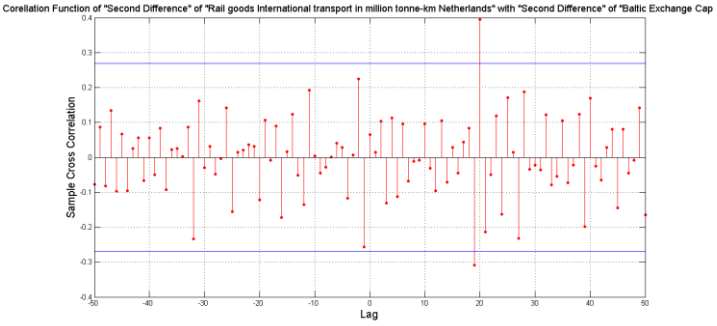
Table 11 Baltic Exchange Capesize Index half period result table

Parameter 1	Transformation 1	Parameter 2	Transformation 2	Lag (days)	Cross Correlation value
'Handymax Bulker Sales DWT'	'Log Ratio'	'Baltic Exchange Capesize Index'	'Second Difference'	30,83	0.39
'Rail goods International transport in million tonne-km Netherlands'	'Second Difference'	'Baltic Exchange Capesize Index'	'Second Difference'	603,68	0,39
'EU-28 Grain Exports Milion tonnes'	' Difference'	'Baltic Exchange Capesize Index'	'Second Difference'	1209,43	0.4
'Baltic Exchange Dry Index'	'Second Difference'	'Baltic Exchange Capesize Index'	'Second Difference'	0	0,78
'Argentina Grain Exports Milion tonnes'	'Second Difference'	'Baltic Exchange Capesize Index'	'Second Difference'	1179,43	0,33
'Baltic Exchange Capesize Index'	'Second Difference'	'Baltic Exchange Freight Index (BFI)'	'Second Difference'	0	0,66









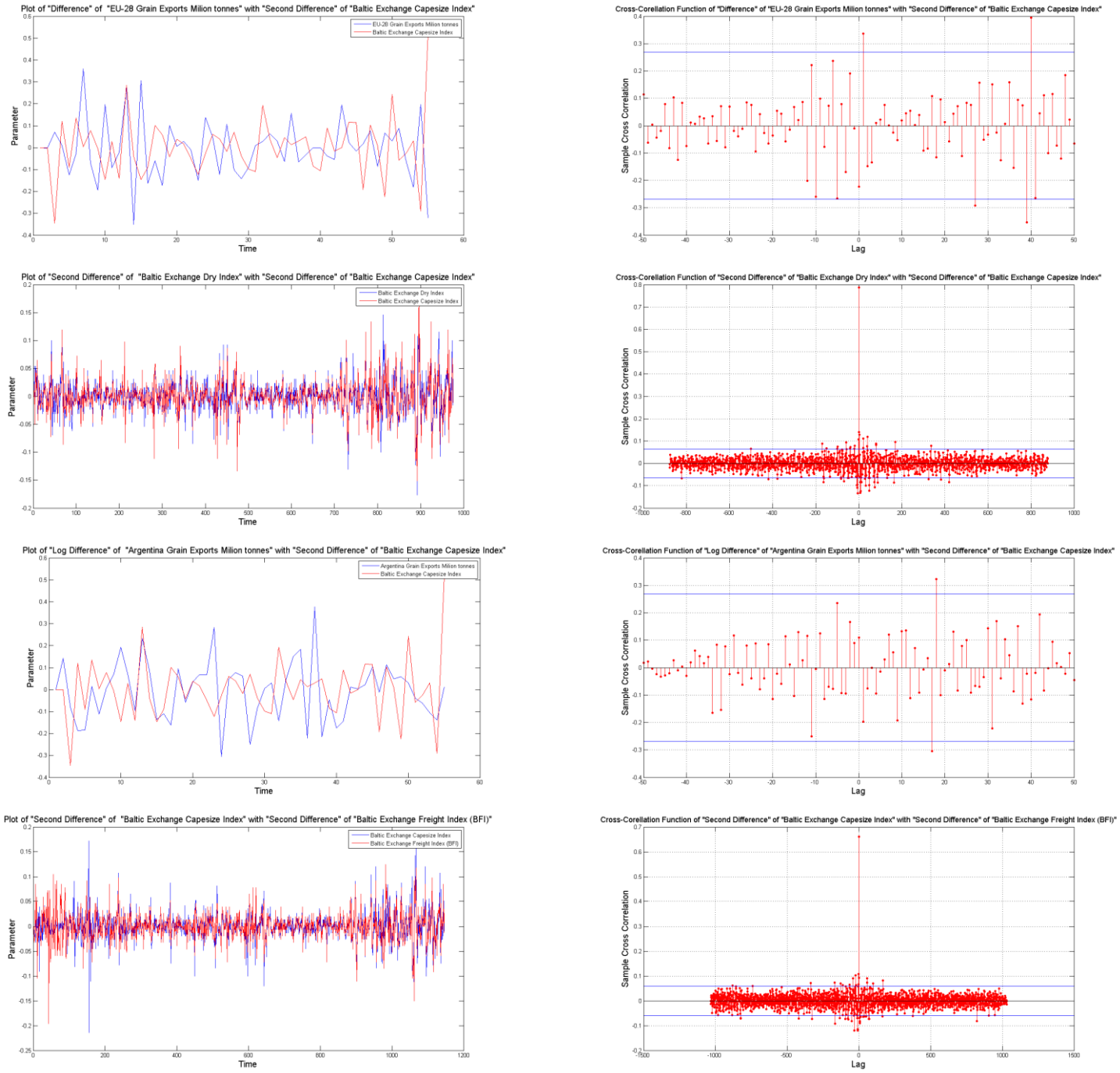


Figure 48 Baltic Exchange Capesize Index half period correlation graphs

5.5.4 Baltic Exchange Capesize Index half period comments

For the half period the strongest relation observed iis with BDI and BFI, which actually is the same thing. Again the BDI presents a stronger relation with 0.78, while the BFI has 0.66 correlation. The next strongest relation is observed with the grain exports from EU-28 and Argentina with positive correlations of 0.4 and 0.33 respectively and they are sharing almost the same lag time of 1200 days. Again a relation with the Rail goods International transport from Netherlands is observed with same strength as at the Panamax half period but this time the BCI is following the Rail transport after almost 2 years. Finally a positive correlation of 0.39 is observed with Handymax sales after 30 days.

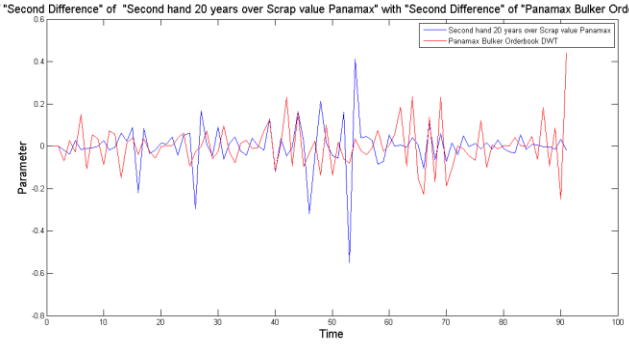
5.6 Panamax Bulker Orderbook DWT

5.6.1 Complete time period

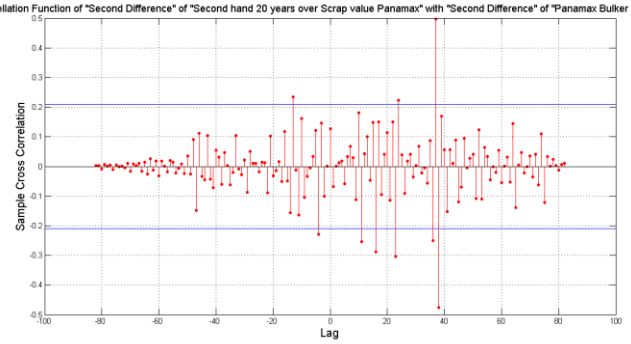
Table 12 Panamax Bulker Orderbook DWT complete period result table

Parameter 1	Transformation 1	Parameter 2	Transformation 2	Lag (days)	Cross Correlation value
'Second hand 20 years over Scrap value Panamax'	'Second Difference'	'Panamax Bulker Orderbook DWT'	'Second Difference'	1782,5	0,49
'Panamax Bulker Orderbook DWT'	'Second Difference'	'Bulkcarrier Orderbook DWT'	'Second Difference'	0	0,55
'Handymax Bulker Scrap Value $ Million'	'Second Difference'	'Panamax Bulker Orderbook DWT'	'Second Difference'	1835,99	0,44
'Panamax Bulker Orderbook DWT'	'Second Difference'	'Operational Speed Bulk Carrier "100000-199999"'	'Difference'	696,90	0,40
'Panamax Bulker Orderbook DWT'	'Second Difference'	'Operational Speed Bulk Carrier "60000-99999" (Panamax)	'Difference'	696,90	0,39
'Panamax Bulker Orderbook DWT'	'Second Difference'	'Average days in the sea "35000-59999" (Handymax)'	'Second Difference'	333,30	-0,53
'Panamax Bulker Orderbook DWT'	'Second Difference'	'Average days in the sea "60000-99999" (Panamax)'	'Second Difference'	333,30	-0,40

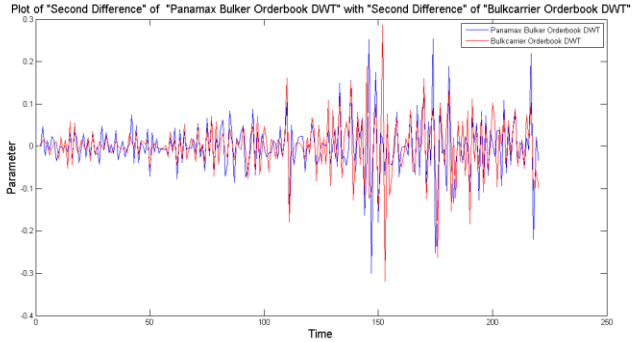
Plot of "Second Difference" of "Second hand 20 years over Scrap value Panamax" with "Second Difference" of "Panamax Bulker Orderbook DWT



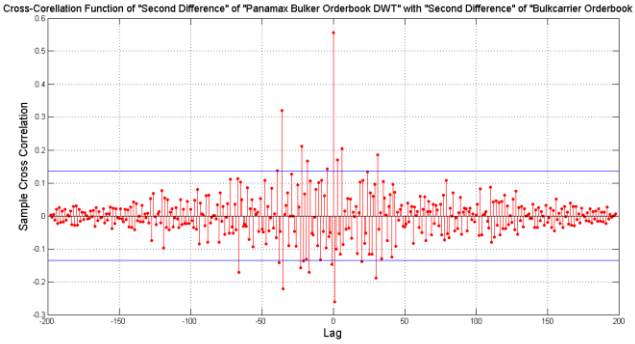
Cross-Corellation Function of "Second Difference" of "Second hand 20 years over Scrap value Panamax" with "Second Difference" of "Panamax Bulker Orderbook D



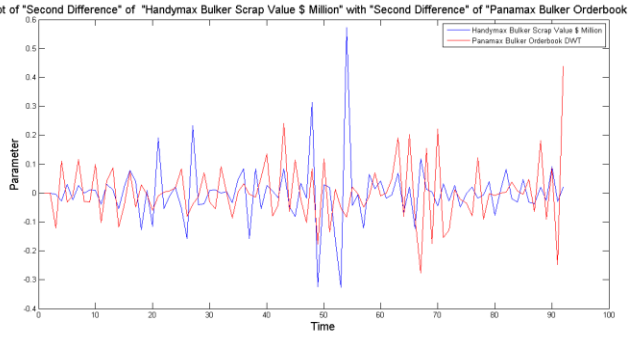
Plot of "Second Difference" of "Panamax Bulker Orderbook DWT" with "Second Difference" of "Bulkcarrier Orderbook DWT"



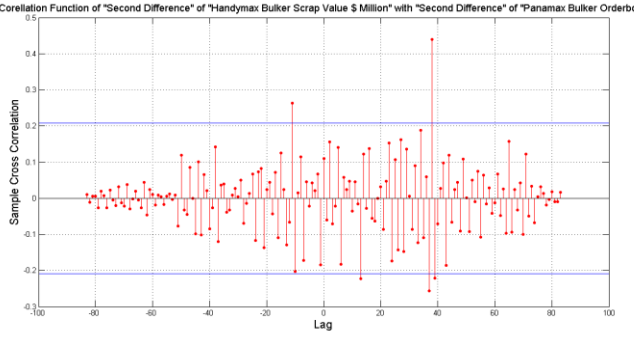
Cross-Corellation Function of "Second Difference" of "Panamax Bulker Orderbook DWT" with "Second Difference" of "Bulkcarrier Orderbook DWT"



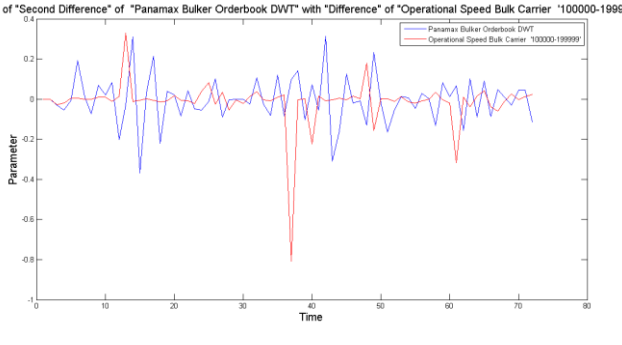
Plot of "Second Difference" of "Handymax Bulker Scrap Value $ Million" with "Second Difference" of "Panamax Bulker Orderbook DWT"



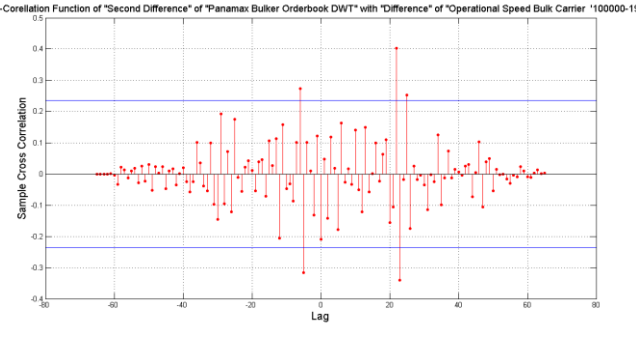
Cross-Corellation Function of "Second Difference" of "Handymax Bulker Scrap Value $ Million" with "Second Difference" of "Panamax Bulker Orderbook DWT"



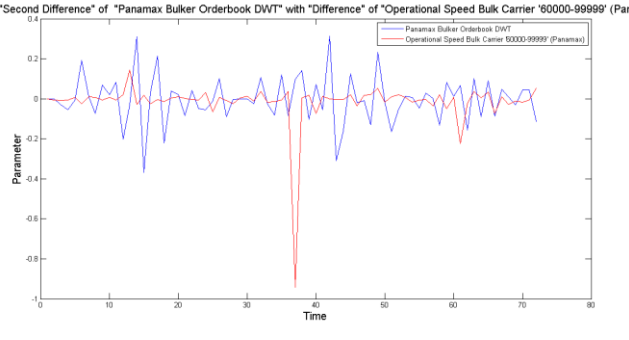
Plot of "Second Difference" of "Panamax Bulker Orderbook DWT" with "Difference" of "Operational Speed Bulk Carrier '100000-199999'"



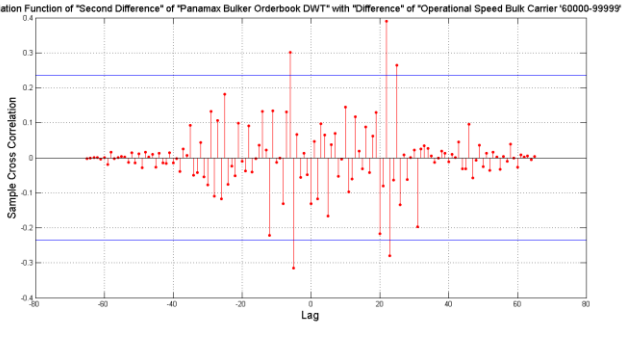
Cross-Corellation Function of "Second Difference" of "Panamax Bulker Orderbook DWT" with "Difference" of "Operational Speed Bulk Carrier '100000-199999'



Plot of "Second Difference" of "Panamax Bulker Orderbook DWT" with "Difference" of "Operational Speed Bulk Carrier '60000-99999' (Panamax



Cross-Corellation Function of "Second Difference" of "Panamax Bulker Orderbook DWT" with "Difference" of "Operational Speed Bulk Carrier '60000-99999' (Panan



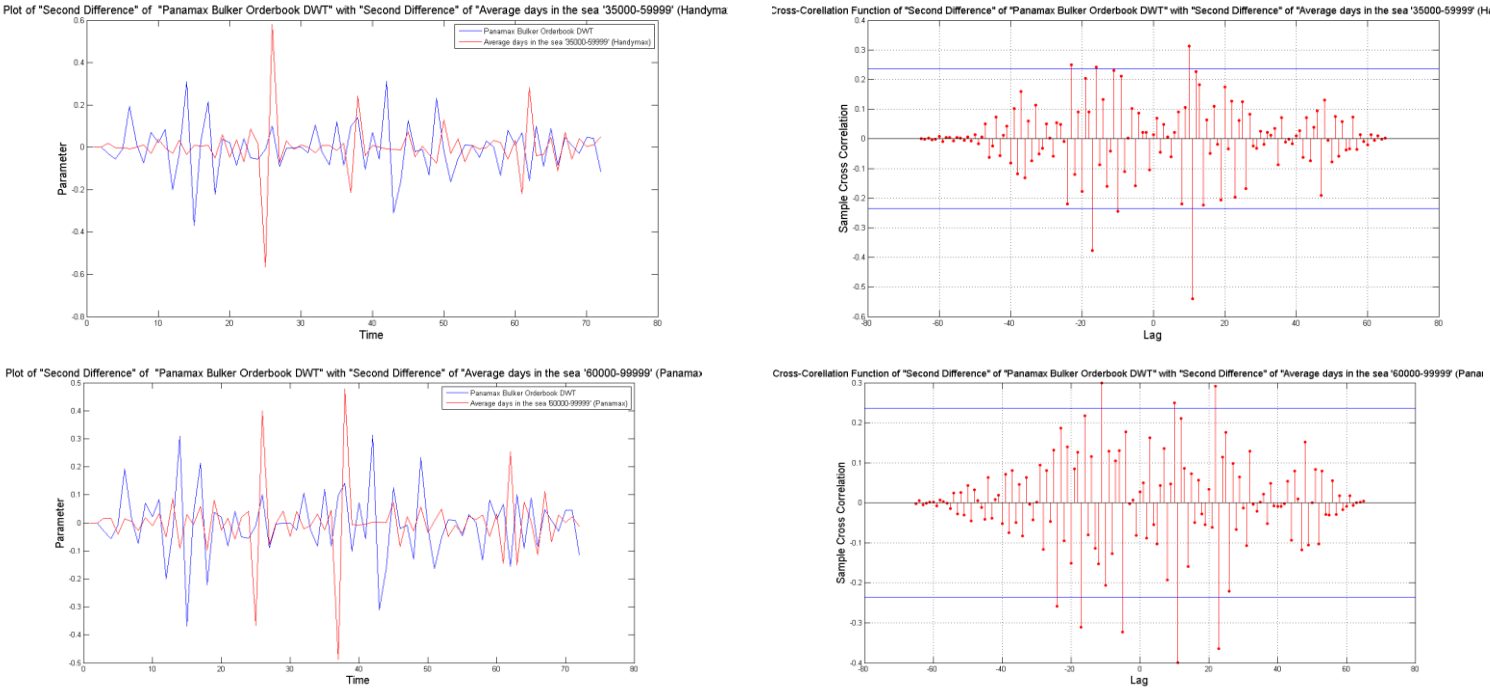


Figure 49Panamax Bulker Orderbook DWT complete period correlation graphs

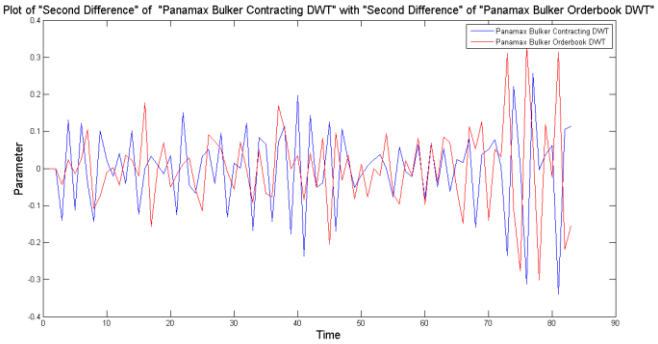
5.6.2 Panamax Bulker Orderbook DWT complete period comments

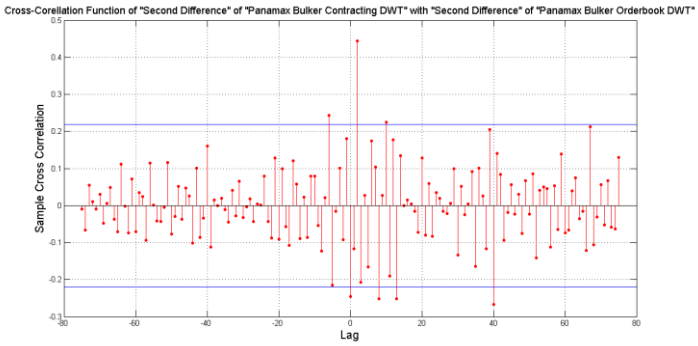
As it is shown the Panamax orderbook represents the 0.55 of the average bulker orderbook as per DWT. However the most interesting thing is the correlation of the orderbook with the operational speed and the average days at sea. There is a negative correlation with average days at sea of Handymax and Panamax of 0.53 and 0.40 respectively both of them with a time lag of one year. On the other hand there is a positive correlation with the operational speed of Capesizes and Panamaxes of 0.40 with a time lag of almost two years. The possible explanations for these two phenomena could point to port congestions for the average days at sea and the increase of the design speed for the new vessels. The last relations are with the scrap value of Handymaxes and the ration of Second hand 20 years over Scrap value for Panamax vessels. Both of them positive at a strength of almost 0.4 and a lag of 1800 days.

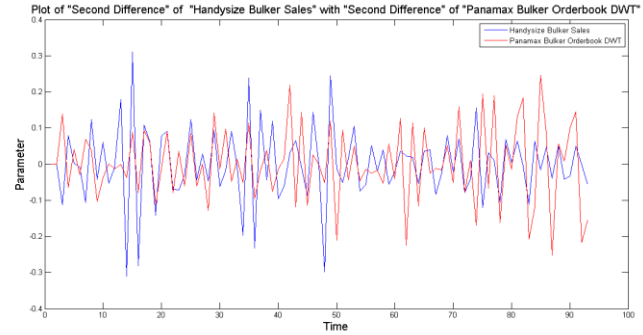
5.6.3 Half time period

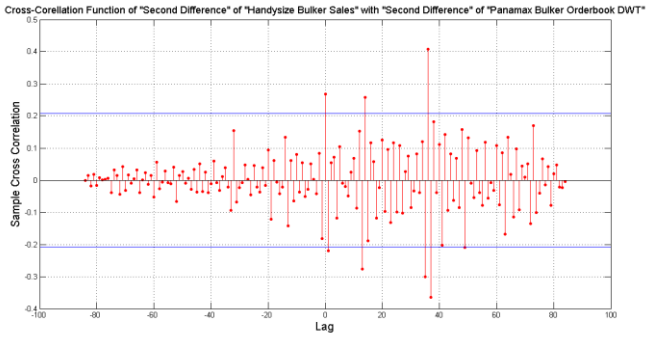
Table 13 Panamax Bulker Orderbook DWT half period result table

Parameter 1	Transformation 1	Parameter 2	Transformation 2	Lag (days)	Cross Correlation value
'Panamax Bulker Contracting DWT'	'Second Difference'	'Panamax Bulker Orderbook DWT'	'Second Difference'	67,49	0,44
'Handysize Bulker Sales'	'Second Difference'	'Panamax Bulker Orderbook DWT'	'Second Difference'	1085,49	0,41
'Panamax Bulker Orderbook DWT'	'Second Difference'	'Bulkcarrier Orderbook DWT'	'Second Difference'	0	0,70
'Panamax Bulker Orderbook DWT'	'Second Difference'	'Orderbook over fleet development DWT'	'Second Difference'	0	0,60









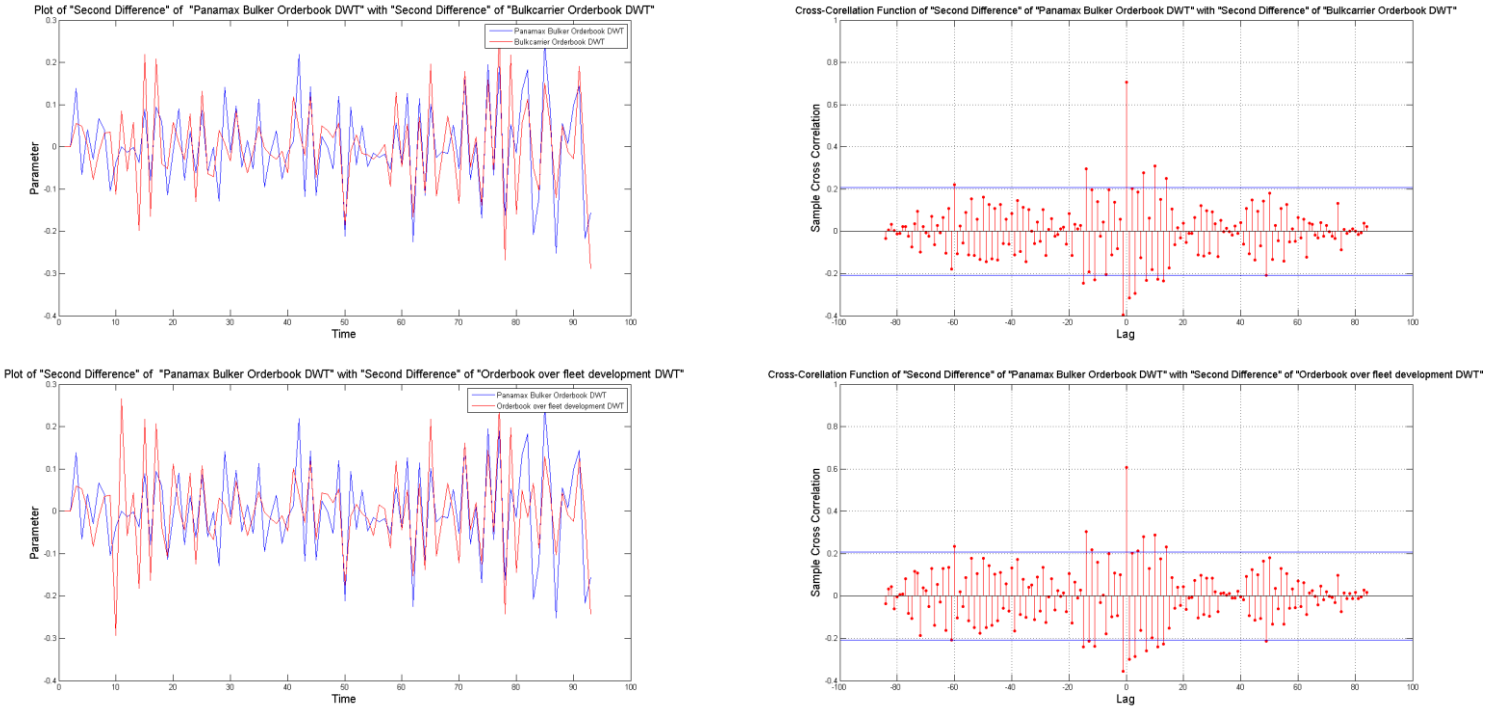


Figure 50 Panamax Bulker Orderbook DWT half period correlation graphs

5.6.4 Panamax Bulker Orderbook DWT half period comments

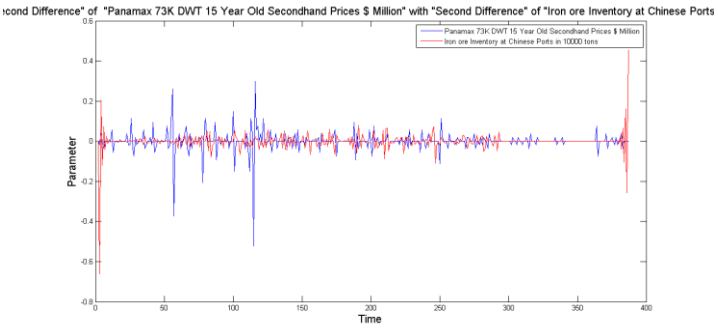
For the half period the relation with Bulkcarrier Orderbook per DWT increased to 0.70 and the relation with orderbook over fleet development per DWT is observed with strength of 0.60. The next two correlation are observed with Panamax Bulker Contracting per DWT and with Handysize Bulker Sales.

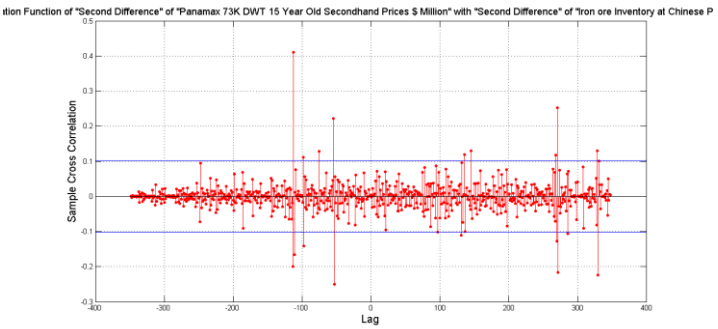
5.7 Iron ore Inventory at Chinese Ports in 10000 tons

5.7.1 Complete time period

Table 14 Iron ore inventory at Chinese Ports complete period result table

Parameter 1	Transformation 1	Parameter 2	Transformation 2	Lag (days)	Cross Correlation value
'Panamax 73K DWT 15 Year Old Secondhand Prices $ Million'	'Second Difference'	'Iron ore Inventory at Chinese Ports in 10000 tons'	'Second Difference'	-823,54	0,41
'Capesize 180k dwt Secondhand Bulker Resale Prices $ Million'	'Second Difference'	'Iron ore Inventory at Chinese Ports in 10000 tons'	'Second Difference'	-182,10	0,40
'Panamax 76k dwt Secondhand Bulker Resale Prices $ Million'	'Second Difference'	'Iron ore Inventory at Chinese Ports in 10000 tons'	'Second Difference'	-174,82	0,55
'Bulkcarrier Average Newbuilding Prices'	'Difference'	'Iron ore Inventory at Chinese Ports in 10000 tons'	'Log Difference'	-873,92	0,62
'Handymax 56K 5 Year Old Secondhand Prices $ Million'	'Second Difference'	'Iron ore Inventory at Chinese Ports in 10000 tons'	'Second Difference'	-298,53	0,52





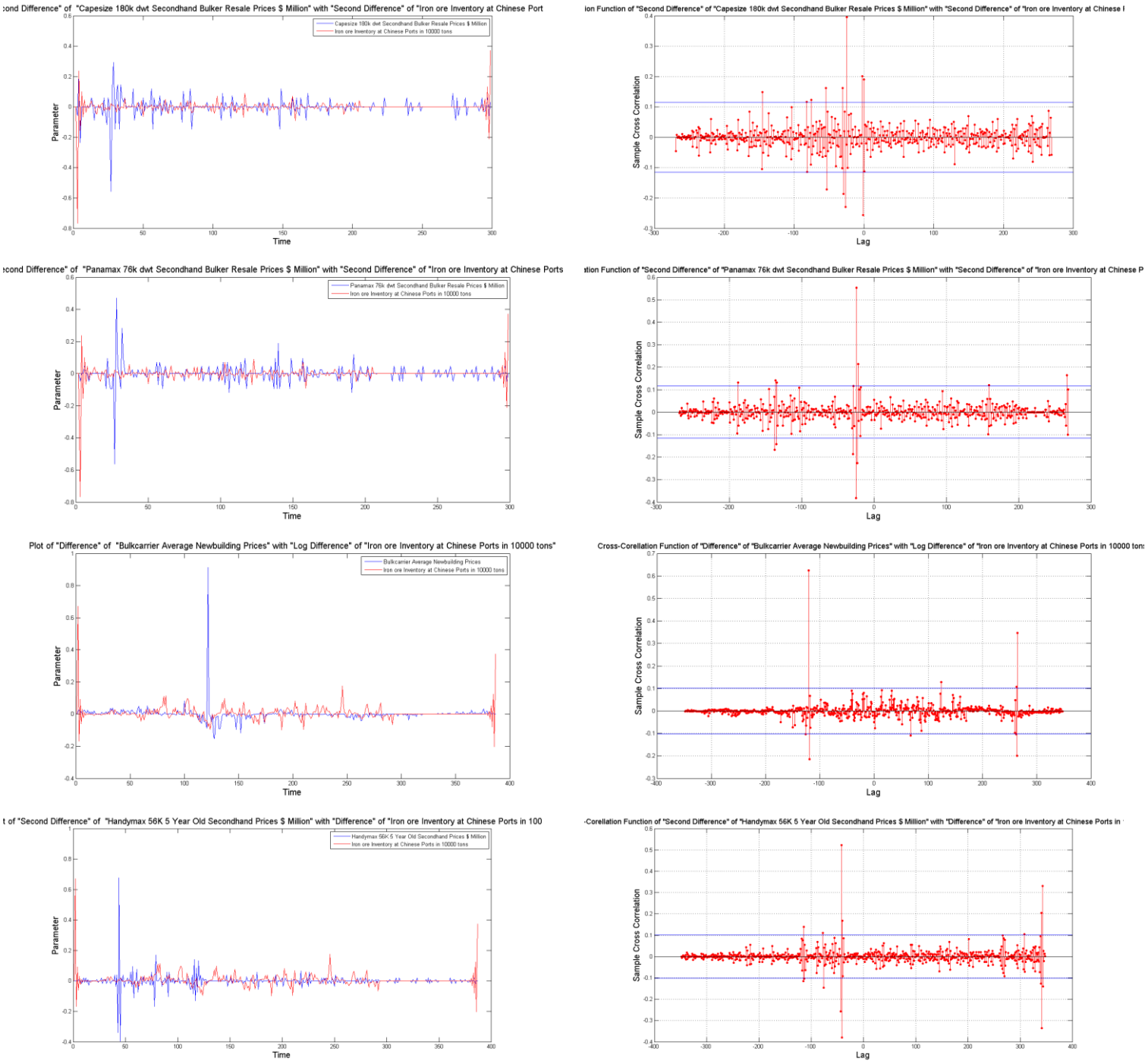


Figure 51Iron ore inventory at Chinese Ports complete period correlation graphs

5.7.2 Iron ore inventory at Chinese Ports complete period comments

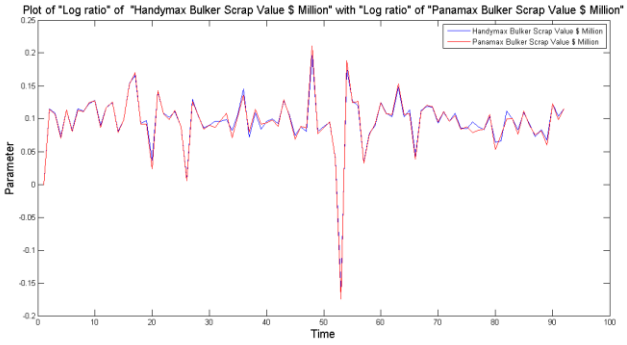
The iron ore inventory at the Chinese ports, the world's biggest buyer, may be used as a flag signal for a market which doesn't have the same wealth of data available compared with commodities such as copper and gold, or even oil, another market awash with supply. In this thesis the only strong correlations observed were with the sales market and the newbulding market and most of them may be spurious correlations.

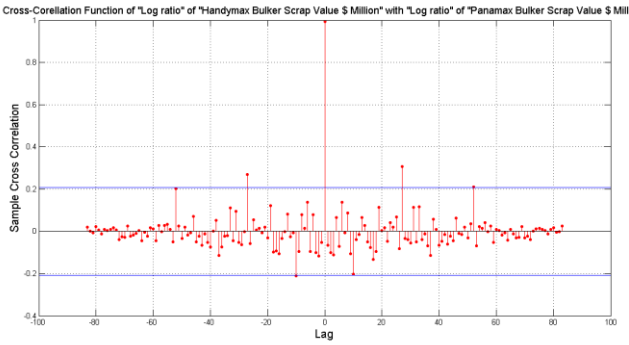
5.8 'Panamax Bulker Scrap Value $ Million

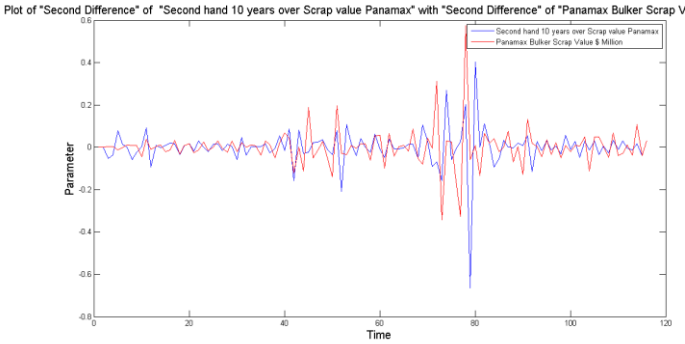
5.8.1 Complete time period

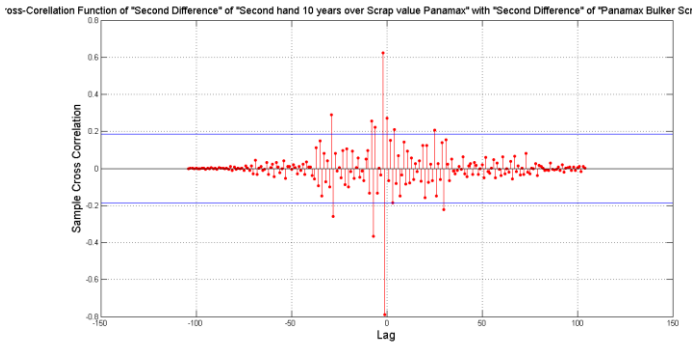
Table 15 Panamax Bulker scrap value complete period result table

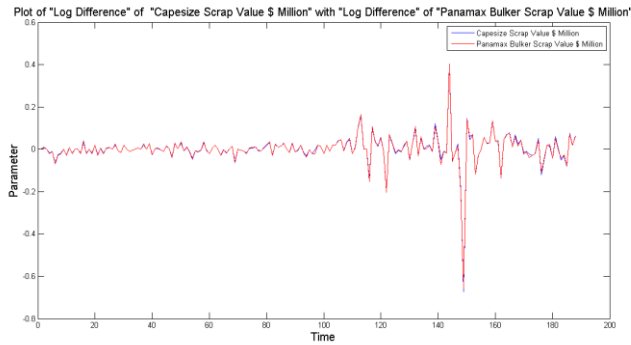
Parameter 1	Transformation 1	Parameter 2	Transformation 2	Lag (days)	Cross Correlation value
'Handymax Bulker Scrap Value $ Million'	'Log ratio'	'Panamax Bulker Scrap Value $ Million'	'Log ratio'	0	0,99
'Second hand 10 years over Scrap value Panamax'	'Second Difference'	'Panamax Bulker Scrap Value $ Million'	'Second Difference'	-47,62	-0,78
'Capesize Scrap Value $ Million'	'Log Difference'	'Panamax Bulker Scrap Value $ Million'	'Log Difference'	0	0,99
'Panamax Bulker Scrap Value $ Million'	'Log ratio'	'Operational Speed Bulk Carrier "60000-99999" (Panamax)'	'Difference'	-648,47	-0,69
'Panamax Bulker Scrap Value $ Million'	'Log Difference'	'Handysize Bulker Scrap Value $ Million'	'Difference'	0	0,90
'Panamax Bulker Scrap Value $ Million'	'Log ratio'	'Operational Speed Bulk Carrier "10000-34999" Handysize'	'Difference'	-648,46	-0,71
'Panamax Bulker Scrap Value $ Million'	'Difference'	'Capesize Bulkcarrier 100-115k dwt Newbuilding Prices $ Million'	'Second Difference'	-92,63	0,72
'Panamax Bulker Scrap Value $ Million'	'Log Difference'	'Panamax 91-93k dwt Bulkcarrier Newbuilding Prices $ Million'	'Second Difference'	-46,31	0,73
'Panamax Bulker Scrap Value $ Million'	'Log Difference'	'Panamax 80-82k dwt Bulkcarrier (Kamsarmax) Newbuilding Prices $ Million'	'Second Difference'	-46,31	0,77
'Panamax Bulker Scrap Value $ Million'	'Log Difference'	'Panamax Tanker 73,000 dwt coated Resale Values $ Million'	'Second Difference'	-138,95	0,75

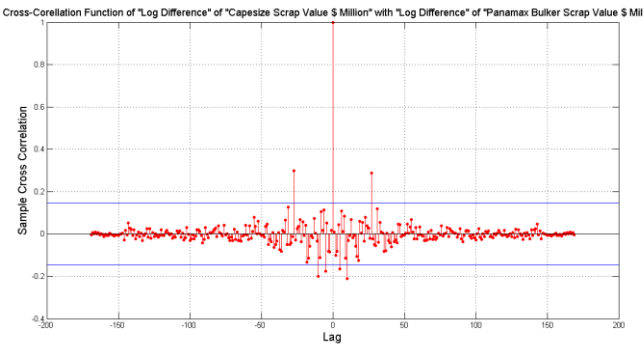

Plot of "Log ratio" of "Handymax Bulker Scrap Value $ Million" with "Log ratio" of "Panamax Bulker Scrap Value $ Million"
Handymax Bulker Scrap Value $ Million
Panamax Bulker Scrap Value $ Million
Parameter
Time

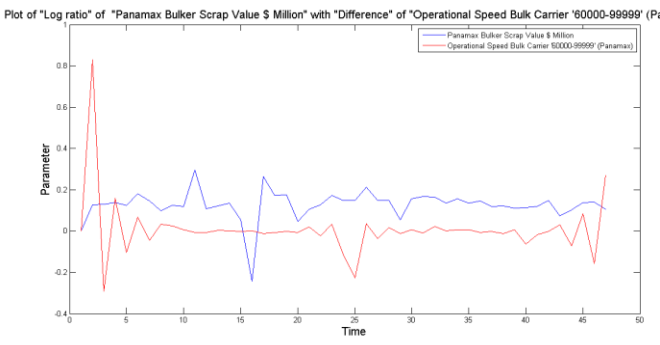

Cross-Corellation Function of "Log ratio" of "Handymax Bulker Scrap Value $ Million" with "Log ratio" of "Panamax Bulker Scrap Value $ Million"
Sample Cross Correlation
Lag

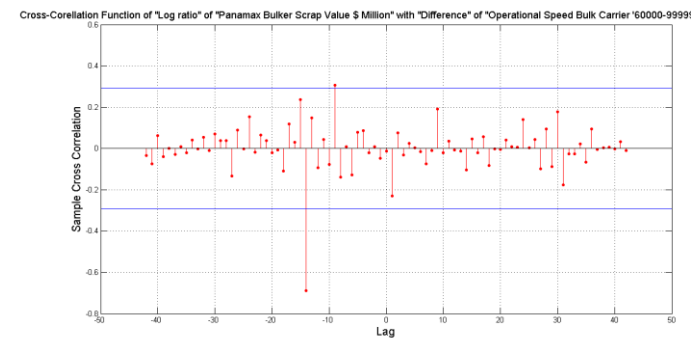

Plot of "Second Difference" of "Second hand 10 years over Scrap value Panamax" with "Second Difference" of "Panamax Bulker Scrap Value $ Mill
Second hand 10 years over Scrap value Panamax
Panamax Bulker Scrap Value $ Million
Parameter
Time

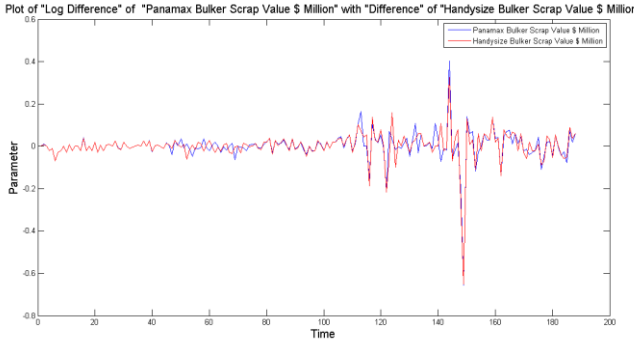

oss-Corellation Function of "Second Difference" of "Second hand 10 years over Scrap value Panamax" with "Second Difference" of "Panamax Bulker Scrap Value $
Sample Cross Correlation
Lag

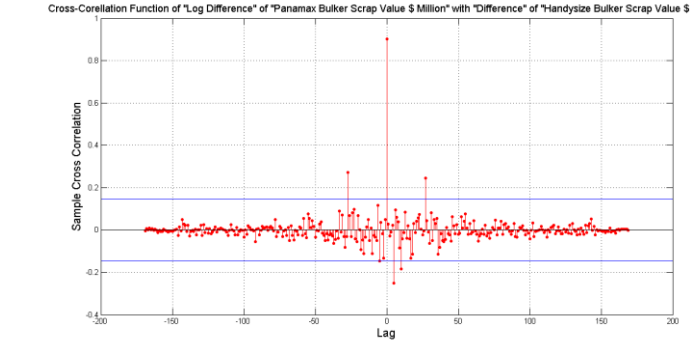

Plot of "Log Difference" of "Capesize Scrap Value $ Million" with "Log Difference" of "Panamax Bulker Scrap Value $ Million"
Capesize Scrap Value $ Million
Panamax Bulker Scrap Value $ Million
Parameter
Time


Cross-Corellation Function of "Log Difference" of "Capesize Scrap Value $ Million" with "Log Difference" of "Panamax Bulker Scrap Value $ Million"
Sample Cross Correlation
Lag


Plot of "Log ratio" of "Panamax Bulker Scrap Value $ Million" with "Difference" of "Operational Speed Bulk Carrier '60000-99999' (Panamax)"
Panamax Bulker Scrap Value $ Million
Operational Speed Bulk Carrier '60000-99999' (Panamax)
Parameter
Time


Cross-Corellation Function of "Log ratio" of "Panamax Bulker Scrap Value $ Million" with "Difference" of "Operational Speed Bulk Carrier '60000-99999' (Panama
Sample Cross Correlation
Lag


Plot of "Log Difference" of "Panamax Bulker Scrap Value $ Million" with "Difference" of "Handysize Bulker Scrap Value $ Million"
Panamax Bulker Scrap Value $ Million
Handysize Bulker Scrap Value $ Million
Parameter
Time


Cross-Corellation Function of "Log Difference" of "Panamax Bulker Scrap Value $ Million" with "Difference" of "Handysize Bulker Scrap Value $ Million"
Sample Cross Correlation
Lag

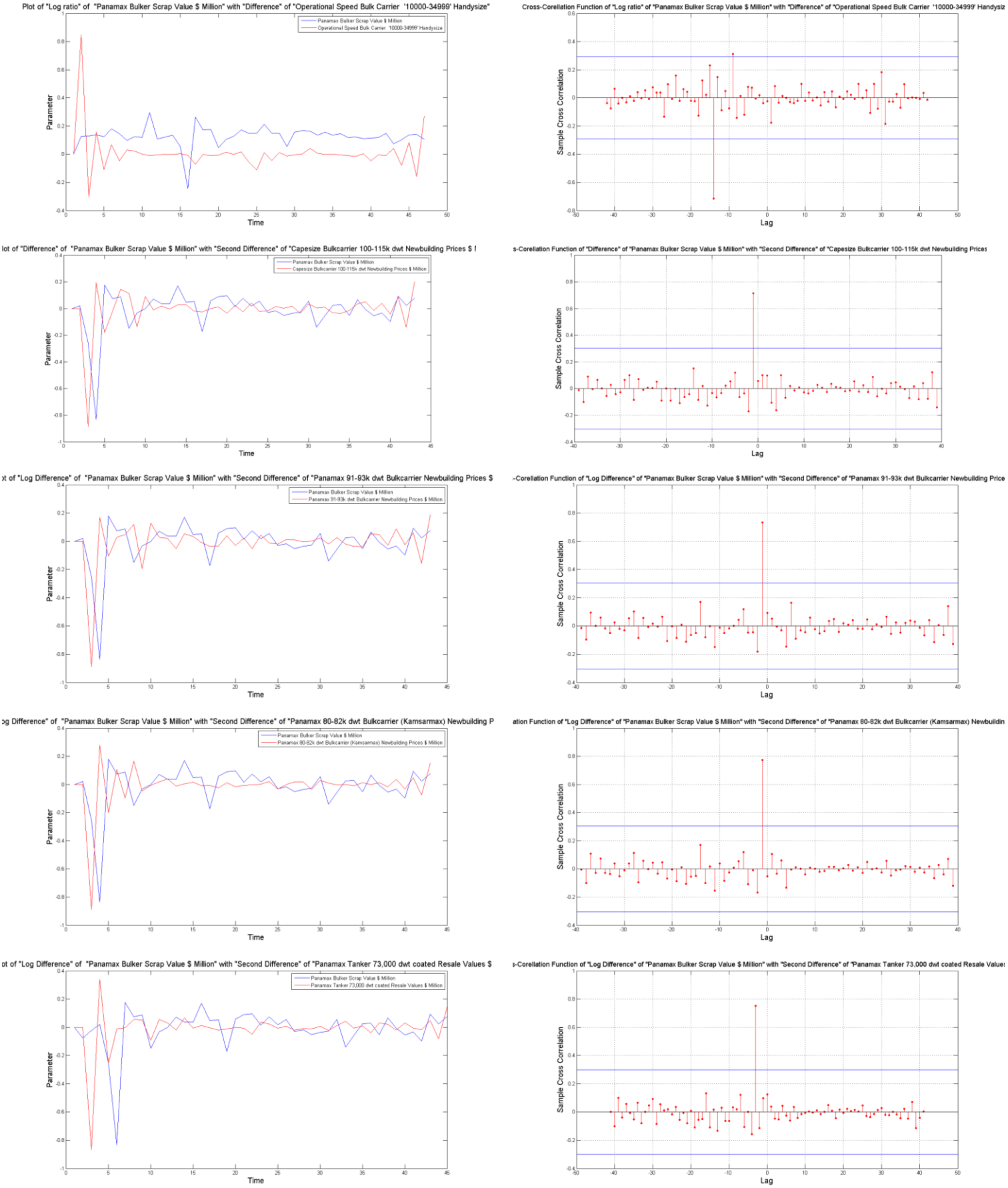


Figure 52Panamax Bulker scrap value complete period correlation graphs

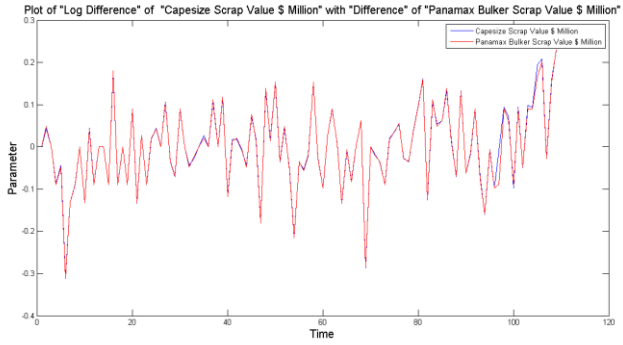
5.8.2 Panamax Bulker scrap value complete period comments

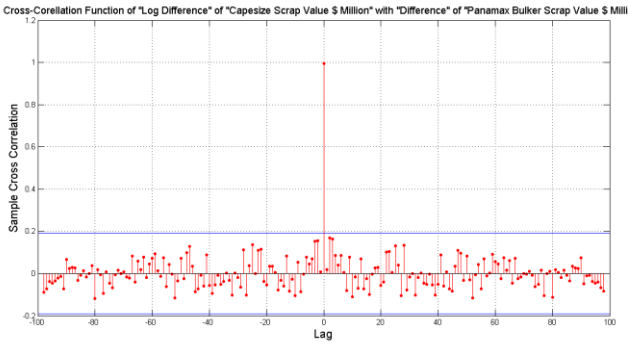
The Panamax scrap market is used here as representative for the scrap market. The strongest relation observed with the Handymax, Capesize and Handysize scrap values, all of them with no lag and with strength from 0.99 to 0.90. Then a relation with the Newbuilding market observed. The newbuilding of Kamsarmax, Panamax and Capesize vessels are positive correlated with a lag of almost 3 months. An interesting issue is the negative correlation observed with the operational speed of Handysize and Panamax vessels with a lag of 650 days. The fall of the speed is leading the rise of the scrap value.

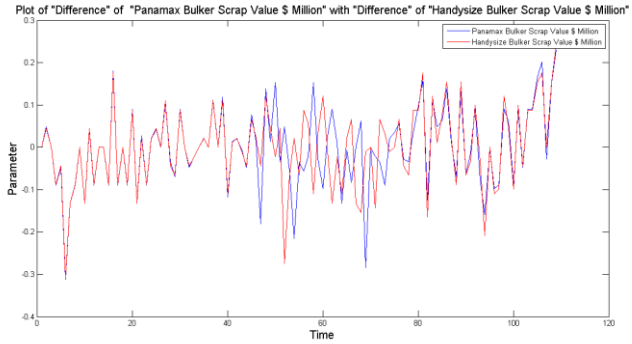
5.8.3 Half time period

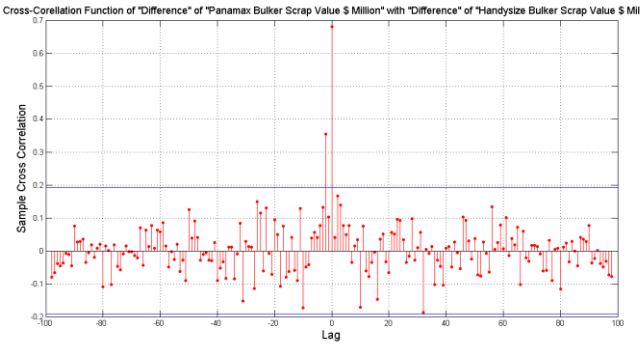
Table 16 Panamax Bulker scrap value half period result table

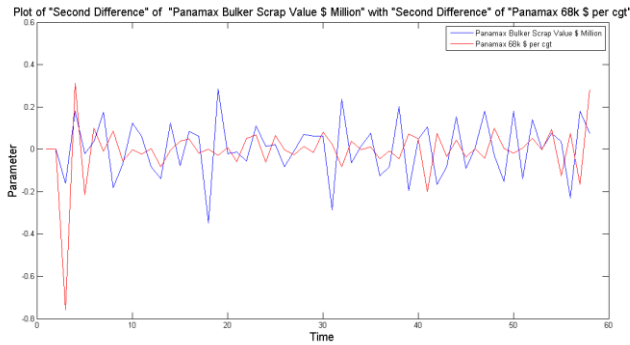
Parameter 1	Transformation 1	Parameter 2	Transformation 2	Lag (days)	Cross Correlation value
'Capesize Scrap Value $ Million'	'Log Difference'	'Panamax Bulker Scrap Value $ Million'	'Difference'	0	0,99
'Panamax Bulker Scrap Value $ Million'	'Difference'	'Handysize Bulker Scrap Value $ Million'	'Difference'	0	0,68
'Panamax Bulker Scrap Value $ Million'	'Second Difference'	'Panamax 68k $ per cgt'	'Second Difference'	-670,32	0,43
'Panamax Bulker Scrap Value $ Million'	'Second Difference'	'Capesize 170K 10 Year Old Secondhand Prices $ Million'	'Second Difference'	-357,50	0,43
'Panamax Bulker Scrap Value $ Million'	'Second Difference'	'Capesize 180K 5 Year Old Secondhand Prices $ Million'	'Second Difference'	-357,50	0,41
'Panamax Bulker Scrap Value $ Million'	'Second Difference'	'Panamax 75K Bulkcarrier 10 Year Old Secondhand Prices $ Million'	'Second Difference'	-357,50	0,41

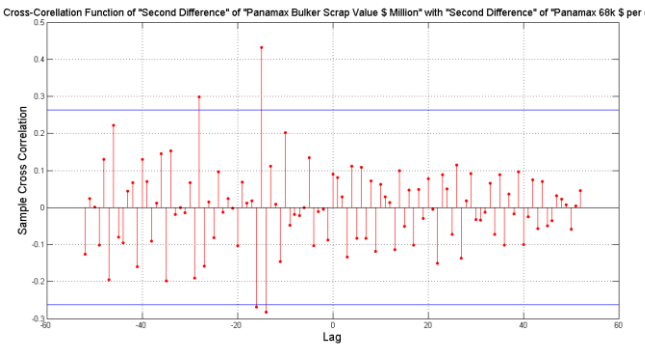

Plot of "Log Difference" of "Capesize Scrap Value $ Million" with "Difference" of "Panamax Bulker Scrap Value $ Million"
Capesize Scrap Value $ Million
Panamax Bulker Scrap Value $ Million
Parameter
Time

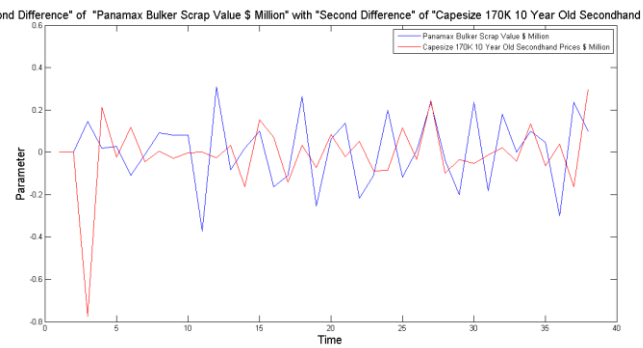

Cross-Corellation Function of "Log Difference" of "Capesize Scrap Value $ Million" with "Difference" of "Panamax Bulker Scrap Value $ Million"
Sample Cross Correlation
Lag

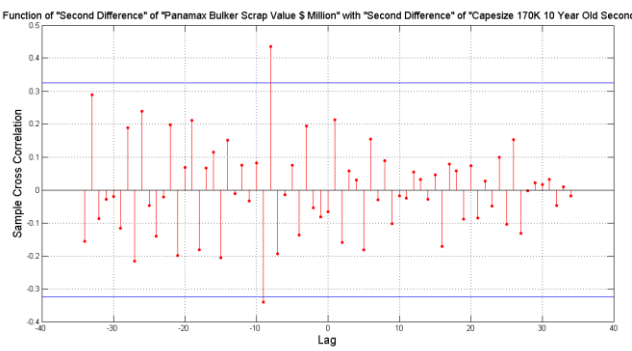

Plot of "Difference" of "Panamax Bulker Scrap Value $ Million" with "Difference" of "Handysize Bulker Scrap Value $ Million"
Panamax Bulker Scrap Value $ Million
Handysize Bulker Scrap Value $ Million
Parameter
Time

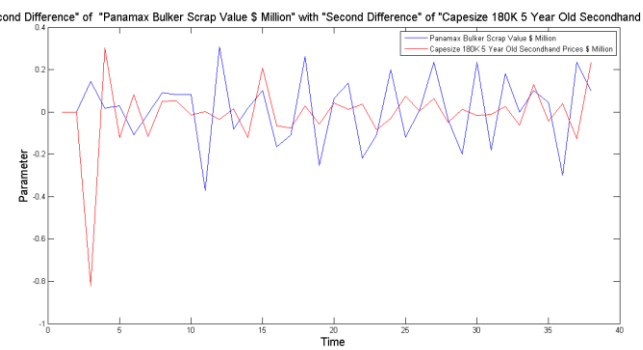

Cross-Corellation Function of "Difference" of "Panamax Bulker Scrap Value $ Million" with "Difference" of "Handysize Bulker Scrap Value $ Million"
Sample Cross Correlation
Lag

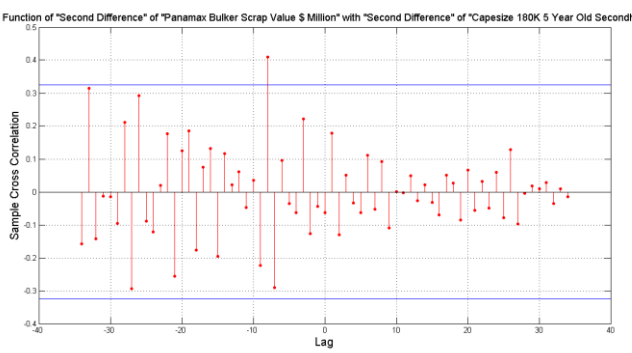

Plot of "Second Difference" of "Panamax Bulker Scrap Value $ Million" with "Second Difference" of "Panamax 68k $ per cgt"
Panamax Bulker Scrap Value $ Million
Panamax 68k $ per cgt
Parameter
Time


Cross-Corellation Function of "Second Difference" of "Panamax Bulker Scrap Value $ Million" with "Second Difference" of "Panamax 68k $ per cgt"
Sample Cross Correlation
Lag


Panamax Bulker Scrap Value $ Million
Capesize 170K 10 Year Old Secondhand Prices $ Million
Parameter
Time


Sample Cross Correlation
Lag


Panamax Bulker Scrap Value $ Million
Capesize 180K 5 Year Old Secondhand Prices $ Million
Parameter
Time


Sample Cross Correlation
Lag

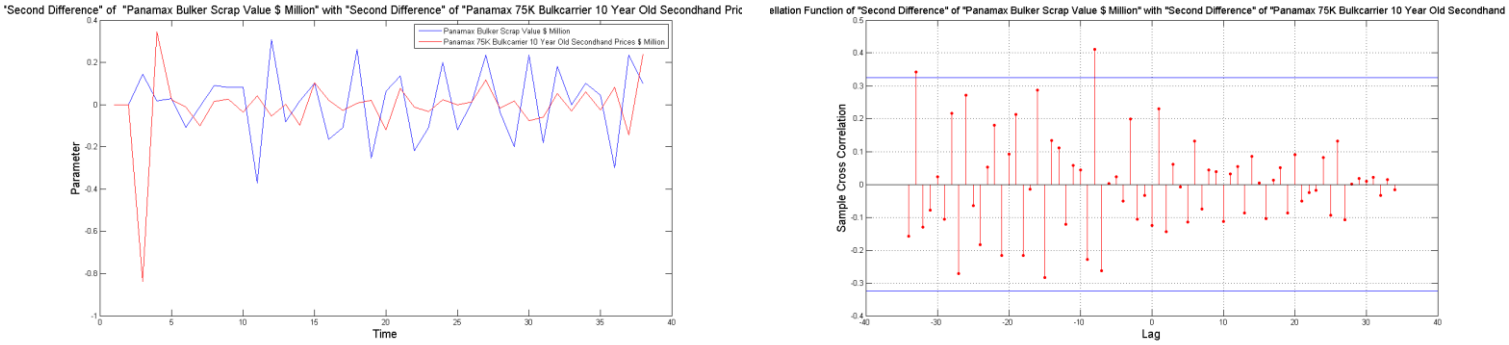


Figure 53 Panamax Bulker scrap value half period correlation graphs

5.8.4 Panamax Bulker scrap value half period comments

In the half period the correlation with the Capsize and the Handysize are respectively 0.99 and 0.68. The sales market are represented with the Capesize and the Panamax vessels both of them at a strength of 0.40 and a lag of almost one year. The sales market is leading and the scrap market is following. An interesting positive correlation with the newbuilding market is represented with the Panamax newbuilding value. The newbuilding Panamax value is leading with a time lag of two years.

5.9 Various Parameters

5.9.1 Complete time period

Table 17 Various Parameters Complete time period result table

Parameter 1	Transformation 1	Parameter 2	Transformation 2	Lag (days)	Cross Correlation value
'Handysize Bulker Scrap Value $ Million'	'Log ratio'	'Operational Speed Bulk Carrier "35000-59999" (Handymax)'	'Second Difference'	-602.152	0.73
'Operational Speed Bulk Carrier "60000-99999" (Panamax)'	'Difference'	'Panamax D_H 73K DWT "Coated" 5 Yr Old Secondhand Prices $ Million'	'Second Difference'	-1020.94	0.74
'Dry Cargo Average Newbuilding Prices $ Per DWT'	'Difference'	'Panamax 76k dwt Secondhand Bulker Resale Prices $ Million'	'Difference'	-1335.29	0.72
'Handymax Bulker Scrap Value $ Million'	'Difference'	'Handysize 32K 5 Year Old Secondhand Prices $ Million'	'Difference'	-48.31	0.71
'Handysize Bulker Scrap Value $ Million'	'Difference'	'Operational Speed Bulk Carrier "10000-34999" Handysize'	'Second Difference'	-602.15	0.68
'Bulkcarrier Average Newbuilding Prices'	'Second Difference'	'LIBOR USD 3M TD156N'	'Second Difference'	-725,76	-0.68

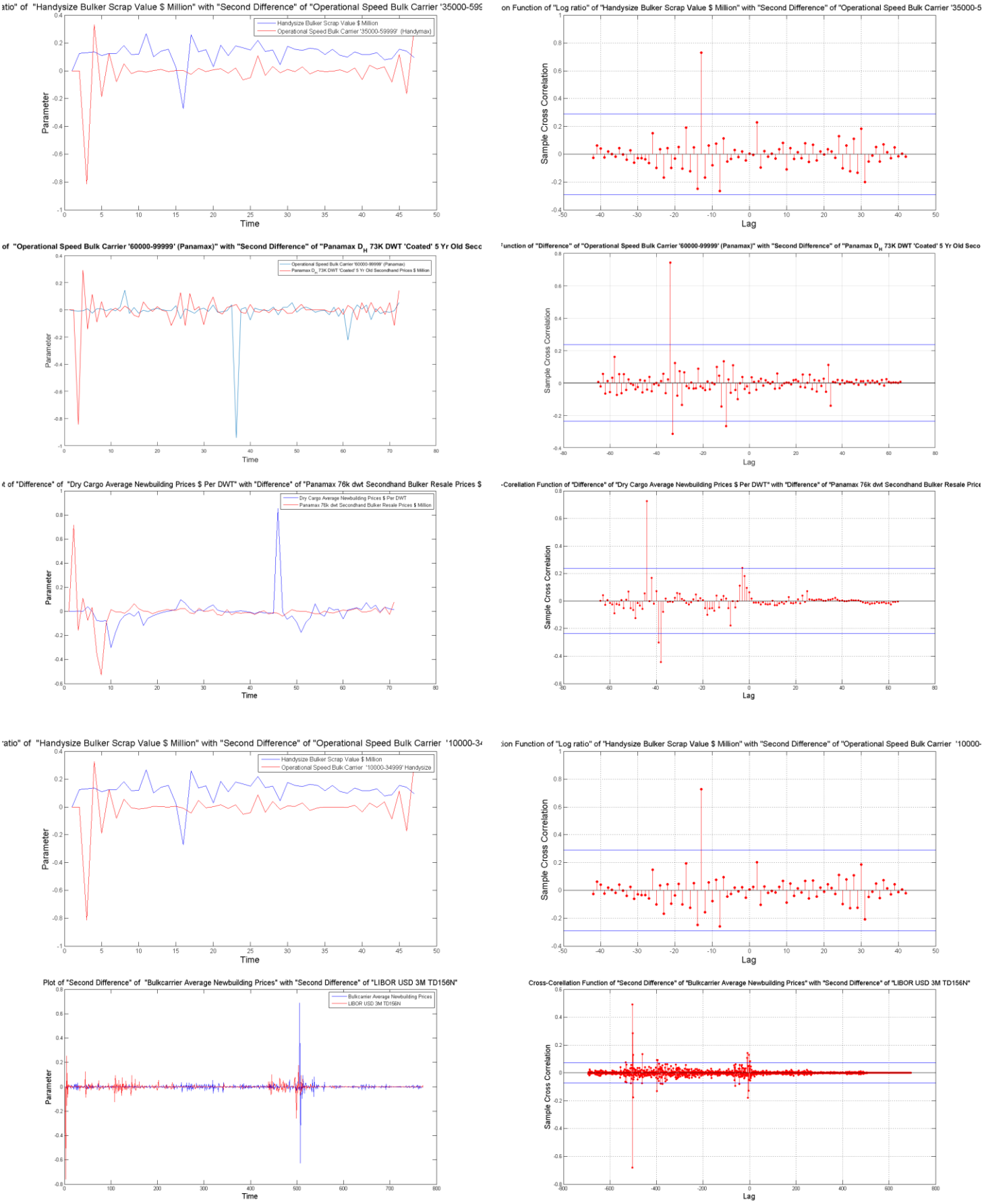


Figure 54 Various Parameters Complete time period correlation graphs

5.9.2 Various Parameters Complete time period comments

Finally, some interesting correlation which occurred with a various combination of parameters are presented. The strongest correlations occurred with the Panamax vessels secondhand prices. The first is with Panamax operational speed of strength 0.74 and lag of almost 3 years. The second is with Dry cargo average Newbuilding prices which follows after 4 years. Actually this correlation is really important and needs further investigation with more data. Further, the Handysize scrap value is correlated positively with the Handymax operational speed at a strength of 0.73 after 2 years. The leading parameter seems to be the operational speed. Perhaps this speed increase is forcing some older vessels outside of the market. The same relation, with the same lag, is observed with the Handysize scrap and the Handysize operational speed. Lastly, an interesting negative correlation is observed between the LIBOR 3M and the average bulkcarrier Newbuilding prices. The strength is 0.68 and the time lag is almost 2 years.

6 CONCLUSIONS

As it is mentioned earlier in this Thesis, we took a step back from prediction and explanatory analysis. The aim was to investigate the existence of correlations between the Dry cargo freight market and most of the parameters, economic and maritime, that have been identified as correlated in the literature. For this reason a large amount of data was collected, cleaned and structured. Also a Matlab code was developed to assess the data. After the assessment the below conclusions and suggestions for further research arise.

First, it become obvious that there is a need for more reliable, accurate and frequent data. We are living in the age of data but still in the maritime community the benefits are not fully acquired yet. The maritime community started to collect data electronically through IT systems thirty years ago but only the recent years, through the environmental requirements, started to analyze those data in a holistic and systematic way. This lack of data is obvious in the whole process and lowers the capabilities for the analysis. The major parameter is the frequency of the data. The lower frequency the better for the analysis. Also, it must be mentioned that fleet operational data should be included in the analysis. Nowadays, with the existing technology we are able to gather information regarding operational speed, distance travelled and fleet geographical distribution. All those data should be included in the future into relevant research.

A second conclusion is the lack of correlation between parameters which are considered to be correlated in the literature. A characteristic example is the country's population with the maritime trade. The absence of correlation of course does not ensure that there is no relation. On the contrary, further research is required in order to identify the reasons for that. Possible explanation may be that the correlation of those parameters are not of linear nature. The Pearson correlation coefficient which was used, assess the linear correlation between the parameters and it is blind in nonlinear relations. In a further research correlation coefficients such as Kendall's tau and Spearman's rho should be used to investigate for nonlinear effects.

On the other hand, some interesting correlations were observed. Correlations between the scrap value and the operational speed or the freight index and the fuel oil price can be used as examples. Another observation is the effect of the "neighboring" vessel sizes which after a certain period could be used as a substitute for the primary vessel size. Those relations where referred in literature but they become more obvious with the results. Moreover a big advantage was that those effects not only were discovered, but also the strength of their influence and the time lag before that happened were assessed. If we were able to validated the time lag between the correlations of those parameters that could be of great importance in prediction models for the maritime market. Regression models such as NARMAX type of models need the time lag for assessing the number of maximum lags in the past values.

As last conclusion, it could be said that there is a need for further investigation of the findings. For most of the data, only a limited time could be found and if the cyclic nature of the maritime industry is taken into consideration, it is easy to understand the need for data from longer periods. If patterns like these identified here could be found more than once in the history then those relations could gain validity and further

knowledge could be acquired. The existence of correlation does not imply causality as it was already mentioned before. Also the shipping cycle has an average length of 7.8 years according to (Grammenos, 2013). That frequency is not constant and if the volatility of the industry is taken into consideration, it can be seen that in order to clearly observe the pattern at least 3 cycles are needed. An average period for 3 cycles lasts almost 25 years. That period is large and there were not enough data in this thesis.

As propositions for further research the first observation is the need for more geographical targeted analysis. This kind of analysis may be more accurate and provide better results. Yet this kind of data are difficult to be found

Another thought is the analysis of the FFAs market. This market plays a significant role in the freight market as it is the tool which removes the volatility risk of the industry. But as (Gratsos, 2010) pinpoint and already mentioned FFAs are not representing the actual state of the market and it may not be as valid info as it considered to be.

Lastly, some suggestions for further development of the code are to take into consideration the number of available observations in the timeseries comparison. This parameter so far is taken into consideration only for the assessment of the confidence boundaries. And an efficient way to expand the code may be the development of a GUI version code which could give the capability to assess on the fly the analysis for a predefined selection of parameters.

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8 ANNEX

8.1 Baltic Exchange Indices

According the Baltic Exchange web page[24]

"the indices for the dry bulk markets are published from London and Singapore and based on the professional assessments of independent shipbrokers in London, New York, Singapore, Tokyo, Shanghai, Beijing, Mumbai, Oslo, Athens, Hong Kong, Geneva, Delhi and Genoa."

Below there is the matrix with the information for the indices, the routes and the panel members for the evaluation of the index.

Table 18 Baltic Exchange freight indices

Index	Routes	Publishing times	Frequency	Panel Members
Baltic Exchange Dry Index (BDI)	Timecharter elements of the Baltic Capesize, Panamax, Supramax & Handysize Indices	1300 (London)	Monday to Friday	1. See below
Capesize (BCI)	1. Tubarao to Rotterdam 2. Tubarao to Qingdao 3. Richards Bay to Rotterdam 4. W Australia to Qingdao 5. Bolivar to Rotterdam 6. Gibraltar-Hamburg Transatlantic Round Voyage 7. Continent/Mediterranean trip Far East 8. Pacific Round Voyage 9. China/Japan trip Mediterranean/Continent 10. China-Brazil round voyage 11. Richards Bay to Fangcheng 12. Revised backhaul	1300 (London)	Monday to Friday	13. Arrow Chartering (UK) 14. Banchero-Costa 15. Barry Rogliano Salles 16. Clarksons Platou 17. Fearnleys 18. EA Gibson Shipbrokers 19. Howe Robinson Partners 20. Ifchor 21. I & S Shipping 22. LSS Geneva 23. Simpson Spence Young 24. Thurlestone Shipping
Panamax (BPI)	1. Transatlantic RV 2. Skaw-Gibraltar/Far East 3. Japan-South Korea/Pacific Round Voyage 4. Implied voyage Newcastle-Qingdao 5. Far East/NoPac-Australia/Skaw-Passero	1300 (London)	Monday to Friday	1. Acropolis Chartering 2. Arrow Chartering (UK) 3. Banchero-Costa 4. Chinica Shipbrokers 5. Clarksons Platou 6. Fearnleys 7. EA Gibson Shipbrokers 8. Hai Young 9. Howe Robinson Partners 10. Ifchor 11. LSS Geneva 12. Optima Chartering 13. Simpson Spence Young 14. Thurlestone Shipping 15. Yamamizu Shipping Co

[24] http://www.balticexchange.com/market-information/product-overview/indics/

Supramax (BSI)	1. Antwerp-Skaw trip Far East 2. Canakkale trip Far East 3. Japan-South Korea/NoPac or Australia Round Voyage 4. Japan-South Korea trip Gibraltar-Skaw range 5. US Gulf-Skaw-Passero 6. Skaw-Passero-US Gulf 7. West Africa via east coast South America to North China 8. West Africa via east coast South America-Skaw-Passero	1300 (London)	Monday to Friday	1. Arrow Chartering (UK) 2. Ausea Beijing 3. Clarksons Platou 4. Hartland Shipping 5. Ifchor 6. Howe Robinson Partners 7. John F Dillon & Co 8. Lightship Chartering 9. Rigel Shipping 10. Simpson Spence Young 11. Yamamizu Shipping Co
Handysize (BHSI)	1. Skaw-Passero trip Recalada-Rio de Janeiro 2. Skaw-Passero trip Boston-Galveston 3. Recalada-Rio de Janeiro trip Skaw-Passero 4. US Gulf trip via US Gulf or north coast South America to Skaw-Passero 5. South East Asia trip via Australia to Singapore-Japan 6. South Korea-Japan via NoPac to Singapore-Japan	1300 (Singapore)	Monday to Friday	1. Ausea Beijing 2. Barry Rogliano Salles 3. Braemar ACM Shipbroking 4. Clarksons Platou Shipbroking (Switzerland) SA 5. Clarksons Platou Asia Pte Limited 6. Doric Shipbrokers 7. Hartland Shipping 8. Howe Robinson Partners 9. H Vogemann 10. Ifchor 11. Lightship Chartering 12. Rigel Shipping 13. Simpson Spence Young 14. Simpson Spence Young (Asia) 15. Yamamizu Shipping Co

8.2 Table of Parameters

Table 19 Table of parameters for Complete and Half period with the sampling frequencies

	Parameter for Complete Time Period	Sampling Frequency [days]	Parameter for Half Time Period	Sampling Frequency [days]
1	'Date'	1	'Date'	1
2	'Baltic Exchange Freight Index (BFI)'	1.45	'Baltic Exchange Freight Index (BFI)'	1.44
3	'Baltic Exchange Panamax Index'	1.46	'Baltic Exchange Panamax Index'	1.45
4	'Baltic Exchange Capesize Index'	1.46	'Baltic Exchange Capesize Index'	1.45
5	'Baltic Exchange Dry Index'	1.46	'Baltic Exchange Dry Index'	1.45
6	'Baltic Exchange Handymax Index'	1.45	'Baltic Exchange Handymax Index'	1.45
7	'Baltic Exchange Supramax Index'	1.46	'EU-12_15 iron ore imports Thousand Tonnes'	47.87
8	'Baltic Exchange Handysize Index'	1.49	'Japan Iron Ore Imports Million Tonnes'	47.87
9	'EU-12_15 iron ore imports Thousand Tonnes'	47.21	'South Korea Iron Ore Imports Million Tonnes'	47.87
10	'Japan Iron Ore Imports Million Tonnes'	47.21	'Australia Iron Ore Exports Million Tonnes'	47.87
11	'South Korea Iron Ore Imports Million Tonnes'	47.21	'China Iron Ore Imports Million Tonnes'	47.13
12	'Australia Iron Ore Exports Million Tonnes'	47.21	'Taiwan Iron Ore Imports Thousand Tonnes'	48.23
13	'China Iron Ore Imports Million Tonnes'	46.78	'Brazil Iron Ore Exports Thousand Tonnes'	48.59
14	'Taiwan Iron Ore Imports Thousand Tonnes'	47.23	'Total Bulkcarrier Fleet Development Milion DWT'	132.3
15	'Brazil Iron Ore Exports Thousand Tonnes'	47.32	'Total Bulkcarrier Fleet Development Number'	132.3
16	'Total Bulkcarrier Fleet Development Milion DWT'	136.32	'Clarksons Average Bulker Earnings $ Per Day'	7.24
17	'Total Bulkcarrier Fleet Development Number'	136.32	'Capesize Scrap Value $ Million'	44.68
18	'Clarksons Average Bulker Earnings $ Per Day'	7.27	'Panamax Bulker Scrap Value $ Million'	44.68
19	'Capesize Scrap Value $ Million'	46.31	'Handysize Bulker Scrap Value $ Million'	44.68
20	'Panamax Bulker Scrap Value $ Million'	46.31	'Handymax Bulker Scrap Value $ Million'	46.76
21	'Handysize Bulker Scrap Value $ Million'	46.31	'Australia Population'	345
22	'Handymax Bulker Scrap Value $ Million'	48.31	'Canada Population'	345
23	'Australia Population'	352.25	'France Population'	345
24	'Canada Population'	352.25	'Germany Population'	345

25	'France Population'	352.25	'Greece Population'	345
26	'Germany Population'	352.25	'Italy Population'	345
27	'Greece Population'	352.25	'Japan Population'	345
28	'Italy Population'	352.25	'Korea Population'	345
29	'Japan Population'	352.25	'Netherlands Population'	345
30	'Korea Population'	352.25	'Spain Population'	345
31	'Netherlands Population'	352.25	'United Kingdom Population'	345
32	'Spain Population'	352.25	'United States Population'	345
33	'United Kingdom Population'	352.25	'Euro area (17 countries) Population'	345
34	'United States Population'	352.25	'G7 Population'	345
35	'Euro area (17 countries) Population'	352.25	'OECD - Total Population'	345
36	'G7 Population'	352.25	'World Population'	345
37	'OECD - Total Population'	351.74	'Brazil Population'	345
38	'World Population'	352.25	'China Population'	345
39	'Brazil Population'	352.25	'India Population'	345
40	'China Population'	352.25	'Russian Federation Population'	345
41	'India Population'	352.25	'South Africa Population'	345
42	'Russian Federation Population'	352.25	'Australia'	30.3
43	'South Africa Population'	352.25	'Canada Normalised GDP'	30.3
44	'Australia'	30.35	'France Normalised GDP'	30.3
45	'Canada Normalised GDP'	30.35	'Germany Normalised GDP'	30.3
46	'France Normalised GDP'	30.35	'Greece Normalised GDP'	30.14
47	'Germany Normalised GDP'	30.35	'Italy Normalised GDP'	30.3
48	'Greece Normalised GDP'	30.3	'Japan Normalised GDP'	30.3
49	'Italy Normalised GDP'	30.35	'Korea Normalised GDP'	30.3
50	'Japan Normalised GDP'	30.35	'Netherlands Normalised GDP'	30.3
51	'Korea Normalised GDP'	30.35	'Spain Normalised GDP'	30.3
52	'Netherlands Normalised GDP'	30.35	'United Kingdom Normalised GDP'	30.3
53	'Spain Normalised GDP'	30.35	'United States Normalised GDP'	30.3
54	'United Kingdom Normalised GDP'	30.35	'Euro area (18 countries) Normalised GDP'	30.3

55	'United States Normalised GDP'	30.35	'Four Big European Normalised GDP'	30.3
56	'Euro area (18 countries) Normalised GDP'	30.35	'G7 Normalised GDP'	30.3
57	'Four Big European Normalised GDP'	30.35	'NAFTA Normalised GDP'	30.3
58	'G7 Normalised GDP'	30.35	'OECD - Europe Normalised GDP'	30.3
59	'NAFTA Normalised GDP'	30.35	'OECD - Total Normalised GDP'	30.3
60	'OECD - Europe Normalised GDP'	30.35	'OECD + Major Six NME Normalised GDP'	30.3
61	'OECD - Total Normalised GDP'	30.35	'Major Five Asia Normalised GDP'	30.1
62	'OECD + Major Six NME Normalised GDP'	30.35	'Brazil Normalised GDP'	30.3
63	'Major Five Asia Normalised GDP'	30.29	'China Normalised GDP'	30.11
64	'Brazil Normalised GDP'	30.35	'India Normalised GDP'	30.25
65	'China Normalised GDP'	30.3	'Russian Federation Normalised GDP'	30.3
66	'India Normalised GDP'	30.33	'380cst bunker prices, Rotterdam $ Per Tonne'	7.24
67	'Russian Federation Normalised GDP'	30.35	'380cst bunker prices, Genoa $ Per Tonne'	7.29
68	'380cst bunker prices, Rotterdam $ Per Tonne'	7.27	'380cst bunker prices, Los Angeles $ Per Tonne'	7.29
69	'380cst bunker prices, Genoa $ Per Tonne'	7.3	'380cst bunker prices, Singapore $ Per Tonne'	7.24
70	'380cst bunker prices, Los Angeles $ Per Tonne'	7.3	'380cst bunker prices, Philadelphia $ Per Tonne'	7.24
71	'380cst bunker prices, Singapore $ Per Tonne'	7.27	'380cst bunker prices, Japan $ Per Tonne'	7.24
72	'380cst bunker prices, Philadelphia $ Per Tonne'	7.27	'380cst bunker prices, Fos $ Per Tonne'	7.32
73	'380cst bunker prices, Japan $ Per Tonne'	7.27	'380cst bunker prices, Fujairah $ Per Tonne'	7.24
74	'380cst bunker prices, Fos $ Per Tonne'	7.31	'380cst bunker prices, Houston $ Per Tonne'	7.35
75	'380cst bunker prices, Fujairah $ Per Tonne'	7.27	'380cst bunker prices, Panama $ Per Tonne'	7.43
76	'380cst bunker prices, Houston $ Per Tonne'	7.33	'380cst Bunker Prices, Korea $ Per Tonne'	7.16
77	'380cst bunker prices, Panama $ Per Tonne'	7.37	'380cst bunker Prices, Hong Kong $ Per Tonne'	7.16
78	'380cst Bunker Prices, Korea $ Per Tonne'	7.28	'Average Value of 380cst bunker prices $ Per Tonne'	7.24
79	'380cst bunker Prices, Hong Kong $ Per Tonne'	7.28	'Panamax 75-77K DWT Bulkcarrier Newbuilding Prices $ Million'	30.29
80	'380cst bunker prices, Gibraltar $ Per Tonne'	7.29	'Handysize 25-30K DWT Bulkcarrier Newbuilding Prices $ Million'	30.29
81	'380cst Low Sulphur Fuel Oil, Rotterdam $ Per Tonne'	7.29	'Handysize 32-35K DWT Bulkcarrier Newbuilding Prices $ Million'	30.29
82	'380cst Low Sulphur Fuel Oil, Hamburg $ Per Tonne'	7.29	'Bulkcarrier Average Newbuilding Prices $ per DWT'	30.29

83	'380cst Low Sulphur Fuel Oil, Great Belt, Denmark $ Per Tonne'	7.29	'Bulkcarrier Newbuilding Price Index'	30.29
84	'380cst Low Sulphur Fuel Oil, Falmouth $ Per Tonne'	7.29	'Panamax 70k $ per cgt'	30.29
85	'380cst Low Sulphur Fuel Oil, Antwerp $ Per Tonne'	7.29	'Handysize 32-35k $ per cgt'	30.29
86	'380cst Low Sulphur Fuel Oil, Gibraltar $ Per Tonne'	7.26	'Handysize 25-30k $ per cgt'	30.29
87	'380cst Low Sulphur Fuel Oil, Houston $ Per Tonne'	7.17	'Average Bulkcarrier $ per cgt'	30.29
88	'380cst Low Sulphur Fuel Oil, Philadelphia $ Per Tonne'	7.2	'Index Weight Bulkcarriers $ per cgt'	30.29
89	'380cst Low Sulphur Fuel Oil, Los Angeles $ Per Tonne'	7.2	'Weighted Average Bulker $ per cgt'	30.29
90	'Average Value of 380cst bunker prices $ Per Tonne'	7.27	'Bulkcarrier Newbuilding Price Index Yr per Yr Change'	32.01
91	'Average Value of 380cst Low Sulphur Fuel Oil $ Per Tonne'	7.29	'Capesize 120k $ per cgt'	30.29
92	'Panamax 75-77K DWT Bulkcarrier Newbuilding Prices $ Million'	30.34	'Newbuilding Price Index'	30.29
93	'Handysize 25-30K DWT Bulkcarrier Newbuilding Prices $ Million'	30.34	'Dry Cargo Newbuilding Prices Index'	30.29
94	'Handysize 32-35K DWT Bulkcarrier Newbuilding Prices $ Million'	30.34	'Dry Cargo Average Newbuilding Prices $ Per DWT'	30.29
95	'Bulkcarrier Average Newbuilding Prices $ per DWT'	30.34	'Newbuilding Price Index Yrper Yr Change'	30.29
96	'Bulkcarrier Newbuilding Price Index'	30.34	'Dry Cargo Newbuilding Price Index Yr per Yr Change'	32.01
97	'Panamax 70k $ per cgt'	30.34	'Handymax 61-63K DWT Bulkcarrier Newbuilding Prices $ Million'	30.29
98	'Handysize 32-35k $ per cgt'	30.34	'Handymax 40k $ per cgt'	30.29
99	'Handysize 25-30k $ per cgt'	30.34	'Capesize 150 155k $ per cgt'	30.29
100	'Average Bulkcarrier $ per cgt'	30.34	'Capesize 176-180K DWT Newbuilding Prices $ Million'	30.29
101	'Index Weight Bulkcarriers $ per cgt'	30.34	'Panamax 68k $ per cgt'	30.09
102	'Weighted Average Bulker $ per cgt'	30.34	'Capesize Sales $ Million'	37.77
103	'Bulkcarrier Newbuilding Price Index Yr per Yr Change'	31.42	'Panamax Bulker Sales $ Million'	31.03
104	'Capesize 120k $ per cgt'	30.34	'Handymax Bulker Sales $ Million'	31.03
105	'Newbuilding Price Index'	30.34	'Handysize Bulker Sales'	30.15
106	'Dry Cargo Newbuilding Prices Index'	30.34	'Capesize Sales DWT'	36.88
107	'Dry Cargo Average Newbuilding Prices $ Per DWT'	30.34	'Panamax Bulker Sales DWT'	31.03
108	'Newbuilding Price Index Yrper Yr Change'	30.34	'Handymax Bulker Sales DWT'	31.03
109	'Dry Cargo Newbuilding Price Index Yr per Yr Change'	31.42	'Handysize Bulker Sales DWT'	30.15
110	'Handymax 61-63K DWT Bulkcarrier Newbuilding Prices $ Million'	30.34	'Capesize Sales Number'	36.88

111	'Handymax 40k $ per cgt'	30.34	'Panamax Bulker SalesNumber'	31.03
112	'Capesize 150 155k $ per cgt'	30.34	'Handymax Bulker SalesNumber'	31.03
113	'Capesize 176-180K DWT Newbuilding Prices $ Million'	30.34	'Handysize Bulker SalesNumber'	30.15
114	'Panamax 68k $ per cgt'	30.29	'Ships Sales - Buyers" Country Greece Number'	30.15
115	'Panamax 80-82k dwt Bulkcarrier ("Kamsarmax") Newbuilding Prices $ Million'	30	'Capesize Sales GT'	36.88
116	'Capesize Bulkcarrier 100-115k dwt Newbuilding Prices $ Million'	30	'Panamax Bulker Sales GT'	31.03
117	'Panamax 91-93k dwt Bulkcarrier Newbuilding Prices $ Million'	30	'Handymax Bulker Sales GT'	31.03
118	'Capesize Sales $ Million'	34.65	'Handysize Bulker Sales GT'	30.15
119	'Panamax Bulker Sales $ Million'	30.7	'USA Grain Exports Milion tonnes'	30.24
120	'Handymax Bulker Sales $ Million'	30.97	'Canada Grain Exports Milion tonnes'	30.24
121	'Handysize Bulker Sales'	30.43	'Australia Grain Exports Milion tonnes'	30.24
122	'Capesize Sales DWT'	33.98	'Argentina Grain Exports Milion tonnes'	30.24
123	'Panamax Bulker Sales DWT'	30.7	'EU-28 Grain Exports Milion tonnes'	30.24
124	'Handymax Bulker Sales DWT'	30.83	'Capesize 170K 10 Year Old Secondhand Prices $ Million'	7.22
125	'Handysize Bulker Sales DWT'	30.3	'Capesize 180K 5 Year Old Secondhand Prices $ Million'	7.22
126	'Capesize Sales Number'	33.98	'Panamax 75K Bulkcarrier 10 Year Old Secondhand Prices $ Million'	7.22
127	'Panamax Bulker SalesNumber'	30.7	'Handysize 32K 5 Year Old Secondhand Prices $ Million'	7.22
128	'Handymax Bulker SalesNumber'	30.83	'Handysize 32K 10 Year Old Secondhand Prices $ Million'	7.22
129	'Handysize Bulker SalesNumber'	30.3	'Handymax 52K 10 Year Old Secondhand Prices $ Million'	7.22
130	'Ships Sales - Buyers" Country Greece Number'	30.3	'Panamax 76K Bulkcarrier 5 Year Old Secondhand Prices $ Million'	7.22
131	'Capesize Sales GT'	33.98	'Handymax 56K 5 Year Old Secondhand Prices $ Million'	7.22
132	'Panamax Bulker Sales GT'	30.7	'Bulkcarrier Average Newbuilding Prices'	7.23
133	'Handymax Bulker Sales GT'	30.83	'Panamax S_H 65K DWT 20 Year Old Secondhand Prices $ Million'	7.17
134	'Handysize Bulker Sales GT'	30.3	'Handymax 42-45K DWT 20 Year Old Secondhand Prices $ Million'	7.17
135	'USA Grain Exports Milion tonnes'	30.33	'Capesize 150K DWT 20 Year Old Secondhand Prices $ Million'	7.17
136	'Canada Grain Exports Milion tonnes'	30.33	'Capesize 170K DWT 15 Year Old Secondhand Prices $ Million'	7.17
137	'Australia Grain Exports Milion tonnes'	30.33	'Panamax D_H 70K DWT 10 Year Old Secondhand Prices $ Million'	7.17

138	'Argentina Grain Exports Milion tonnes'	30.32	'Handysize 28K DWT 15 Year Old Secondhand Prices $ Million'	7.17
139	'EU-28 Grain Exports Milion tonnes'	30.33	'Handysize 27K DWT 20 Year Old Secondhand Prices $ Million'	7.17
140	'Total Port Congestion as % of Fleet %'	29.82	'Panamax 73K DWT 15 Year Old Secondhand Prices $ Million'	7.17
141	'Capesize Port Congestion as % of Capesize Fleet %'	29.82	'Panamax 69K DWT 20 Year Old Secondhand Prices $ Million'	7.17
142	'Panamax Port Congestion as % of Panamax Fleet %'	29.82	'Handymax 56K DWT 3 Year Old Secondhand Prices $ Million'	7.17
143	'Handymax Port Congestion as % of Handymax Fleet %'	29.82	'Handymax 45-48K DWT 15 Year Old Secondhand Prices $ Million'	7.17
144	'Capesize 170K 10 Year Old Secondhand Prices $ Million'	7.28	'Panamax D_H 73K DWT "Coated" 5 Yr Old Secondhand Prices $ Million'	7.17
145	'Capesize 180K 5 Year Old Secondhand Prices $ Million'	7.28	'Handysize Bulker Contracting $ Million'	32.19
146	'Panamax 75K Bulkcarrier 10 Year Old Secondhand Prices $ Million'	7.28	'Handymax Bulker Contracting $ Million'	35.45
147	'Handysize 32K 5 Year Old Secondhand Prices $ Million'	7.28	'Panamax Bulker Contracting $ Million'	33.74
148	'Handysize 32K 10 Year Old Secondhand Prices $ Million'	7.28	'Capesize Bulker Contracting $ Million'	40.91
149	'Handymax 52K 10 Year Old Secondhand Prices $ Million'	7.28	'Handysize Bulker Orderbook $ Million'	30.11
150	'Panamax 76K Bulkcarrier 5 Year Old Secondhand Prices $ Million'	7.28	'Handymax Bulker Orderbook DWT'	30.11
151	'Handymax 56K 5 Year Old Secondhand Prices $ Million'	7.28	'Panamax Bulker Orderbook DWT'	30.11
152	'Bulkcarrier Average Newbuilding Prices'	7.28	'Capesize Bulker Orderbook DWT'	30.11
153	'Panamax S_H 65K DWT 20 Year Old Secondhand Prices $ Million'	7.28	'Bulkcarrier Orderbook DWT'	30.11
154	'Handymax 42-45K DWT 20 Year Old Secondhand Prices $ Million'	7.28	'Handysize Bulker Contracting DWT'	32.19
155	'Capesize 150K DWT 20 Year Old Secondhand Prices $ Million'	7.28	'Handymax Bulker Contracting DWT'	35.45
156	'Capesize 170K DWT 15 Year Old Secondhand Prices $ Million'	7.28	'Panamax Bulker Contracting DWT'	33.74
157	'Panamax D_H 70K DWT 10 Year Old Secondhand Prices $ Million'	7.28	'Capesize Bulker Contracting DWT'	40.91
158	'Handysize 28K DWT 15 Year Old Secondhand Prices $ Million'	7.28	'Handysize Bulker Orderbook Number'	30.11
159	'Handysize 27K DWT 20 Year Old Secondhand Prices $ Million'	7.28	'Handymax Bulker Orderbook Number'	30.11
160	'Panamax 73K DWT 15 Year Old Secondhand Prices $ Million'	7.28	'Panamax Bulker Orderbook Number'	30.11
161	'Panamax 69K DWT 20 Year Old Secondhand Prices $ Million'	7.28	'Capesize Bulker Orderbook Number'	30.11
162	'Handymax 56K DWT 3 Year Old Secondhand Prices $ Million'	7.28	'Bulkcarrier Orderbook Number'	30.11
163	'Handymax 45-48K DWT 15 Year Old Secondhand Prices $ Million'	7.28	'Handysize Bulker Contracting Number'	32.19
164	'Panamax D_H 73K DWT "Coated" 5 Yr Old Secondhand Prices $ Million'	7.28	'Handymax Bulker Contracting Number'	35.45
165	'Bulk Carrier Secondhand Prices Index % Change'	7.26	'Panamax Bulker Contracting Number'	33.74

166	'Bulk Carrier Secondhand Prices Index Average $ Per DWT'	7.26	'Capesize Bulker Contracting Number'	40.91
167	'Bulk Carrier Secondhand Prices Index'	7.26	'Handysize Bulker Orderbook CGT'	30.11
168	'Panamax Tanker 73,000 dwt coated Resale Values $ Million'	7.28	'Handymax Bulker Orderbook CGT'	30.11
169	'Capesize 180k dwt Secondhand Bulker Resale Prices $ Million'	7.28	'Panamax Bulker Orderbook CGT'	30.11
170	'Panamax 76k dwt Secondhand Bulker Resale Prices $ Million'	7.28	'Capesize Bulker Orderbook CGT'	30.11
171	'Handymax 61k dwt Secondhand Bulker Resale Prices $ Million'	7.28	'Bulkcarrier Orderbook CGT'	30.11
172	'Handysize 33k dwt Secondhand Bulker Resale Prices $ Million'	7.28	'Handysize Bulker Contracting CGT'	32.19
173	'Panamax 80-82k dwt Bulkcarrier (Kamsarmax) Newbuilding Prices $ Million'	7.29	'Handymax Bulker Contracting CGT'	35.45
174	'Panamax 82k dwt Secondhand Bulker (Kamsarmax) Resale Prices $ Million'	7.19	'Panamax Bulker Contracting CGT'	33.74
175	'Handysize Bulker Contracting $ Million'	31.44	'Capesize Bulker Contracting CGT'	40.91
176	'Handymax Bulker Contracting $ Million'	32.83	'Australia Current account, balance in millions'	90.12
177	'Panamax Bulker Contracting $ Million'	32.51	'Canada Current account, balance in millions'	89.69
178	'Capesize Bulker Contracting $ Million'	35.9	'France Current account, balance in millions'	88.77
179	'Handysize Bulker Orderbook $ Million'	30.3	'Germany Current account, balance in millions'	90.12
180	'Handymax Bulker Orderbook DWT'	30.3	'Greece Current account, balance in millions'	90.12
181	'Panamax Bulker Orderbook DWT'	30.3	'Italy Current account, balance in millions'	89.88
182	'Capesize Bulker Orderbook DWT'	30.3	'Japan Current account, balance in millions'	90.12
183	'Bulkcarrier Orderbook DWT'	30.3	'Netherlands Current account, balance in millions'	90.12
184	'Handysize Bulker Contracting DWT'	31.44	'Spain Current account, balance in millions'	89.69
185	'Handymax Bulker Contracting DWT'	32.51	'United Kingdom Current account, balance in millions'	90.12
186	'Panamax Bulker Contracting DWT'	32.51	'United States Current account, balance in millions'	90.12
187	'Capesize Bulker Contracting DWT'	35.9	'G7 Current account, balance in millions'	88.77
188	'Handysize Bulker Orderbook Number'	30.3	'OECD - Europe Current account, balance in millions'	88.41
189	'Handymax Bulker Orderbook Number'	30.3	'OECD - Total Current account, balance in millions'	88.41
190	'Panamax Bulker Orderbook Number'	30.3	' Brazil Current account, balance in millions'	90.12
191	'Capesize Bulker Orderbook Number'	30.3	' China Current account, balance in millions'	87.43
192	'Bulkcarrier Orderbook Number'	30.3	' India Current account, balance in millions'	90.12
193	'Handysize Bulker Contracting Number'	31.44	' Russian Federation Current account, balance in millions'	89.02

194	'Handymax Bulker Contracting Number'	32.51	' South Africa Current account, balance in millions'	90.12
195	'Panamax Bulker Contracting Number'	32.51	'Supramax Design Speed (knots)'	345
196	'Capesize Bulker Contracting Number'	35.9	'Panamax Design Speed (knots)'	345
197	'Handysize Bulker Orderbook CGT'	30.3	'HandySize Design Speed (knots)'	345
198	'Handymax Bulker Orderbook CGT'	30.3	'HandyMax Design Speed (knots)'	345
199	'Panamax Bulker Orderbook CGT'	30.3	'Capesize Design Speed (knots)'	345
200	'Capesize Bulker Orderbook CGT'	30.3	'Capesize Sales USD Million'	37.77
201	'Bulkcarrier Orderbook CGT'	30.3	'Panamax Bulker Sales USD Million'	31.03
202	'Handysize Bulker Contracting CGT'	31.44	'Handymax Bulker Sales USD Million'	31.03
203	'Handymax Bulker Contracting CGT'	32.51	'Rail goods International transport in million tonne-km France'	30.18
204	'Panamax Bulker Contracting CGT'	32.51	'Rail goods International transport in million tonne-km Germany'	30.11
205	'Capesize Bulker Contracting CGT'	35.9	'Rail goods International transport in million tonne-km Greece'	30.18
206	'Australia Current account, balance in millions'	90.54	'Rail goods International transport in million tonne-km Italy'	30.18
207	'Canada Current account, balance in millions'	90.38	'Rail goods International transport in million tonne-km Netherlands'	30.18
208	'France Current account, balance in millions'	90.14	'Trade in goods Exports Million US dollars Australia'	90.08
209	'Germany Current account, balance in millions'	90.54	' Trade in goods Exports Million US dollars Brazil'	90.08
210	'Greece Current account, balance in millions'	90.54	'Trade in goods Exports Million US dollars Canada'	90.08
211	'Italy Current account, balance in millions'	90.45	'Trade in goods Exports Million US dollars China (People"s Republic of)'	87.18
212	'Japan Current account, balance in millions'	90.54	'Trade in goods Exports Million US dollars Euro area (19 countries)'	87.8
213	'Netherlands Current account, balance in millions'	90.54	'Trade in goods Exports Million US dollars France'	86.27
214	'Spain Current account, balance in millions'	90.38	'Trade in goods Exports Million US dollars Germany'	89.5
215	'United Kingdom Current account, balance in millions'	90.54	'Trade in goods Exports Million US dollars India'	90.08
216	'United States Current account, balance in millions'	90.54	'Trade in goods Exports Million US dollars Korea'	90.08
217	'G7 Current account, balance in millions'	90.14	'Trade in goods Exports Million US dollars Russia'	88.92
218	'OECD - Europe Current account, balance in millions'	90.05	'Trade in goods Exports Million US dollars Spain'	88.64
219	'OECD - Total Current account, balance in millions'	89.88	'Trade in goods Exports Million US dollars United Kingdom'	86.27
220	' Brazil Current account, balance in millions'	90.54	'Trade in goods Exports Million US dollars United States'	90.08
221	' China Current account, balance in millions'	89.87	'Total Coal Imports Thousand Short Tons North America'	345

222	' India Current account, balance in millions'	90.46	'Total Coal Imports Thousand Short Tons Canada'	345
223	' Russian Federation Current account, balance in millions'	90.1	'Total Coal Imports Thousand Short Tons United States'	345
224	' South Africa Current account, balance in millions'	90.44	'Total Coal Imports Thousand Short Tons Central & South America'	345
225	'Operational Speed Bulk Carrier "0-9999"'	30.02	'Total Coal Imports Thousand Short Tons Brazil'	345
226	'Operational Speed Bulk Carrier "10000-34999" Handysize'	30.02	'Total Coal Imports Thousand Short Tons Europe'	345
227	'Operational Speed Bulk Carrier "35000-59999" (Handymax)'	30.02	'Total Coal Imports Thousand Short Tons France'	345
228	'Operational Speed Bulk Carrier "60000-99999" (Panamax)'	30.02	'Total Coal Imports Thousand Short Tons Germany'	345
229	'Operational Speed Bulk Carrier "100000-199999"'	30.02	'Total Coal Imports Thousand Short Tons Greece'	345
230	'Operational Speed Bulk Carrier "200000-+"'	30.02	'Total Coal Imports Thousand Short Tons Italy'	345
231	'Average days in the sea "0-9999"'	30.02	'Total Coal Imports Thousand Short Tons Netherlands'	345
232	'Average days in the sea "10000-34999" (Handysize)'	30.02	'Total Coal Imports Thousand Short Tons Spain'	345
233	'Average days in the sea "35000-59999" (Handymax)'	30.02	'Total Coal Imports Thousand Short Tons United Kingdom'	345
234	'Average days in the sea "60000-99999" (Panamax)'	30.02	'Total Coal Imports Thousand Short Tons Eurasia'	345
235	'Average days in the sea "100000-199999"'	30.02	'Total Coal Imports Thousand Short Tons Russia'	332.09
236	'Average days in the sea "200000-+"'	30.02	'Total Coal Imports Thousand Short Tons Middle East'	345
237	'Supramax Design Speed (knots)'	352.68	'Total Coal Imports Thousand Short Tons Africa'	345
238	'Panamax Design Speed (knots)'	352.68	'Total Coal Imports Thousand Short Tons Asia & Oceania'	345
239	'HandySize Design Speed (knots)'	352.68	'Total Coal Imports Thousand Short Tons China'	345
240	'HandyMax Design Speed (knots)'	352.68	'Total Coal Imports Thousand Short Tons India'	345
241	'Capesize Design Speed (knots)'	352.68	'Total Coal Imports Thousand Short Tons Japan'	345
242	'Capesize Sales USD Million'	34.65	'Total Coal Imports Thousand Short Tons Korea, South'	345
243	'Panamax Bulker Sales USD Million'	30.7	'Total Coal Imports Thousand Short Tons World'	345
244	'Handymax Bulker Sales USD Million'	30.97	'LIBOR USD 6M TD156N'	1.44
245	'Iron ore Inventory at Chinese Ports in 10000 tons'	1	'LIBOR USD 3M TD156N'	1.44
246	'Rail goods International transport in million tonne-km Canada'	30.03	'Second hand 5 years over New building Panamax'	29.93
247	'Rail goods International transport in million tonne-km France'	30.26	'Second hand 10 years over New building Panamax'	29.93
248	'Rail goods International transport in million tonne-km Germany'	30.3	'Second hand 10 years over Scrap value Panamax'	45.65
249	'Rail goods International transport in million tonne-km Greece'	30.31	'Second hand 20 years over Scrap value Panamax'	45.58
250	'Rail goods International transport in million tonne-km Italy'	30.26	'Orderbook over fleet development DWT'	30.11

251	'Rail goods International transport in million tonne-km Netherlands'	30.23		
252	'Trade in goods Exports Million US dollars Australia'	90.53		
253	' Trade in goods Exports Million US dollars Brazil'	90.53		
254	'Trade in goods Exports Million US dollars Canada'	90.53		
255	'Trade in goods Exports Million US dollars China (People"s Republic of)'	89.85		
256	'Trade in goods Exports Million US dollars Euro area (19 countries)'	90		
257	'Trade in goods Exports Million US dollars France'	89.83		
258	'Trade in goods Exports Million US dollars Germany'	90.34		
259	'Trade in goods Exports Million US dollars Greece'	87		
260	'Trade in goods Exports Million US dollars India'	90.45		
261	'Trade in goods Exports Million US dollars Japan'	87		
262	'Trade in goods Exports Million US dollars Korea'	90.53		
263	'Trade in goods Exports Million US dollars Netherlands'	87.68		
264	'Trade in goods Exports Million US dollars Russia'	90.09		
265	'Trade in goods Exports Million US dollars Spain'	90.14		
266	'Trade in goods Exports Million US dollars United Kingdom'	89.83		
267	'Trade in goods Exports Million US dollars United States'	90.53		
268	'Total Coal Imports Thousand Short Tons North America'	352.25		
269	'Total Coal Imports Thousand Short Tons Canada'	352.25		
270	'Total Coal Imports Thousand Short Tons United States'	352.25		
271	'Total Coal Imports Thousand Short Tons Central & South America'	352.25		
272	'Total Coal Imports Thousand Short Tons Brazil'	352.25		
273	'Total Coal Imports Thousand Short Tons Europe'	352.25		
274	'Total Coal Imports Thousand Short Tons France'	352.25		
275	'Total Coal Imports Thousand Short Tons Germany'	352.25		
276	'Total Coal Imports Thousand Short Tons Greece'	352.25		
277	'Total Coal Imports Thousand Short Tons Italy'	352.25		
278	'Total Coal Imports Thousand Short Tons Netherlands'	352.25		
279	'Total Coal Imports Thousand Short Tons Spain'	352.25		

280	'Total Coal Imports Thousand Short Tons United Kingdom'	352.25		
281	'Total Coal Imports Thousand Short Tons Eurasia'	352.25		
282	'Total Coal Imports Thousand Short Tons Russia'	347.9		
283	'Total Coal Imports Thousand Short Tons Middle East'	352.25		
284	'Total Coal Imports Thousand Short Tons Africa'	352.25		
285	'Total Coal Imports Thousand Short Tons Asia & Oceania'	352.25		
286	'Total Coal Imports Thousand Short Tons China'	352.25		
287	'Total Coal Imports Thousand Short Tons India'	352.25		
288	'Total Coal Imports Thousand Short Tons Japan'	352.25		
289	'Total Coal Imports Thousand Short Tons Korea, South'	352.25		
290	'Total Coal Imports Thousand Short Tons World'	352.25		
291	'LIBOR USD 6M TD156N'	1.44		
292	'LIBOR USD 3M TD156N'	1.44		
293	'Second hand 5 years over New building Panamax'	30.27		
294	'Second hand 10 years over New building Panamax'	30.27		
295	'Second hand 10 years over Scrap value Panamax'	47.62		
296	'Second hand 20 years over Scrap value Panamax'	48.17		
297	'Orderbook over fleet development DWT'	30.3		
298	'Freight analogy (formula) Bulk Carrier "0-9999"'	30.02		
299	'Freight analogy (formula) Bulk Carrier "10000-34999" (Handysize)'	30.02		
300	'Freight analogy (formula) Bulk Carrier "35000-59999" (Handymax)'	30.02		
301	'Freight analogy (formula) Bulk Carrier "60000-99999" (Panamax)'	30.02		
302	'Freight analogy (formula) Bulk Carrier "100000-199999"'	30.02		

8.3 Matlab Codes

8.3.1 Main Code

```
%% Sort the parameters based on their frequency
[B, IX]=sort (param_freq,'descend'

%% Create the folders
for i=1:size(B,2)
    folder =char( strcat(label(2,IX(i))))
    mkdir(strcat('D:\Piraeus University\THESIS\RESULTS\FIRST TRY
PLOTS2\',folder));
    clear folder
end
clear i

tic
s=1;
for i=1:size(IX,2)
    i
    for j=i:size(IX,2)
        j   ;
        %% Check if it is in the desire range of parameters
        if (ismember(i,[225,226,227,228])|
ismember(j,[225,226,227,228]))


        %% Check the overlapping of the two signals

        [A_lim,C_lim]=overlapping(limits,IX,i,j);
        if IX(i)~=1  %% Check if i is time, if not proceed
            par=data(A_lim(1,1):A_lim(2,1),IX(i));  %% take the
values for the limits
            par1_0=par((par~=0));
%%% Create a timeline
        else
            continue
        end

        if size(par1_0,1)<20
            FIN(1,s)={NaN};
            FIN(2,s)= label(2,IX(i));
            FIN(3,s)={NaN};
            FIN(4,s)= label(2,IX(j));
            FIN(5,s)={NaN};
            FIN_n(1,s)= 0;
            FIN_n(2,s)= 0;
            FIN_n(3,s)=0;
            FIN_n(4,s)= i;
            FIN_n(5,s)= j;
            FIN_n(6,s)= toc;
            FIN_cor(1,s)=0;
            FIN_cor(2,s)=0;
            FIN_cor(3,s)=0;
            FIN_cor(4,s)=0;
            FIN_cor(5,s)=0;
            FIN_cor(6,s)=0;
            s=s+1;
            break
```

```
        end
        [A,label_A,stat_ind]=transfor(par1_0);

        if IX(j)~=1
            par2=data(C_lim(1,1):C_lim(2,1),IX(j));
            par2_0=par2((par2~=0));
        else
            continue
        end

        %% Resampling
        if size(par2_0,1)>size(A,1)    %%% Check if the timeserie have
less values than  the primary

par2_res_0=resample(par2_0,length(par1_0),length(par2_0)); %% if yes
resample the secondary to the primary's frequency
            if size(par2_res_0,1)<20
                FIN(1,s)={NaN};
                FIN(2,s)= label(2,IX(i));
                FIN(3,s)={NaN};
                FIN(4,s)= label(2,IX(j));
                FIN(5,s)={NaN};
                FIN_n(1,s)= 0;
                FIN_n(2,s)= 0;
                FIN_n(3,s)=0;
                FIN_n(4,s)= i;
                FIN_n(5,s)= j;
                FIN_n(6,s)= toc;
                FIN_cor(1,s)=0;
                FIN_cor(2,s)=0;
                FIN_cor(3,s)=0;
                FIN_cor(4,s)=0;
                FIN_cor(5,s)=0;
                FIN_cor(6,s)=0;
                s=s+1;
                break
            end
            [C,label_C,stat_ind]=transfor(par2_res_0);
        else
            A_2=resample(A,length(par2_0),length(par1_0));%% if no
resample the primary to the secondary's frequency
            par2_res_0=par2_0;
            if size(par2_res_0,1)<20
                FIN(1,s)={NaN};
                FIN(2,s)= label(2,IX(i));
                FIN(3,s)={NaN};
                FIN(4,s)= label(2,IX(j));
                FIN(5,s)={NaN};
                FIN_n(1,s)= 0;
                FIN_n(2,s)= 0;
                FIN_n(3,s)=0;
                FIN_n(4,s)= i;
                FIN_n(5,s)= j;
                FIN_n(6,s)= toc;
                FIN_cor(1,s)=0;
                FIN_cor(2,s)=0;
                FIN_cor(3,s)=0;
                FIN_cor(4,s)=0;
                FIN_cor(5,s)=0;
                FIN_cor(6,s)=0;
                s=s+1;
```

```
                break
            end
            [C,label_C,stat_ind]=transfor(par2_res_0);
        end
        %%
        for u=1:size(A,2)
            %                           u
            for w=1:size(C,2)
                %                                   w
                %% Plot the 2 signals
                if size(par2_res_0,1)>=size(A,1)

                    h=figure('visible','off');
                    %
h=figure('visible','on');
                    set(h, 'Position', [50 50 1300 640])
                    plot(A(:,u)/norm(A(:,u)));
                    hold on
                    plot(C(:,w)/norm(C(:,w)),'r')
                    xlabel('Time','fontsize',15)
                    ylabel('Parameter','fontsize',15)
                    title(strcat('Plot of " ', label_A(1,u),'" of  "
' , label(2,IX(i)),'" with " ' ,label_C(1,w), '" of "',
label(2,IX(j)),'"'),'fontsize',15)
                    leg(1,1)=label(2,IX(i));
                    leg(1,2)=label(2,IX(j));
                    legend(leg);
                    hold off

[xcf,lags,bounds]=crosscorr(A(:,u),C(:,w),round(0.9*size(A(:,u),1)));
                else
                    h=figure('visible','off');
                    set(h, 'Position', [50 50 1300 640])
                    plot(A_2(:,u)/norm(A_2(:,u)));
                    hold on
                    plot(C(:,w)/norm(C(:,w)),'r')
                    xlabel('Time','fontsize',15)
                    ylabel('Parameter','fontsize',15)
                    title(strcat('Plot of " ', label_A(1,u),'" of  "
' , label(2,IX(i)),'" with " ' ,label_C(1,w), '" of "',
label(2,IX(j)),'"'),'fontsize',15)
                    leg(1,1)=label(2,IX(i));
                    leg(1,2)=label(2,IX(j));
                    legend(leg);

[xcf,lags,bounds]=crosscorr(A_2(:,u),C(:,w),round(0.9*size(A_2(:,u),1
)));
                    hold off
                end

                %% Save the 2 signals plot
                folder =char( strcat(label(2,IX(j))));
                folder1 =char( strcat(label(2,IX(i))));
                options.Format = 'png';
                %
hgsave((strcat('D:\Piraeus University\THESIS\Matlab\FIRST TRY
PLOTS\',strcat(folder),'\',folder1)))
                hgexport(h,(strcat('D:\Piraeus
University\THESIS\RESULTS\FIRST TRY
PLOTS2\',strcat(folder),'\',folder1,num2str(u),num2str(w))),options)
                clear h folder folder1 options
```

```
                close all
                %
save(strcat('D:\Piraeus University\THESIS\Matlab\FIRST TRY
PLOTS\',folder))
                if size(A(:,u),1)==size(C(:,w),1)

[out_limits,out_limits_lag,out_per]=out_lim_calculator(A,C,xcf,u,w,bo
unds,B,i);
                else

[out_limits,out_limits_lag,out_per]=out_lim_calculator(A_2,C,xcf,u,w,
bounds,B,i);
                end

                %% Plot the crosscorrelation function
                if size(par2_res_0,1)>=size(A(:,u),1)
                    f=figure('visible','off');
                    set(f, 'Position', [50 50 1300 640])

crosscorr(A(:,u),C(:,w),round(0.9*size(A(:,u),1)));
                    xlabel('Lag','fontsize',15)
                    ylabel('Sample Cross Correlation','fontsize',15)
                    title(strcat('Cross-Corellation Function of "' ,
label_A(1,u),'" of " ' , label(2,IX(i)),'" with "' ,label_C(1,w), '"
of "', label(2,IX(j)),'"'),'fontsize',13)

                else
                    f=figure('visible','off');
                    set(f, 'Position', [50 50 1300 640])

crosscorr(A_2(:,u),C(:,w),round(0.9*size(A_2(:,u),1)));
                    xlabel('Lag','fontsize',15)
                    ylabel('Sample Cross Correlation','fontsize',15)
                    title(strcat('Cross-Corellation Function of "' ,
label_A(1,u),'" of " ' , label(2,IX(i)),'" with "' ,label_C(1,w), '"
of "', label(2,IX(j)),'"'),'fontsize',13)

                end
                %% Save the correllation function plot
                folder =char( strcat(label(2,IX(j))));
                folder1 =char( strcat(label(2,IX(i))));
                options.Format = 'png';
                hgexport(f,(strcat('D:\Piraeus
University\THESIS\RESULTS\FIRST TRY
PLOTS2\',strcat(folder),'\Correlation-
',folder1,num2str(u),num2str(w))),options)
                clear f folder folder1 options leg
                close all
                %% Calculate all the analysis data
                if size(par2_res_0,1)>=size(A(:,u),1)
                    [RHO2,PVAL2] =
corr(A(:,u),C(:,w),'type','Kendall');
                    [RHO3,PVAL3] =
corr(A(:,u),C(:,w),'type','Spearman');
                    [RHO,PVAL] = corr(A(:,u),C(:,w));
                else
                    [RHO2,PVAL2] =
corr(A_2(:,u),C(:,w),'type','Kendall');
                    [RHO3,PVAL3] =
corr(A_2(:,u),C(:,w),'type','Spearman');
                    [RHO,PVAL] = corr(A_2(:,u),C(:,w));
```

```
                end
                FIN(1,s)=label_A(1,u);
                FIN(2,s)= label(2,IX(i));
                FIN(3,s)=label_C(1,w);
                FIN(4,s)= label(2,IX(j));
                FIN(5,s)={stat_ind};
                FIN_n(1,s)= out_limits_lag(1,1);
                FIN_n(2,s)= out_limits(1,1);
                FIN_n(3,s)=out_per(1,1);
                FIN_n(4,s)= i;
                FIN_n(5,s)= j;
                FIN_n(6,s)= toc;
                FIN_cor(1,s)=RHO;
                FIN_cor(2,s)=PVAL;
                FIN_cor(3,s)=RHO2;
                FIN_cor(4,s)=PVAL2;
                FIN_cor(5,s)=RHO3;
                FIN_cor(6,s)=PVAL3;
                clear out_* RHO* PVAL*
                save('D:\Piraeus
University\THESIS\RESULTS\FINAL2','FIN','FIN_n','FIN_cor')

                s=s+1;

            end

        end

        clear C C_lim A_lim
        else
            continue
        end
    end

    clear A u w  A_2 j

end
clear i

total_time=toc
```

8.3.2 Frequency Analysis and Preanalysis

```
load C:\Users\Christos\Desktop\NEW\kostoulas_7
%%% Try to assess the frequency of each column

% Sort per date
double_date=find(diff(data_n(:,1))==0);  %%% Find duplicate dates

data=data_n;
data(double_date,:)=[]; %%%% Delete duplicates dates

for i=2:size(data,2)

    if isempty(find (data(:,i)~=0))
        limits(:,i)=1;
```

```
    else
        limits(1,i)=find (data(:,i)~=0,1,'first');      %%% Find
first value of each parameter
        limits(2,i)=find (data(:,i)~=0,1,'last');       %%% Find last
value of each parameter
    end

%     supercycle

         diaf=find(data(limits(1,i):limits(2,i),i)==0);

         if  isempty(diaf)                                          %%%
Check if there is data for every entry

                 mis_par(i)=0;

         else

                mis_par(i)=length(diaf);                  %%%% Find
number of missing values

         end
        clear diaf
end
clear i
num_entries=diff(limits) +1;  %%% Number of maximum values for each
parameter
num_val=num_entries - mis_par;
param_freq=num_entries./(num_val);
 %% Delete collumns witout data
 ind1=sum(limits);
ind2=find(ind1==2);
data(:,ind2)=[];
label(:,ind2)=[];
num_entries(:,ind2)=[];
param_freq(:,ind2)=[];
limits(:,ind2)=[];
clear ind* data_n double_date mis_par num_val
 %% Check for equal arrays
for i =1:size(data,2)

    for j=1:size(data,2)

         tf(i,j) = isequal(data(:,i),data(:,j));
         if tf(i,j)==1 && i~=j
             ind(i)=1;
         end


    end
end
clear i j ind tf
```

8.3.3 Stationary Check

```
function [H]=stationarity(y)

%%% Perform test for stationarity

h = kpsstest(y);  %%% Null univariate time series y is trend
stationary
[h1] = lmctest(y); %%% null hypothesis that a univariate time series
y is a trend-stationary
[h2] = ~pptest(y); %%%%   the null hypothesis of a unit root in a
univariate time series y  INVERSED
h3= ~adftest(y); %%% the null hypothesis of a unit root in a
univariate time series, Y.  INVERSED
[h4] = ~pptest(y);%%% null hypothesis of a unit root in a univariate
time series y  INVERSED

H=[h;h1;h2;h3;h4];
```

8.3.4 Transformations

```
function[A,label_A,stat_ind]=transfor(x)

            stat_ind='Station';
 %%% Normalise the timeserie
            x1=x/norm(x);
            %%% First stationarity control
            H(:,1)=stationarity(x1);
            %%% Second sationarity control
             fi_x1=diff(x1);
              H(:,2)=stationarity(fi_x1);
             %%% Third stationarity control
             x2=x1+abs(min(x))+1;
             dif_log_x1=diff(log(x2));
             clear x2
              H(:,3)=stationarity( dif_log_x1);
             %%% Fourth stationarity control
             sec_x1=diff(fi_x1);
             H(:,4)=stationarity( sec_x1);

             for k=2:size(x1,1)
                 klasma(k-1,1)=((x1(k)-x1(k-1))/x1(k-1));
             end
             clear k

             klasma2=klasma+2*abs(min(klasma));
             %%% Fifth stationarity test
             log_div_x1=log(klasma2);
             M= log_div_x1(0== sum(isinf(log_div_x1), 1), :); %%%
Delete all collumn containing an inf value
             if isempty(M)
                 H(:,5)=1;
             else
                 H(:,5)=stationarity(log_div_x1);
```

```
            end

            Crit_ind=sum(H);

               clear  klasma*

                   %%% Check if none transformation removes
                   %%% nonstationarity, If yes assume nonstation for
the one with the less tests failed
                   if min(Crit_ind)~=0
                       ind_a=min(Crit_ind(1,:));
                       ind_b=find(Crit_ind==ind_a);
                       Crit_ind(1,ind_b(1,1))=0;
                       stat_ind='Non-station';
                   end

               c=1;
                   if Crit_ind(1,1)==0
                       A(:,c)=x1;
                       label_A(1,c)={'Normalise'};
                       c=c+1;
                   end

                    if Crit_ind(1,2)==0
                       A(1,c)=0;
                       A(2:size(x1,1),c)=fi_x1;
                        label_A(1,c)={'Difference'};
                       c=c+1;
                    end

                    if Crit_ind(1,3)==0
                        A(1,c)=0;
                       A(2:size(x1,1),c)= dif_log_x1;
                       label_A(1,c)={'Log Difference'};
                       c=c+1;
                    end

                   if Crit_ind(1,4)==0
                       A(1,c)=0;
                       A(2,c)=0;
                       A(3:size(x1,1),c)= sec_x1;
                       label_A(1,c)={'Second Difference'};
                       c=c+1;
                   end

                   if  Crit_ind(1,5)==0
                       A(1,c)=0;
                        A(2:size(x1,1),c)= log_div_x1;
                         label_A(1,c)={'Log ratio'};
                        c=c+1;
                   end
                   clear c


end
```

8.3.5 Correllation Time Finder

```
function
[out_limits,out_limits_lag,out_per]=out_lim_calculator(A,C,xcf,u,w,bo
unds,B,i)
%% Autocorrelation
if A(:,u)==C(:,w)
    one_ind=round(0.9*size(A,1))+1;   %%% find value equal to 1
    off_lim_ind=find(abs(xcf)>bounds(1,1));  %%% Find out of bounds
    if   isempty(off_lim_ind)
        out_limits(:,1)=0;
        out_limits_lag(:,1)=0;
    else
        out_lim=xcf(off_lim_ind);
        out_lim(find(out_lim==1))=[]; %%% Delete one magnitude
        b=abs(out_lim);
        max_ind=find(b==max(b));
        if isempty(max_ind)
            out_limits(:,1)=0;
            out_limits_lag(:,1)=0;
            out_per(:,1)=0;
        else
            out_limits(:,1)=out_lim(max_ind,1);
            out_lim_ind=find(xcf== out_limits(1,1));
            out_limits_lag(:,1)=(one_ind-out_lim_ind)*B(1,i);
            out_per(:,1)=(abs(out_limits(:,1))-
bounds(1,1))/bounds(1,1);
        end
    end
else
    %% Crosscorrellation
    off_lim_ind=find(abs(xcf)>bounds(1,1));  %%% Find out of bounds

    if   isempty(off_lim_ind)  %%%% Check if off_lim_ind is empty
        out_limits(:,1)=0;
        out_limits_lag(:,1)=0;
        out_per(:,1)=(abs(out_limits(:,1))-bounds(1,1))/bounds(1,1);
    else
        out_lim=xcf(off_lim_ind);
        b=abs(out_lim);
        max_ind=find(b==max(b));
        out_limits(:,1)=out_lim(max_ind,1);
        out_lim_ind=find(xcf== out_limits(1,1));
        out_limits_lag(:,1)=(  (round(0.9*size(A,1))+1)  -
out_lim_ind)*B(1,i);
        out_per(:,1)=(abs(out_limits(:,1))-bounds(1,1))/bounds(1,1);
    end

end
```