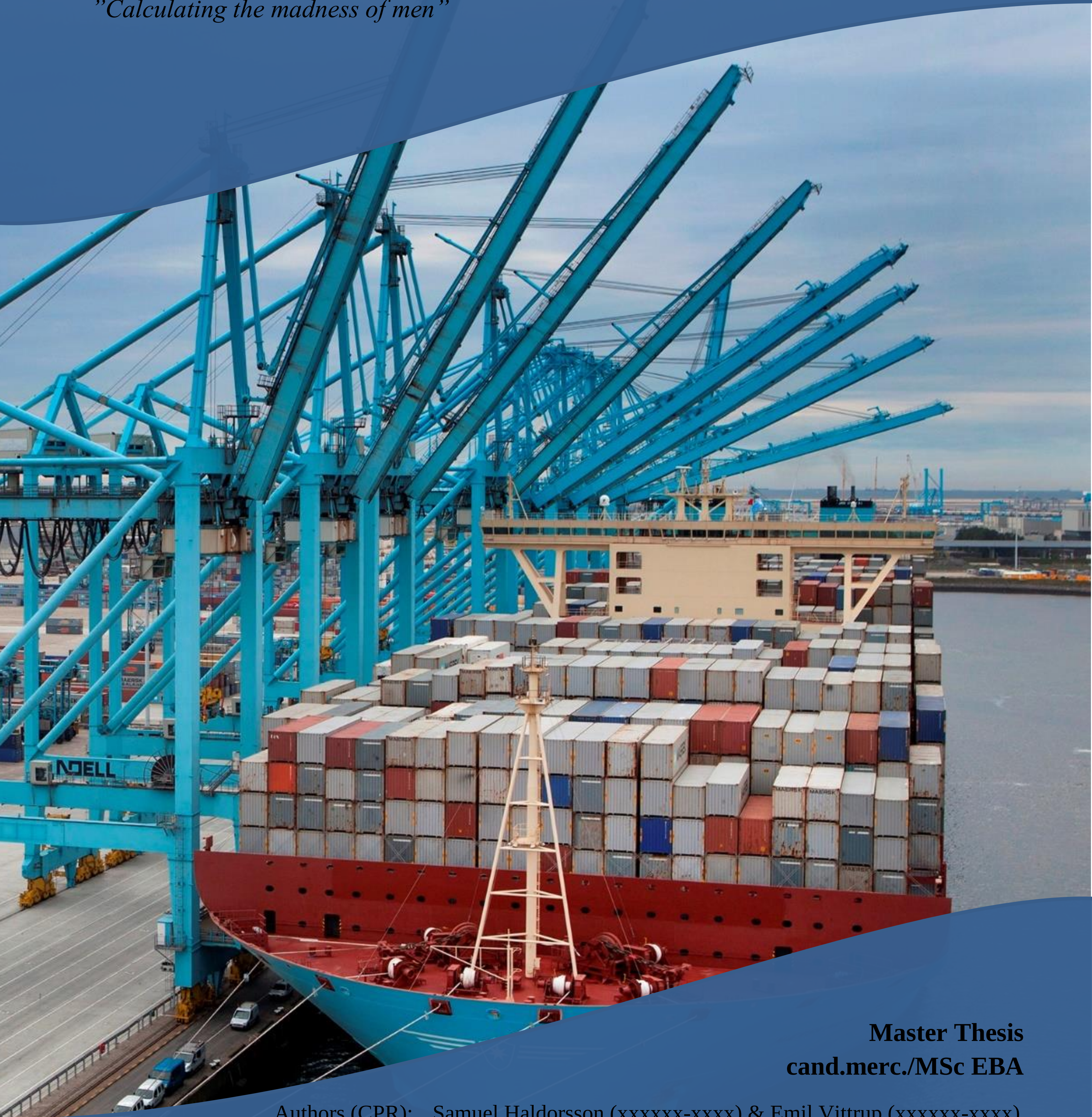
An analysis of irrational behaviour in container shipping

Historical analysis from an intrinsic value perspective

”Calculating the madness of men”



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Executive summary

Shipping is a highly volatile and cyclical industry, where earnings, investments and return on capital appear in waves. The 2003-2009 super-cycle rocked the industry, which is still recovering today. The collapse of the market coincides with the financial crisis, but that does not tell the whole story. In the race to the top, prices seem to have been driven by something inexplicable by neoclassical economics. In this paper we set out to investigate this phenomenon.

We first define the fundamental value as a calculation of the expected future cash flow accruing the asset, devout and value-expressive characteristics or reference to its market value. By travelling back in time and applying the most common vessel valuation models from 1996-2015, we get an estimation of the fundamental value of our chosen reference boat: a 1-2000 TEU handy size container vessel. Despite using two completely different models, the result in both cases reveal significantly lower fundamental values (prices of the vessels) compared to market prices during the shipping boom. Based on persistent and systematic deviations in market prices, we conclude that there is an irrational price element added to the assets fundamental value, because it is contrarian to homo economicus – the logically consistent economic man in neoclassic models.

By closely investigating the relationship between prices, earnings and investments, we empirically test the hypotheses that shipping firms over extrapolate exogenous demand shocks and partially neglect the endogenous investment response by competitors. We prove that investors value vessels as if they anticipate considerably less mean reversion in earnings than what we find in the actual data, supporting our extrapolative bias hypothesis. While both prices and investments negatively forecast excess returns, the investment coefficient is statistically insignificant in our sample, why we reject our hypothesis of competition neglect.

Based on our analysis, we conclude on the basis of rational choice theory that shipping is not a fully rational market. Our findings thus contribute to existing literature by proving that irrational exuberance is not confined to retail investors, but also thrives among institutional investors. We view this as a contribution to the current break-up with axioms of homo economicus. We go on to suggest improved methods for calculating the value of a containership based on our research. Rather than a magic formula, we arrive at different refined valuation methods for different purposes. The result allows firms to attenuate the impact of over extrapolation and prevent it from adversely affecting the valuation, more accurately estimate actual market prices for investor purposes and optimize profit as a function of cruising speed in relation to bunker cost.

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Declaration of Authorship

(To be placed at page 2 in the assignment])

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1 Research design

The research design outlines how the research is structured, i.e. a systematic plan/blueprint of the study. It defines the research question, study type and research approach, experimental design (how we aim to describe or explain the variation of the dependent variable), important considerations regarding project delineation, the theoretical underpinnings and the empirical basis.

1.1 Research question

Looking at the shipping market historically, it is immediately apparent that we are dealing with a highly cyclical industry. After further researching cases on the shipping industry, primarily surrounding the tremendous boom-bust cycle in shipping prices that collapsed in the late 2000s, we are drawn to a more thorough maritime study to understand what is going on. The goal of this thesis is to study whether shipping exhibits irrational investment behaviour. We want to think about business cycles more broadly, especially how they fit into the populist concept of “bubbles” and what role irrational behaviour plays in this. In other words, we want to investigate if the recent super-cycle is simply a natural consequence of uncontrollable conditions in the global economy, or if it is to some extend fuelled by irrational bubble tendencies within the shipping industry. Our fix point is the utilitarian-economic definition of rational behaviour defined by rational choice theory. With this reductive neo-classical definition in hand and detailed market data from the container shipping industry, we set out answer our research question:

Is there evidence of an irrational bubble in second-hand vessel prices in container shipping?

To thoroughly answer the research question, we will first attempt to define the relationship between irrational behaviour, boom-bust cycles and economic cycles. We then test for behavioural biases in second-hand container vessel prices, and finally we try our hand at refining the existing valuation frameworks, using data from our analysis. This is formalized in the following three sub questions:

- *How can we define irrational behaviour in the clamping field between business cycles and speculative bubbles?*
- *Are there evidence of behavioural biases in second-hand vessel pricing in Container shipping?*
- *Can we apply our analysis to more accurately estimate the value of a second-hand container vessel?*

1.2 Study type

The paper will consist of both quantitative and qualitative research. Quantitative research because we want to analyse numerical data such as time charter rates, newbuilding cost, scrap value and operating cost etc., and qualitative research because we seek to understand human behaviour and reasons that govern it, i.e. social and cognitive psychological.

The quantitative part of the project will be done as a retrospective and descriptive cohort case study, analysing a specific asset class over several decades, to observe the correlation between the estimated fundamental and actual price. Along the way, we perform simple econometric calculations to obtain time series such as net earnings and excess return etc., which allow us to develop deeper insights into the raw data. We are in a sense conducting a quasi-experiment, where natural conditions that are hypothesized to influence the variation, are selected for observation.

Specifically, we travel back in time and apply the most commonly used valuation models to estimate the price of a reference vessel, using the data available at the time, thus appearing as homo economicus at particular points in time. The theory of homo economicus portrays humans as consistently rational agents who pursue their subjectively-defined ends optimally, in contrast to, e.g. behavioural economics, which includes widespread cognitive biases and other irrationalities. The rational agent is assumed to take account of all available information in determining preferences, and to act consistently in choosing the self-determined best choice of action. This contrast with behaviour that is impulse, conditioned or indeed adopted by (unevaluative) imitation. By comparing our results with actual market prices ex ante, we identify variations not explained by the models. By construction, these variations stems from parameters not taken into account by common valuation models.

The qualitative part of the project will consist of two parts. First, a literature review of possible causes for asset bubbles from the school of behavioural finance. This is done to properly frame a discussion of irrational behaviour in the sense of Keynes's "animal spirits" and later scholars' contribution to the field. Second, we rely on our data analysis to either prove or disprove our hypothesis. In other words, our quantitative analysis will concretize our theoretical discussion and allow us to formalize conclusions. Proponents of rational choice, particularly those associated with the Chicago school of economics, specifically do not claim that the underlying assumptions are an accurate descriptions of reality, but rather that they help formulate clear and falsifiable hypothesis. In this view, the only way to judge the validity of a hypothesis is by empirical tests.

The basis of rational choice theory is that aggregate social behaviour is the result of individual actors behaviour. Because individual actors make individual decisions, the theory focuses on the determinants of the individual choices (methodological individualism). In order to empirically test, or falsify, the rationality assumption, we broadly specify the individual's goals in this case as maximizing return on investment from owning a containerized cargo vessel.

Finally, based on our analysis and our conclusions about the industry, we will attempt to create a theoretical valuation model that address the shortcoming of the common valuation models by widening our scope to include other parameters which we identified through our analysis as influential to the accuracy and explanatory power of the model.

1.3 Research approach

We adhere to a post positivistic epistemology (our understanding of what constitutes knowledge and how we can obtain it). Like positivism, we believe that an objective reality exists, but differently, we believe that it can only be known imperfectly and probabilistically. The fact that any given justification of knowledge will itself depend on another belief for its justification appears to lead to an infinite regress. Recognizing the impossibility of completing this infinite chain of reasoning, absolute certainty about knowledge is impossible. Because all knowledge can potentially be amended through further investigation, any of the things we take as matter of course might possibly be false. We pursue objectivity by recognizing the possible effects of these biases.

This research approach is underpinned by an objectivist ontology (our understanding of what constitutes reality and how we can understand existence). This is basically just the notion that an objective reality exists and can be increasingly known through the accumulation of more complete information.

We use deductive reasoning, i.e. going from theory through hypothesis and observation to confirmation (as opposed to inductive – generalizing new theory based on observations).

Data mining in regards to the shipping industry is the art of the possible. Little of the relevant historical data is publicly registered, and for our analysis, we therefore rely heavily on professional industry analysts, such as industry associations and service providers (advisors, brokers, financiers, accountancy etc.). For this reason, we are also limited by said companies lifespan and research activities, which in our case allows us to look back as far as 1996-okt and until present day (we use EOY 2015 as out cut-off point). In general however, the validity and reliability of the data and subsequent calculations is very high, because of access to detailed databases such as Clarksons Research, Drewry Martime, Statista and UNCTAD.

1.4 Distinctions

In favour of research depth versus research breadth, we make some important delineations. First of all, we will focus on the intermediate class containership (handysize) with a capacity between 1.000 and 2.000 TEU.

Our working definition of the fundamental value of an asset is the present value of the stream of cash flows that its holder expects to receive. Fundamental value thus refers to the value of an asset, in this case our reference vessel, determined through fundamental analysis without reference to its market value. It is also frequently called intrinsic value. In this paper we use the two interchangeably. In an efficient market, the price of an asset is equal to its fundamental value, because if the asset is trading at a price below its fundamental value, investors in the market will pounce on the profit opportunity by investing in the asset. This will bid up the price of the asset until it equals its fundamental value – simple supply and demand economics. So, if an asset is persistently trading at a price higher than its fundamental value, said asset is priced irrationally.

Our working definition of a 'bubble' is as an episode were irrationality causes asset prices within a specific market to increases above its fundamental price, higher than they would have in the absence of that irrationality, and were the price level becomes such, that a rational observer with access to all available information would forecast a lower return on those assets.

2 Industry analysis

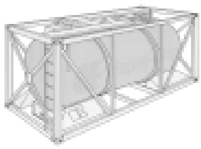
The shipping industry is a sector providing transportation of commodities, merchandise goods or cargo. The transportation can take place by land, air or sea, but this thesis will only deal with seaborne shipping.

2.1 Introduction:

Real ships, unlike carved out tree trunks or other primitive floating objects is first known in 3100 BC from Egypt (Nielsen, 2016), where the Egyptians transported the material for the pyramids on the Nile, and from there the development of seaborne transportation has been under constant development. The primarily developments for the ships has been how to get the energy that enables the vessels to move and secondly how to carry the cargo. In the beginning of the shipping industry, the vessels often carried heterogeneous goods packed in boxes, barrels or bags in the hold of the vessel in accordance with the orders obtained by the ship-owners agents in the respective ports (Nielsen, 2016). Gradually the vessels became specialised and therefore more efficient. Around year 1900 some ships began to transport oil in big tanks inside the ship instead of barrels, and along with oil came other liquids in large quantities, also stored in tanks instead of in barrels. Later the

so called bulk carriers were developed carrying e.g. grains or coal in the holds thus meeting the demand for homogenous transportation in large quantities. However, the demand for shipping different goods in smaller quantities still existed and thus containerised shipping was developed whereby transportation became much more efficient.

Containerized shipping accounts for around 60% of the value carried by sea according to Statista. This takes place in different sizes and types of containers. The most common ones are the 20-foot and 40-foot length containers, but also other lengths and different types are carried depending on the purpose for instance as follows:

 **Tank container:** Suitable for liquid foodstuffs, chemicals etc.	 **Bulk container:** Suitable for bulk, loading hatches in the roof
 **Insulated and refrigerated containers:** Suitable for meet, fruits, dairy products etc.	 **Flat racks:** Used for over height and/or over width cargo

The standardization of the size of the containers render an efficient way to load the ship, because the method makes the possible quantity of goods loaded on to the vessel greater than if the cargo was not systematically stacked. The transfer on and off the ship is made easier and requires less equipment. The same is true when it comes to the interchange between ships, trains and trucks, which can also take place with standardized handling equipment.

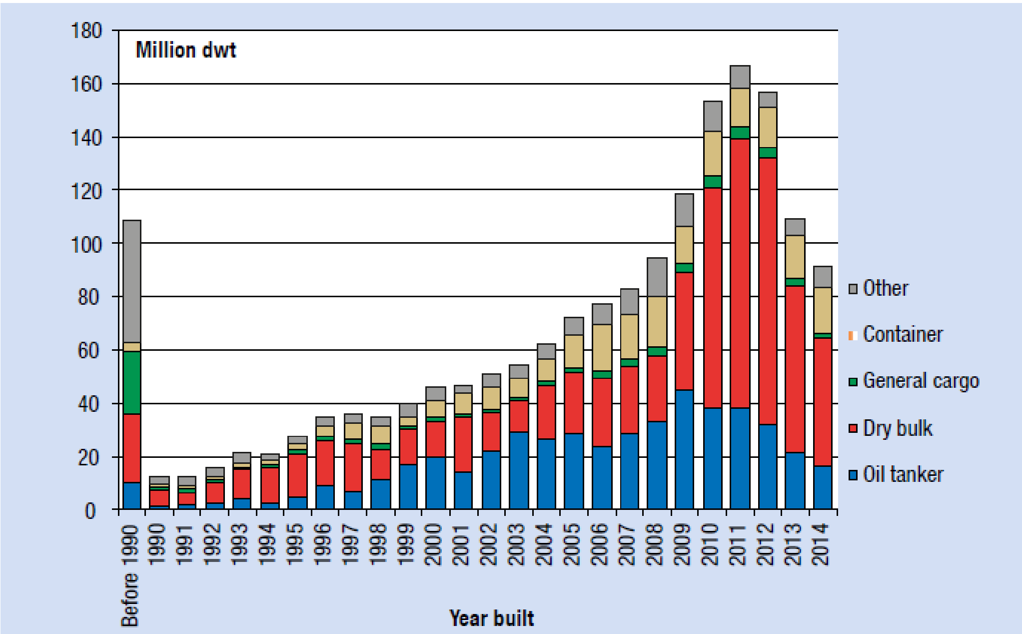
In addition to the tanker-, container and the bulk vessels the shipping fleet also include ferries for transportation of people or specialist ships that supports the off shore industry etc.

 **Container ships:** Carry most of the worlds manufactured goods and products.	 **Bulk carriers:** Transports raw material, recognizable by the hatches

Tankers:	Ferries:
 Contains large amounts of liquids.	 Mostly carries passengers and cars, but some also trains.

The capacity of the merchant fleet is measured in deadweight tonnage *(DWT)*, which means the vessels capacity in weight without the weight of the vessel it self. The capacity is dominated by the bulk carriers followed by tankers, and then container ships as seen in *Figure 1*. The development since 2006 has been noticeable with the top in 2011 and the subsequent fall

Figure 1: Vessel types of the world fleet, by year of building[1]



Source: UNCTAD secretariat, based on data supplied by Clarksons Research.

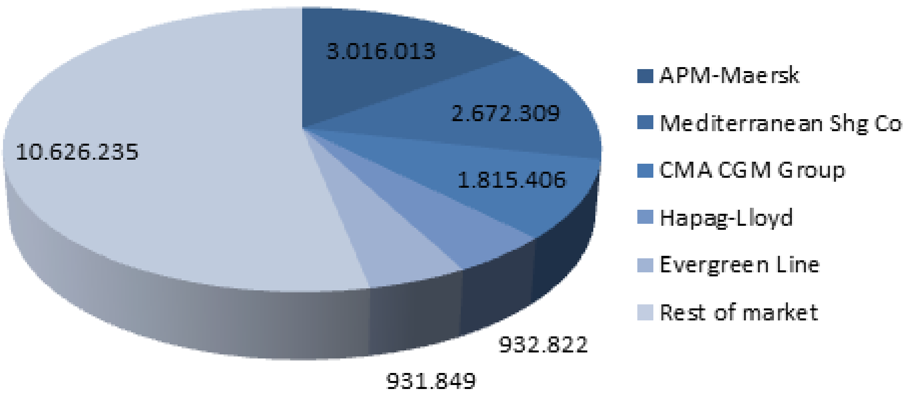
2.2 Overview

The 20-foot container has become the industrial standard of measuring the cargo volume of a vessel, called TEU (Twenty-foot Equivalent Units). The containerized shipping industry is having a capacity on approximately 20 mill TEU where the 5 biggest companies cover almost ½ the market, measured on TEU

[1] *dwt as of 1 January 2015*

capacity. In 1980 the quantity of goods carried by containers was around 100 million tons, but in 2013 it has risen to about 1,3 billion tons.

Figure 2 Shipping companies worldwide - capacity of container ship fleets in TEU



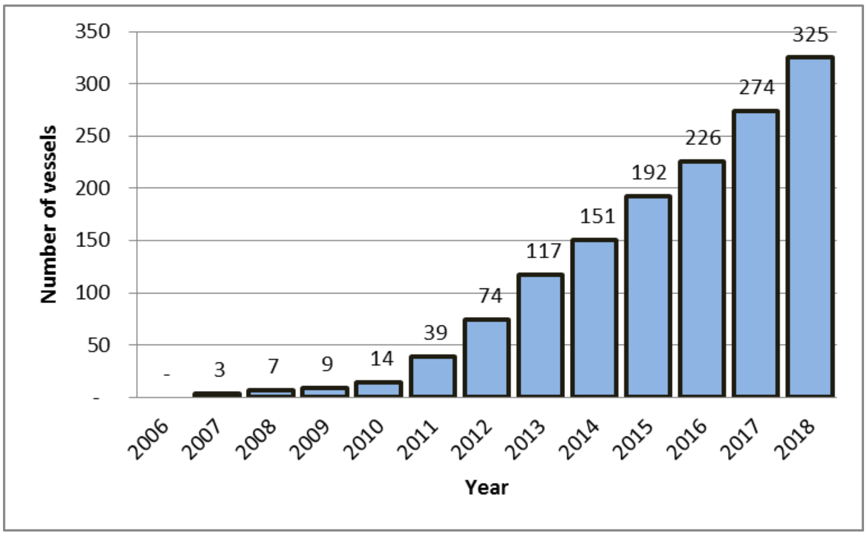
Source: Statistica; time series Shipping companies worldwide

There are primarily to ways the shipping companies operate their ships. Liner trade that entails that they operate over set routes according to established schedules just like a bus. Greater energy efficiency and low cost are some of the benefits for liner trades. A tramp trader on the other hand is a ship without a fixed route or schedule, instead it benefits of the possibility to be ready on short notice, and can load cargo from any port and go to any port, just like a taxi

2.3 Ship sizes

The developments in ports have allowed the shipping companies to take advantage of superior productivity in container handling. The economics of scale is a great competitive advantage since a low operating cost are essential for competing in a very competitive market, and therefore there has been a considerable development within the size of the ships. Since the beginning of containerization in the 1950s and until now, the containerships have grown from approximately 4500 TEU, to over 18.000 TEU. If one only considers the number of 12.000+ TEU containerships, a growing trend has been seen, *Table 1*. It is clear that the number of these super-sized ships has developed from none 10 years ago, to over 200 vessels 10 years later.

Table 1 Development within 12000+ TEU container ships



Source: Statista and Clarkson Research; 2017 and 2018 is estimated from the order book

There are different types of containerships within the containerized shipping industry, each ship serves different purposes.

The feeder is a smaller containership, which transport the containers from the smaller harbours to the larger container terminals, where larger ships can enter. This is done because some docks are limited in size and therefore not able to handle the large containerships. Further it should be less expensive transporting fewer TEU with a smaller ship.

Handysize containerships are similar to the feeder, and therefore in some literature referred to as feedermax. They generally serve the same purposes as the feeder, but in some cases also operates on its own, instead of as feeder to the larger container vessel.

Handymax, as handysize but with a larger capacity in TEU

A *Panamax* container vessel is bigger than the feeder and handysize vessels, and can typically carry 3000+ TEU. The name Panamax indicates that the vessel is small enough to pass through the Panama Canal lock chambers, which can accommodate ships with approximately a beam of up to 32 meters, a length of up to 294 meters and a draft of up to 12 meters. The panamax sized containerships are often operating on the longer routes,

Post-panamax is like the panamax vessel, but it is unable to pass through the Panama Canal, since it does not fit the lock chambers of the canal. The post-panamax vessel has often a size above 5000 TEU, which approximately is the biggest the panama vessel can be, and still be able to pass through the canal.

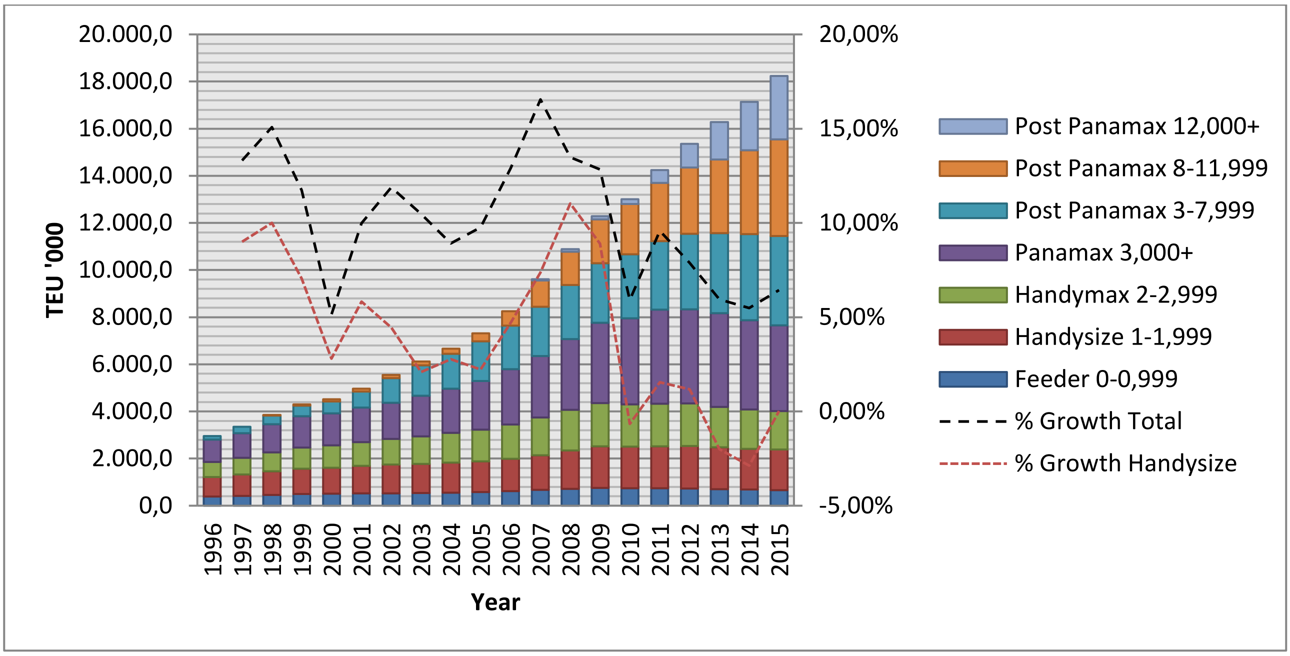
However the distinction between the large container vessels will be redefined as the Panama Canal expansion is opened. The purpose of the expansion of the Panama Canal is primarily the ability to meet the competition from the Suez Canal, especially for shipments from Asia to the U.S East Coast. The Panama Canal is an efficient route, but the expansion is necessary to increase the maximum capacity to fully utilize on the demand (Salin 2010), though it is not dealt with in this paper since it would not influence the result of this paper. But it should be noticed that other literature can differentiate from this description.

Table 2 definitions of vessel types grouped in TEU

Category	Feeder	Handysize	Handymax	Panamax	Post-Panamax
Capacity	0-0,999	1-1,999	2-2,999	3,000+	3,000+

The development in the fleet capacity is visualized in *Figure 3*. From 1996 until 2015, the capacity has increased from 2.920.000 TEU to 18.241.000 TEU, which is a 525% increase in the total TEU capacity over a 10-year period. This huge increase is also visible from *Figure 1*, but these numbers are also a consequence of the fact that the containerization has been developed in newer time, and therefore not as mature a method as other seaborne shipping methods. This is also seen in the capacity development for the post-panamax ships. Here it is seen that the growth within this segment as exponential from the beginning until now. In 1996 there was only a capacity of 150.000 in post-panamax vessels, and all of these were in the small segment for 3.000-7.999 TEU. 10 years later in 2006 this group has extended its capacity to 1.847.000 TEU. Furthermore the bigger post-panamax vessels from 8.000-11.999 TEU, have been developed from being none existing to now covering a capacity on 611.000 TEU. In 2015 the post-panamax vessels are able to carry over 10 million TEU, corresponding to over half the capacity of which 2,7 million TEU are carried on vessels capable of carrying over 12,000 TEU)

Figure 3 Containerfleet in size and annual growth measured in TEU and percentage



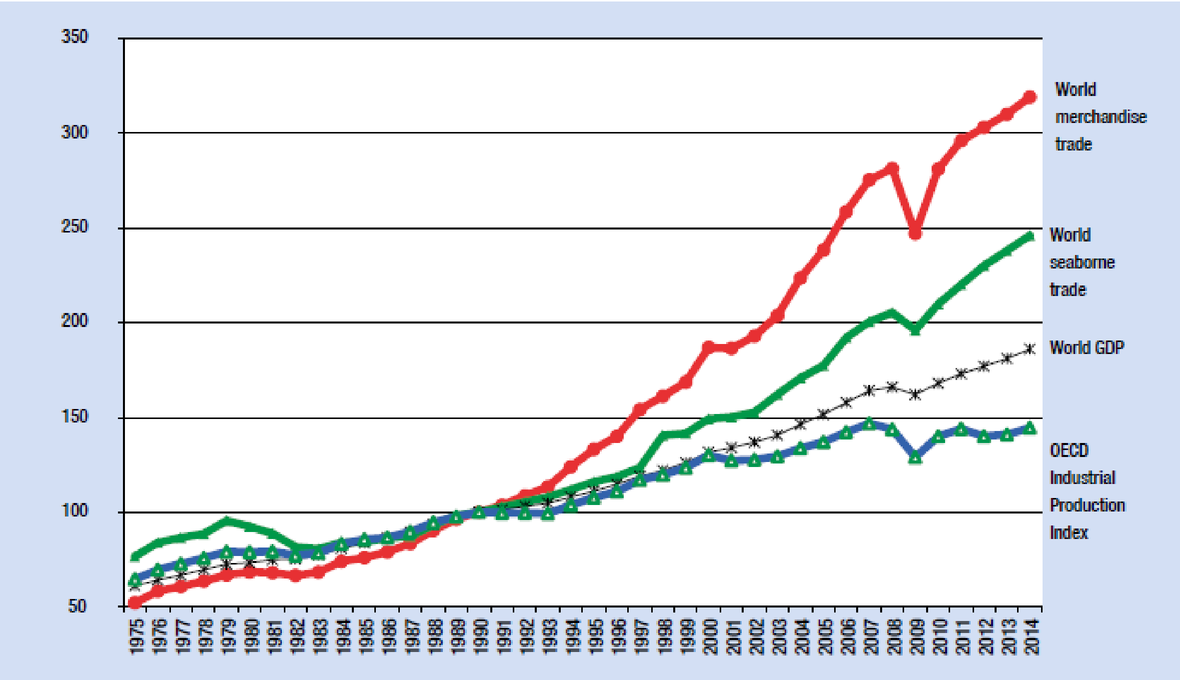
Source: Clarkson Research

Unlike the post-panamax sized vessels, the development in the 4 smaller categories stagnates around 2009. This is not odd for the panamax model since the opening of the 3.rd lock of the Panama Canal is decided in October 2006, and it probably takes a couple of years emptying the order book.

The capacity of the handysized container vessels is increasing steadily until 2010 where it stabilises, and the net change the next 5 years is approximately zero. The changes in this segment roughly follow the variation in the total container capacity and with a correlation coefficient on 86% this is further verified.

The world seaborne trade is of course depending on the world merchandise trade, which is further correlated with the world gross domestic product, as seen in *Figure 4*.

Figure 4 The OECD Industrial Production Index and indices for world GDP, merchandise trade and seaborne shipments[2]



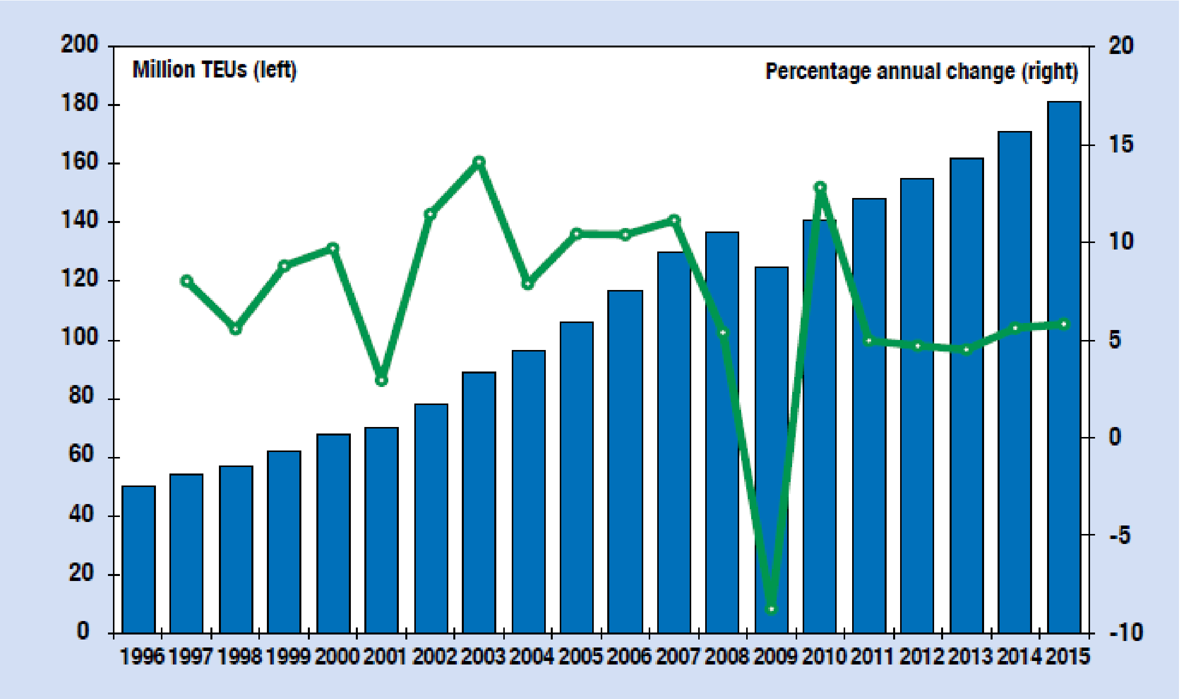
Source: UNCTAD: review of maritime transport 2015

The global containerized trade has been relatively steady in the development since at least 1996 (*Figure 5*). It is seen that the beginning of the period starts at approximately 50 million TEU, which grows with reasonable 10-15 % almost every year until 2008. In 2008 the growth lessens about 7 percentage points compared to the year before, which is quite a bit in an industry with long delivery time of the assets. In 2009 the annual change goes from above 10 % in growth two years earlier to minus 10%, which must be considered as a noticeably fluctuation.

As *Figure 6* shows the decrease in the demand is not fully transferred to the supply. There can be numerous reasons for that, either there still is a shortage on the supply side due to earlier years dominant demand growth. Another reason could be that the change in TEU is particularly high on the short routes where the longer routes have a minor increase. This would make it possible to maintain the same capacity in the industry even with less TEU lifted, but with a constant TEU-mileage. Most probable though, is that the market supply is not as dynamic as the demand, since a vessel is a long-term investment, with a lifecycle of approximately 20 years at least.

[2] *base year 1990 = 100*

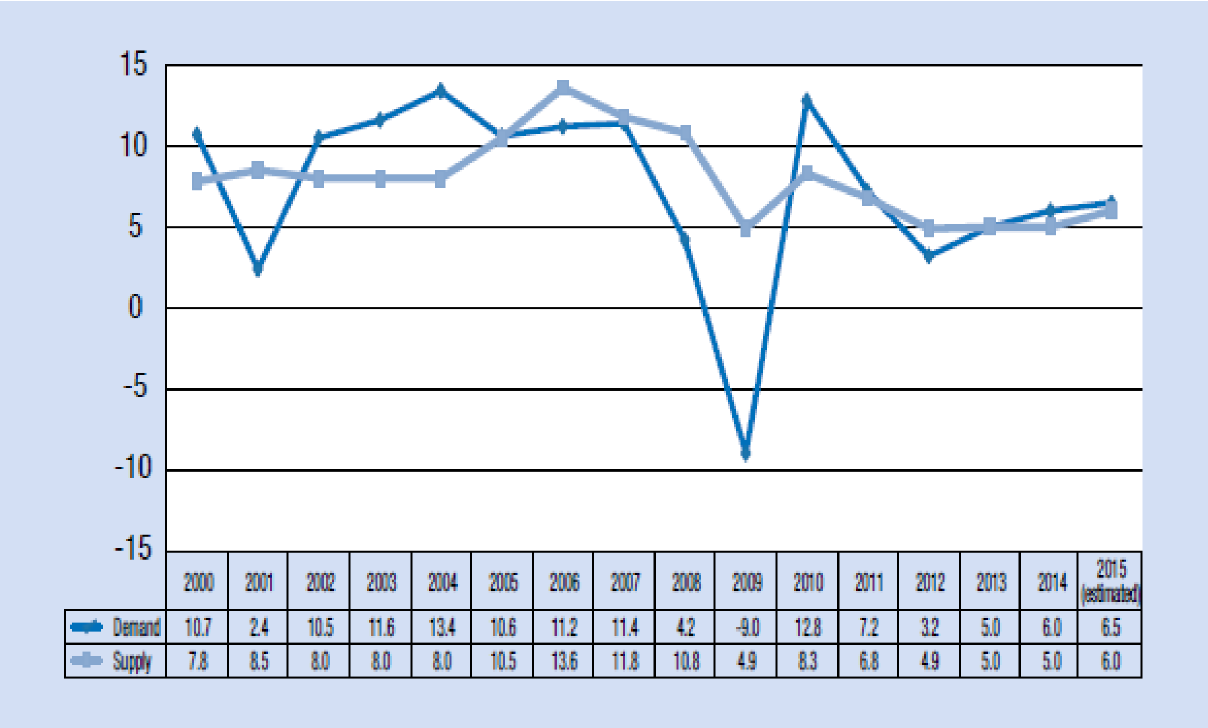
Figure 5 Global containerized trade[3]



Source: UNCTAD secretariat, based on Drewry Shipping Consultants, and Clarksons Research

[3] *million TEUs and percentage annual change*

Figure 6 Annual growth of demand and supply in container shipping

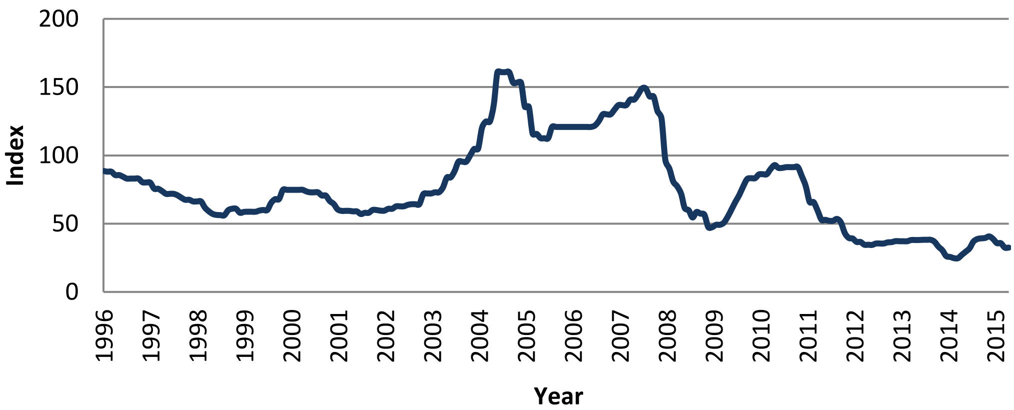


	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015 (estimated)
Demand	10.7	2.4	10.5	11.6	13.4	10.6	11.2	11.4	4.2	-9.0	12.8	7.2	3.2	5.0	6.0	6.5
Supply	7.8	8.5	8.0	8.0	8.0	10.5	13.6	11.8	10.8	4.9	8.3	6.8	4.9	5.0	5.0	6.0

Source: UNCTAD secretariat, based on data from Clarksons Research Container Intelligence Monthly, various issues.[4]

The lack in demand, from *Figure 6* is clearly reflected in the second hand prices, compared analogously from *Figure 7*, which shows an index for the second hand price of a 10 year old container vessel.

Figure 7 Price index 10 year old container vessel, second-hand sale



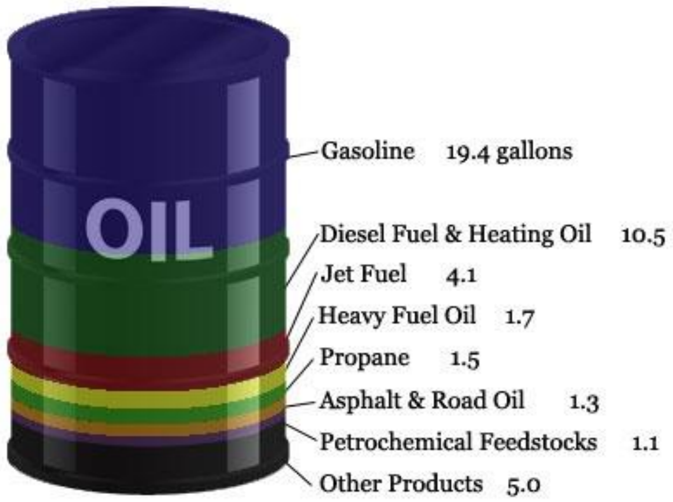
Source: Clarkson Research (Timeseries; 94431)

[4] *Supply data refer to total capacity of the container-carrying fleet, including multipurpose and other vessels with some container-carrying capacity. Demand growth is based on million TEU lifts. The data for 2015 are projected figures.*

2.4 Relationship between bunker fuel and crude oil

Bunker fuel is a derivative of crude oil. In simple terms, bunker fuel is what is left after refineries have processed all the more valuable fuels (gasoline, diesel fuel and heating oil) from the crude source. It is thick and heavy, must be heated before it can be used in an engine, and is difficult to store and transport. Because of this, bunker fuel is mainly stored near major ocean ports. While there are bunker fuel futures, unlike crude futures the contracts normally entail actual physical delivery of the fuel.

Figure 8: Breaking down a barrel of crude oil



Source: 3PL Definitions Education, posted date December 29, 2011

Because bunker fuel is a derivative of crude oil, there is some correlation between crude prices and bunker prices. By comparing current and long term prices of the TSA Weighted Average Bunker Fuel Price against NYMEX and BRENT crude prices, we can determine a simple "bunker fuel multiplier". That makes it handy to at least come up with a rough estimate of where future bunker fuel levels will be, based on any crude oil price assumption.

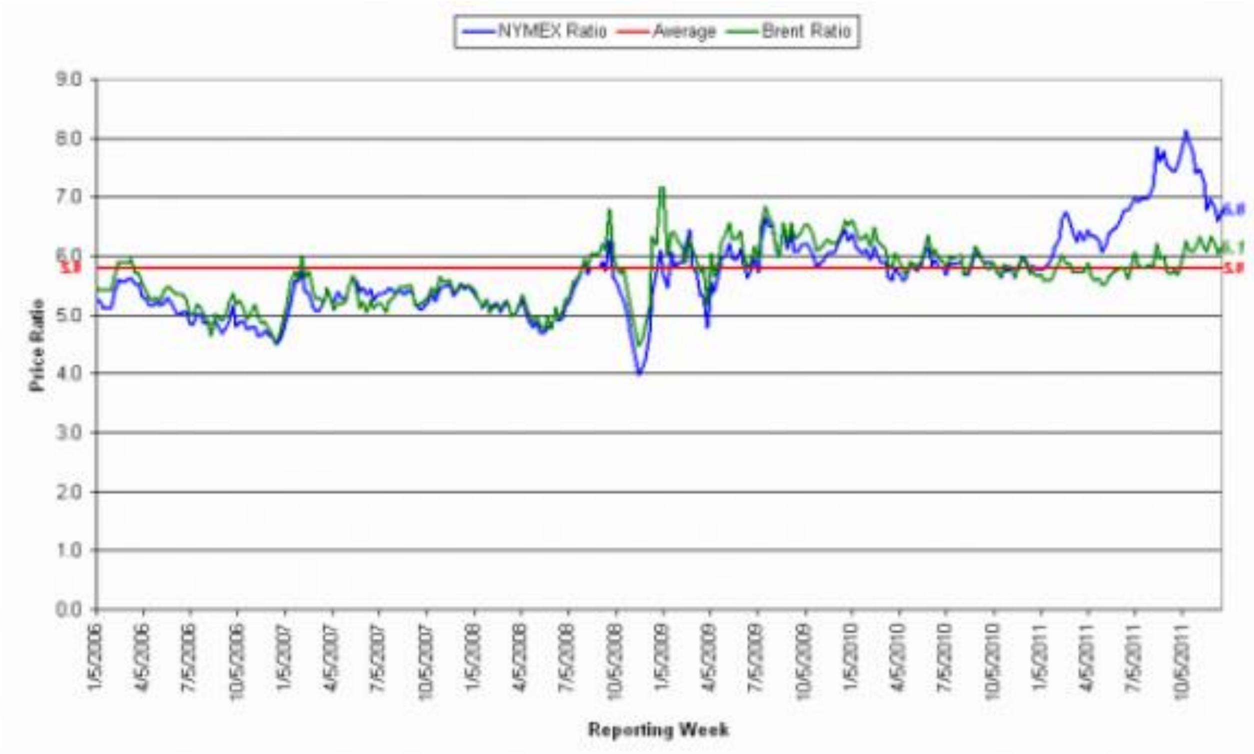
Figure 9: Weekly weighted average bunker fuel price (Europe) vs NYMEX crude futures and BRENT crude spot (jan-2006 to apr-2016)

Source: Nasdaq, TSA

Over the past 5 years, bunker fuel has been priced at an average multiple of 5,8 times the price of NYMEX and BRENT. That means that in the long run you can take the price of NYMEX or BRENT and multiply it by 5,8 to roughly get the bunker fuel price. This in turn means that if firms expect crude to hit USD 200 per barrel next year, this might (again: roughly) equate to a bunker fuel price of USD 1.160 per ton (USD 200 x 5,8).

It should be borne in mind, that this indicator is very broad. There is no clear and direct link between crude oil prices and bunker fuel prices. Looking at Figure 10, we see that within that 5-year average of 5,8, there are weeks and months – and years – where the multiplier was anywhere from 4,8 to 8,1 times the price of crude. Also, notice that for 2011 there has been a huge divergence in the bunker fuel multiplier between NYMEX and BRENT. In that year, the NYMEX multiplier was 6,8 meaning that bunker fuel averaged 6,8x the price of NYMEX crude, while for BRENT the multiplier was 6,3x, meaning that bunker fuel has averaged 6,3x the price of BRENT crude. For reasons unknown, NYMEX has been trading at a 10-20% discount over BRENT over the course of the year, whereas prior to 2011 the two prices were nearly identical.

Figure 10: Bunker fuel to crude price ratio: NYMEX futures (US) vs BRENT spot (Europe)



Source: Nasdaq, TSA

Bunker fuel is a prominent component of ocean carriers' actual vessel operating costs, as we account for in section 2.5. This is a very simplistic way of looking at and calculating potential future bunker fuel costs using the simple price of crude oil. There are certainly other, probably better, ways of looking at and trying to forecast future bunker fuel costs and plan for potential cost increases or decreases.

2.5 Supply in the containerized shipping industry

In an industry like shipping the supply side of the demand/supply equation is relevant to account for. The reason for this is that the lead time for the asset creating the revenue is long, it simply takes long time to produce a new container vessel, and the size of them makes it almost impossible for a shipyard to have a finished goods inventory. The consequence is that the time from the customers order a vessel until it is actually available for their service is up to 3 year. This creates market conditions in which it is difficult to manoeuvre.

Table 3 shows the development in the containership fleet, and the handy size segment itemized. The order book is shown as primo values while the rest of the values are year total. Net orders are the placed order of the year less the cancellation. Order book is calculated as equation *(1)*; the order book the year before adjusted for the year net change.

$$Orderbook_t = Orderbook_{t-1} + NetOrders_{t-1} - Deliveries_{t-1} \tag{1}$$

Table 3 Development in the general containership fleet and handysize – In '000 TEU

CONTAINERSHIP FLEET					HANDYSIZE				
O'BOOK	NET ORDERS	DELVS	SCRAP	CANCEL	O'BOOK	NET ORDERS	DELVS	SCRAP	CANCEL
(Year Start)	(During the Year, 2015 YTD)				(Year Start)	(During the Year, 2015 YTD)			
975,4	502,9	413,5	21,7						
1.064,8	208,3	528,2	25,0		237,8	53,0	111,3	20,5	
744,9	422,2	535,5	87,3		179,5	56,5	112,4	42,1	
631,6	564,7	266,2	52,7		123,6	38,9	63,8	35,6	
930,1	965,4	462,1	15,5		98,7	88,5	69,2	5,1	
1.433,4	533,4	623,4	36,2		117,9	54,5	58,7	5,8	
1.343,4	417,9	645,3	68,1		113,7	18,5	55,4	28,2	
1.116,0	2.076,8	567,6	25,7		76,8	68,3	42,2	7,8	
2.625,2	1.657,9	653,0	7,8		102,9	151,7	32,0	4,9	
3.630,0	1.661,2	941,3	2,3	6,7	222,6	255,7	62,4		6,4
4.349,9	1.702,8	1.385,0	23,8	41,1	415,9	218,5	107,9	5,7	10,8
4.667,6	3.228,3	1.315,3	20,9	22,4	507,7	129,2	169,4	7,9	21,1
6.580,6	1.107,4	1.502,1	101,2	48,2	484,1	38,8	176,0	30,2	5,6
6.185,9	-143,8	1.107,5	378,4	231,5	347,0	-46,8	86,9	97,5	50,0
4.934,6	304,3	1.390,6	132,6	281,3	185,6	1,4	68,0	30,8	34,5
3.848,3	1.719,8	1.212,8	77,8	118,4	143,2	56,7	48,7	24,8	18,4
4.355,3	331,7	1.259,0	334,4	98,4	156,8	-4,2	60,5	95,5	19,4
3.427,9	1.931,8	1.345,8	444,0	216,8	92,1	63,9	47,6	97,4	
4.014,0	927,5	1.488,9	384,0	146,1	108,4	67,8	48,3	47,8	
3.452,6	1.394,2	1.142,9	93,9		127,9	78,2	49,5	34,2	

Source: Clarkson Research, Table 36 and authors own calculations

From *Table 3* the fleet development is derived by the aggregated deliveries less scrap, exemplified by equation *(2)*.

$$\Delta TEU\ capacity_t = Deliveries_t - Scrap_t \tag{2}$$

The $\Delta TEU\ capacity_t$ can also be seen in *Figure 6*, which is difference in the pillars from 1 year to the next year. The "nominal" amount of TEU capacity, meaning the amount of TEU the total fleet can carry at the same time, if all totally loaded, is however a little incomplete, since this number does not take distance travelled into account. The problem with the nominal TEU is, that the difference between e.g. sailing from Denmark to Sweden versus Japan to France is noticeable, it simply demand several more ships carrying a certain amount of TEU for a longer distance, within a certain amount of time. In other words, the vessel transporting from Denmark to Sweden is able to sail the route many times, in the same time as it takes a vessel to go from Japan to France, but they account for the same relative proportion of total fleet capacity.

Table 4 Regional seaborne trade – ‘million TEU

Tradelane	million TEU							
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Mainlane trade								
North America - Far East	7,1	7,0	7,2	7,6	7,6	7,9	7,5	7,3
Far East - North America	13,4	11,4	13,1	13,2	13,3	13,8	14,7	15,5
Europe - Far East	5,4	5,6	5,8	6,2	6,5	6,9	6,9	6,9
Far East - Europe	13,8	11,7	13,8	14,2	13,6	14,3	15,4	14,8
Europe - North America	3,2	2,8	3,0	3,3	3,5	3,6	3,9	4,2
North America - Europe	3,2	2,4	2,7	2,8	2,6	2,7	2,7	2,6
Non-Mainlane trade								
Non-Mainlane East/West	14,3	14,6	16,9	18,8	19,5	20,2	21,7	22,9
North/South	22,9	21,6	24,9	27,2	27,6	29,2	30,6	31,0
Intra-Regional/Other	51,4	45,3	51,9	56,7	60,4	64,0	67,9	70,1
GLOBAL TOTAL	**134,7**	**122,4**	**139,2**	**150,0**	**154,6**	**162,5**	**171,3**	**175,4**

Tradelane	% share of global TEU							
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Transpacific	*15,2%*	*15,0%*	*14,6%*	*13,9%*	*13,5%*	*13,3%*	*13,0%*	*13,0%*
Far East - Europe	*14,2%*	*14,2%*	*14,0%*	*13,6%*	*13,0%*	*13,0%*	*13,0%*	*12,4%*
Transatlantic	*4,8%*	*4,2%*	*4,1%*	*4,0%*	*3,9%*	*3,8%*	*3,9%*	*3,9%*
Non-Mainlane East/West	*10,6%*	*11,9%*	*12,1%*	*12,5%*	*12,6%*	*12,4%*	*12,7%*	*13,1%*
North/South	*17,0%*	*17,6%*	*17,9%*	*18,2%*	*17,9%*	*18,0%*	*17,9%*	*17,7%*
Intra-Regional/Other	*38,1%*	*37,0%*	*37,2%*	*37,8%*	*39,1%*	*39,4%*	*39,6%*	*40,0%*

Source: Clarkson Research

Table 4 displays the seaborne trade stated from the primary trade lanes, measured in TEU (million). *Table 5* on the other hand, show the TEU miles on the different routes, which is a function of the estimated distance travelled multiplied with the nominal TEU carried on the liner freight route. In the percentage *share of global TEU (miles)* it is clarified that TEU contra TEU miles plays a significant role according to the demand. It is apparent that e.g. the Far East to Europe covers 14,2% of the global TEU carried in 2008, but measured in TEU miles it accounts for 27,6% of the global total TEU miles. Other things being equal it may casually be equivalent with a need for a larger fleet.

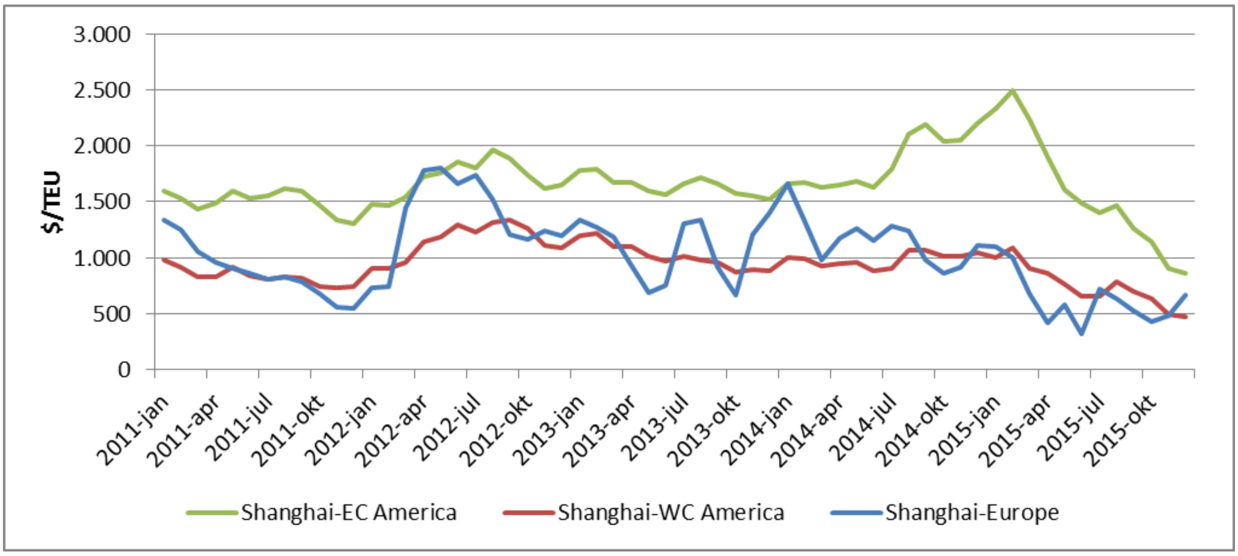
Table 5 Regional seaborne trade – 'billion TEU miles

Tradelane	billion TEU Miles							
	2008	2009	2010	2011	2012	2013	2014	2015
Mainlane trade								
North America - Far East	40,7	40,0	41,5	43,8	43,6	45,2	43,5	42,0
Far East - North America	77,5	65,8	75,6	76,1	76,5	79,7	84,4	89,4
Europe - Far East	57,5	60,1	61,9	66,6	69,4	73,3	73,2	73,9
Far East - Europe	147,0	125,3	146,9	151,8	145,4	152,9	164,3	158,3
Europe - North America	10,9	9,2	10,2	11,0	11,6	12,0	13,1	14,0
North America - Europe	10,8	8,1	9,0	9,3	8,8	9,0	9,2	8,7
Non-Mainlane trade								
Non-Mainlane East/West	85,6	87,0	100,3	110,7	115,0	119,1	128,0	134,6
North/South	159,5	149,3	173,6	191,0	195,4	206,1	215,1	219,1
Intra-Regional/Other	150,2	127,8	146,2	158,6	170,1	179,0	190,9	197,5
GLOBAL TOTAL	**739,6**	**672,7**	**765,1**	**818,8**	**835,9**	**876,3**	**921,6**	**937,4**
Tradelane	**% share of global TEU miles**							
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Transpacific	*16,0%*	*15,7%*	*15,3%*	*14,6%*	*14,4%*	*14,3%*	*13,9%*	*14,0%*
Far East - Europe	*27,6%*	*27,6%*	*27,3%*	*26,7%*	*25,7%*	*25,8%*	*25,8%*	*24,8%*
Transatlantic	*2,9%*	*2,6%*	*2,5%*	*2,5%*	*2,4%*	*2,4%*	*2,4%*	*2,4%*
Non-Mainlane East/West	*11,6%*	*12,9%*	*13,1%*	*13,5%*	*13,8%*	*13,6%*	*13,9%*	*14,4%*
North/South	*21,6%*	*22,2%*	*22,7%*	*23,3%*	*23,4%*	*23,5%*	*23,3%*	*23,4%*
Intra-Regional/Other	*20,3%*	*19,0%*	*19,1%*	*19,4%*	*20,4%*	*20,4%*	*20,7%*	*21,1%*

Source: Clarkson Research

The freight rate also reflects the difference in distance. As *Figure 11* shows the spot freight rates for 1 TEU from Shanghai to the American east coast, is higher than the spot rates from Shanghai to either the American west coast or Europe. The difference in the spot freight prices between Shanghai-WC America/Europe though, is not constant. This may be due to other circumstances affecting the price, for instance changes in demand.

Figure 11: Spot freight rates of 1 TEU

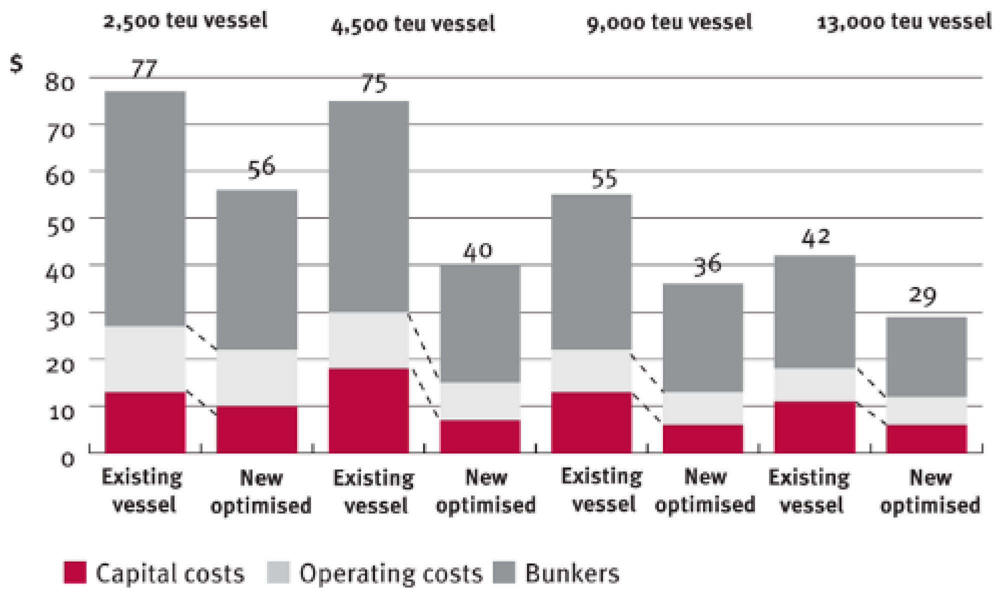


Note: Both EC America and WC America is priced as FEU (forty-foot), it is anticipated that 1 FEU is equivalent with 2 TEU

Source: Clarksons Research

The primary reasons for the spot rates being higher when a container is shipped over a longer distance is the effect of the higher bunker costs. The bunker costs can in some cases constitute more than 75% of the expense per TEU mile. The propellant for the vessels is a noticeable expense. Visualized in *Figure 12*; a large ship may be burning up to 100.000 USD of bunker fuel per day. A study by Ronan (2011) finds that a 20 % reduction in cruse speed results in a 50% reduction in bunker consumption.

Figure 12 Cost per 1.000 container miles



Note: Bunkers at 750 $ per tonne, sailing at 19 knots and excluding port/canal fee

Source: Germanisher Lloyd

The bunker consumption is not only determined by the travelled distance. It is also determined by the speed of the vessel during the travel. The relation between vessel speed and bulker consumption is not linear but must be anticipated to be convex. Same relation is explained by Hooker (1988) but for cars. It can generally be explained that it takes more energy per travelled distance if the speed is high. The disadvantage on the other hand, is that less TEU can be freighted in the same period of time, if the speed is slow. This relation has been further studied by Ronen (2011) in a paper called *The effect of oil price on containership speed and fleet size*, where the relationship between bunker prices and the optimal fleet size and speed is accounted for, for an entire container line route. The consequence of high bunker prices is that the vessel is more profitable at low speed, even though it is then less effective relative to TEU miles. To overcome this more vessels are required to operate on the liner route, if the same amount of TEU has to be carried on the route as before over the same period. The reason for this is of course that the decrease in vessel speed lessens the TEU mile per ship.

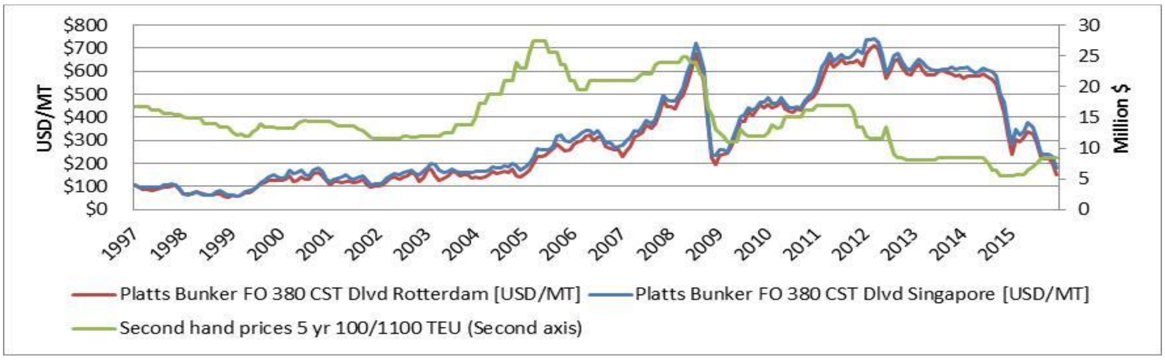
Bunker prices' effect on ship speed in linear shipping is assumed to have the same impact on the rest of the seaborne shipping. There is a constant trade-off between the bunker usage and how many TEU miles a container vessel completes. Higher bunker prices will make a basis for slower vessel speed. Changes in average vessel speed create a change in the supply of TEU, even though the nominal TEU capacity stays the same, the "real" TEU capacity changes; TEU miles. Analogously from earlier explanations, the extraction of this is that the bunker prices for the container vessels are expected to be influencing the demand for container vessels, and thus also the prices of new and second hand container vessels (Ronen, 2011)

For the bunker expense to justify an expansion of the fleet, the increase in bunker prices has to be significant. *Figure 13* shows the bunker prices (IFO 380) traded 2 different places, in Singapore and Rotterdam, and it sees that fluctuations are significant. Bunker fuel are in average traded at a price of 310 $ per megaton and have a standard deviation of 200 $ in the period from primo 1997 until ultimo 2015. 200 $ in standard deviation with a mean of 310 $ should be considered as large fluctuation.

A study by Ronan (2011) finds that a 20 % reduction in cruse speed results in a 50% reduction in bunker consumption.

The conclusion is that high bunker prices combined with considerably lower consumption can have an impact on the new and second hand prices of container vessels. Simplified, it can be economically described that when the savings from lowering the speed exceeds the cost of expanding the fleet, then the expansion is the better option.

Figure 13 Bunker prices of IFO 380 and second hand prices 5 year 1000/1100 TEU vessel



Source: Ship&Bunker and Clarkson Research

If any, the causally between the bunker fuel prices and second hand prices must be, that if the bunker price increase, then the vessel speed must decrease and more vessels are needed; If more vessels are needed, then demand for vessels will increase and so will the prices. So if bunker fuel prices increase, so will the second hand vessel price and vice versa.

Figure 13 shows the monthly development in bunker prices, and the second hand price for a reference vessel of 1000/1100 TEU and 5 years old. Visually it is seen that even though they are not perfectly correlated, there is a tendency of them moving in the same direction. It cannot be excluded that other factors than those already accounted for is influencing the prices of both bunker fuel and second hand vessels. External parameters can be affecting both of them in the same direction, but neither can or should it be excluded that the bunker fuel price is having an effect on the second hand price of container vessels. It seems plausible from the assumptions already made that they are correlated, and that the bunker price is having effect on the demand for container vessels.

2.6 The influence of speed

When the charterer of a vessel chooses the speed of the vessel, it is not only a matter of bunker prices. There is a trade-off between the bunker consumption based on the speed, and the total amount of TEU carried within a certain amount of time. If the speed is decreased, the bunker consumption is to, but the negative effect is that the TEU miles will be lessened too and causally by that, the revenue.

Economically it is described by Ronen (2011) about a linear route, with the conclusion as in *Table 6*; that the bunker price is essential when deciding whether a linear route should be managed by less vessels with high speed or more vessels with low speed. As already stated, the influence of high bunker prices, makes it more profitable managing the route with more vessels. The difference between a bunker price of either 104 or 500 USD/ton is that the linear route should be operated with 9 container vessels at 2000 TEU at a bunker price at 500 and only 5 container vessels of the same size, if the bunker price were 104 USD per ton

The above conclusion, with the fluctuation showed in the bunker price in *Figure 13*, illustrates quite well, that there is a significant effect on the containerized shipping industry, from the prices of the fuel. Intuitively, it is entirely as expected.

Table 6 Average total daily cost ($/Day) as a function of bunker fuel prices

Data Item	*Ting and Tzeng (2003)*
Vessel size (TEU)	2000
Design speed (Knots)	17
Cycle Distance (NM)	11 730
Port time in cycle (HRS)	140
Bunker fuel consumption (Tons/Day)	78
Daily cost of vessel (USD/Day)	12 000
Bunker fuel price (USD/Ton)	104*

*Calculated from the provided data.
**Doesn't include capital costs.

No. Vessels	*Speed*	*Bunker fuel price [USD/Ton]*				
		104	200	300	400	500
5	16.8	**92 372**	122 254	153 381	184 508	215 635
6	13.5	93 054	112 488	132 732	152 975	173 219
7	11.3	98 779	**112 421**	**126 632**	140 842	155 053
8	9.7	106 942	117 043	127 565	**138 086**	148 608
9	8.5	116 427	124 205	132 308	140 410	**148 513**
10	8.5*	128 329	136 018	144 026	152 036	160 045

Source: From *The effect of oil price on containership speed and fleet size*

This can analogously also be transferred to the shipping market in general, where the question of optimization is a function of the container vessel speed. If a single chartered vessel is considered, the profit (Π) can be construed from standard micro economics, as a function of the revenue (TR) and the expenses (TC).

$$\Pi = TR - TC \text{ and } TC = FC + VC \qquad (3)$$

For simplicity the fixed cost donated as FC is anticipated to be the time charter rate for the given period of time, and the variable costs (VC) is anticipated to be the bunker cost[5] as a function of quantity and price denoted BQ and BP, hereby follow equation *(4)* where TCR is the relevant time charter rates

$$TC = TCR + BP * BQ \qquad (4)$$

The revenue (TR) is a function of the freight rate (FR) and the TEU carried.

$$TR = FR * TEU \qquad (5)$$

Equation *(4)* and *(5)* makes basis for the following profit function;

$$\Pi = FR * TEU - (TCR + BP * BQ) \qquad (6)$$

The shortfall of the profit function in *(6)* is that the charterer on a competitive market is price taker on all parameters. He can though, manage the speed of the vessel. A re-writhing of the profit in equation *(6)* as a function of the speed can be done by considering the input as a matter of speed and distance instead. The freight rate is for specific routes, and therefore are the distance for the freight known approximately in advance. Thus the freight rate per distance can be calculated as stated in equation *(7)*, where the *distance in miles* is the expected freighted distance per TEU.

$$FR_M = \frac{FR}{Distance\ in\ miles} \qquad (7)$$

Calculation of FR_M allows the calculation of total revenue in a given period of time as a function of the vessel speed, the TR per day is accounted for in *(8)* where M/H is miles per hour

$$TR_{DAY} = FR_M * \frac{M}{H} * 24 * TEU \qquad (8)$$

[5] Port/Canal fee, capital cost etc. should be implemented for a complete model

The re-writing of TR to of function of the speed, requires a re-writing of the TC so that it is also a function of the vessel speed. Since the time charter rate is a fix cost, it is by definition not variable and therefore not dependent of the speed. The variable cost on the other hand, should be redrafted so this to, is a function of the speed. The last part of equation *(4)* which account for the total bunker expense, is the part there should be changed

The essential part is that even though the higher speed of the vessel makes it more efficient according to TEU mile, the bunker consumption increases and therefore should be taken into account. Analysing this requires that the bunker consumption is measured per distance, the reason for this is that if the bunker usage is accounted for in e.g. hours, it is intuitively clear that the bunker consumption increases with the speed, but this alone is no problem, because the ship will get farther as well. Instead the bunker consumption per distance is the relevant measure, because if the increase in speed increases the bunker consumption per distance, it will be causal with an increase in the average expense per TEU.

The daily variable cost as a function of the vessel speed would be as followed in equation *(9)*:

$$VC_{DAY} = BP * BQ_M * \frac{M}{H} * 24 \tag{9}$$

The bunker quantity per mile (BQ_M) times the speed (M/H) gives the hourly bunker consumption, times the 24 gives the bunker consumption per day, and finally the bunker price gives the daily variable cost as a function of the vessel speed. The total cost can then be derived from equation *(9)* and the daily time charter rate, equation *(10)*:

$$TC_{DAY} = TCR_{DAY} + BP * BQ_M * \frac{M}{H} * 24 \tag{10}$$

The above construction is however lacking input in the bunker consumption parameter, since the BQ_M is assumed to be dependent of the speed, and therefore should be expected to be a function of the speed. Taken from *Table 6* these data can be inferred by analyzing the connections between average total cost of a linear containerized vessel route and the vessel speed. *Table 6* shows the matrix $TC_{DAY\ ROUTE}$ for the linear route, which for the route must be a function of the number of vessel times respectively TCR and the VC.

The variable cost per day for one vessel can from the sample string from the table be derived as equation *(11)*:

$$\mathrm{TC}_{\mathrm{DAY\ ROUTE}} = 5 * TCR_{DAY} + 5 * VC_{DAY}$$

$$\Leftrightarrow \qquad \frac{\mathrm{TC}_{\mathrm{DAY\ ROUTE}} - 5 * TCR_{DAY}}{5} = VC_{DAY}$$

$$\Leftrightarrow \qquad \frac{92.372 - 5 * 12.000}{5} = 6474\ \$\ \text{per day} \qquad (11)$$

The method from *(11)* gives the daily variable cost for a specific bunker price and a given speed, *Table 7* shows the combination of expenses with respect to the bunker prices and the vessel speed. The prices are still affecting *Table 7*, and since the outcome should be a ratio only between the speed and the bunker consumption, the table is therefore cleared for the bunker prices and thus is the bunker consumption per day in ton derived in *Table 8*, done by dividing the VC_{DAY} with BP

For calculation of the bunker consumption per mile, the speed is re-calculated to miles per hour and the consumption is stated in hours instead of daily. The result will be $\mathrm{BQ}_{\mathrm{HOUR}}$ and the distance traveled in in an hour (the speed per hour), where if $\mathrm{BQ}_{\mathrm{HOUR}}$ is divided by the miles, the output is the bunker consumption per mile (BQ_{M}). *Table 9* shows BQ_{M} for the different $\frac{M}{H}$.

Table 7: VC_{DAY} for one vessel in respect to BP and speed – Daily bunker expense

Speed	**Bunker fuel prices ($/TON)**				
Knots	104	200	300	400	500
16,8	6474	12451	18676	24902	31127
13,5	3509	6748	10122	13496	16870
11,3	2111	4060	6090	8120	10150
9,7	1368	2630	3946	5261	6576
8,5	936	1801	2701	3601	4501
8,5'	833	1602	2403	3204	4005

Source: From *The effect of oil price on containership speed and fleet size*, authors own calculations

Table 8: bunker consumption per day for one vessel

Bunker consump. (TON/DAY)		
Knots	BQ	
	16,8	62,3
	13,5	33,7
	11,3	20,3
	9,7	13,2
	8,5	9,0
	8,5'	8,0

Source: From *The effect of oil price on containership speed and fleet size*, authors own calculations

Table 9: BQ_M from the different speeds

Bunker consump. (TON/MILE)		
M/H	$\mathrm{BQ_M}$	
	19,33	0,1342
	15,54	0,0905
	13,00	0,0650
	11,16	0,0491
	9,78	0,0384
	9,78'	0,0341

Source: From *The effect of oil price on containership speed and fleet size*, authors own calculations

The causality by higher speed is seen in *Table 9*, the increase does not only increase the bunker consumption per hour, it also make an impact on the bunker consumption per mile, which is far more critical in an economical view, since this affects the cost per TEU for a predetermined distance.

Re-writing the data from *Table 9* into a function for BQ_M as a function of $\frac{M}{H}$ is done from an anticipation of linearity, which mean that the model is estimated from *(12)*:

$$BQ_M\left(\frac{M}{H}\right) = \alpha + \beta * \frac{M}{H} \tag{12}$$

Figure 14 and *Table 10* shows the regression output and the x y-plot for data in *Table 9*

Figure 14 Regression output from excel

Regression statistics	
Mult R	0,9978
R^2	0,9956
Adj R^2	0,9944
Std. Err	0,0028
Obs	6

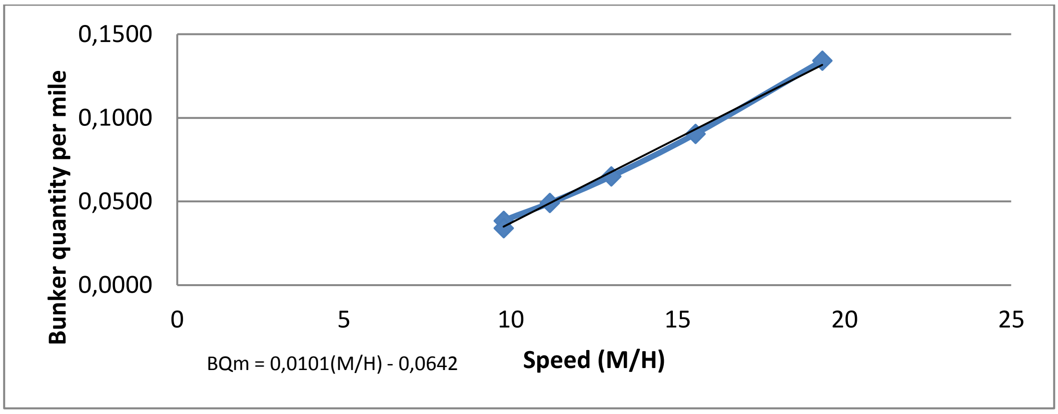
ANAVA

	df	*SS*	*MS*	*F*	*P-value*
Regression	1	0,0072	0,0072	895,8838	7,42033E-06
Residual	4	3,23E-05	8,09E-06		
I alt	5	0,0073			

	Coeff	*Std. Err*	*t-stat*	*P-værdi*	*Low 95%*	*Upp 95%*
α	-0,0642	0,0046	-14,0012	0,0002	-0,0769	-0,0514
β	0,0101	0,0003	29,9313	7,42E-06	0,0092	0,0111

Source: Output from regression data analysis excel

Table 10 X Y-plot for the bunker quantity



Source: Authors own calculations

The profit function, with respect to the speed in miles per hour is compounded by the TR_{DAY} *(8)* and TC_{DAY} *(10)* where BQ_M is substituted with the function of BQ_M showed in *Table 10*. The result is composed in *Equation (13):*

$$\Pi_{\text{DAY}} = FR_M * \frac{M}{H} * 24 * TEU - (TCR_{DAY} + BP * (0{,}0101 * \left(\frac{M}{H}\right) - 0{,}0642) * \frac{M}{H} * 24)$$

$$\Leftrightarrow \quad \Pi_{\text{DAY}} = FR_M * \frac{M}{H} * 24 * TEU - (TCR_{DAY} + BP * (0{,}2432 * \left(\frac{M}{H}\right)^2 - 1{,}5402 * \frac{M}{H})) \qquad (13)$$

The profit function is applicable in relation to finding the speed that optimizes the profit, within certain situations. Different types of market conditions should be taken into account, since the above assumption is that the vessel charterer is price taker on the market, which is typical for perfect competition. Other market situation could make an impact the optimization issue, like natural monopolistic conditions, in which economies of scale cause efficiency to increase continuously with the size of the firm, or oligopoly, i.e. a market which is dominated by a small number of firms which own more than 40% of the market share. Both cases are close to real life conditions for the containerized shipping industry. For further studying this particular issue, general literature of *microeconomics* would be relevant, it is not within the scope of this paper.

Though the model is a draft where other parameters should be included for it to be more precise, the structure in it should be intuitive. It could easily be enhanced by including port/canal fee as fix cost, and the assumption that the freight rate is independent of the time of the freight, could be taken care of by substituting the freight rate (FR) with the function of the freight rate with respect to the time of the freight.

For the purpose of predicting market movements in this paper, it is found sufficient. The consistency of a $\mathrm{BQ_M}\left(\frac{\mathrm{M}}{\mathrm{H}}\right)$ and BP condition that affects the speed, and thereby also the supply in TEU miles is essential. For a matter of optimization, refinement of the model and more vessel data would be needed.

3 Theoretical framework

3.1 Economic bubbles

"Double, double toil and trouble
Fire burn, and cauldron bubble." – Macbeth, Act 4, Scene 1

The first conceptual framework for an economic bubble is a situation where the price of a product or an asset within a specific market, increases above its fundamental price on a current basis and at dramatic scales. This phenomenon was originally called "a mania", rather than a bubble as we denote it today. The canonical mania was the tulip market in Holland in the 1630's, where the price of a single tulip soared to six thousand florins (the price of a home). After the bulbs had been planted to bloom, people mortgaged their homes and industries in order to buy the bulbs for resale at higher prices (speculation). When spring came about and the bulbs were close to flowering, consumer confidence suddenly disappeared like snow in the sun and the market crashed. In the span of little over a month, price dropped to just a single florin (the price of an onion). Massive litigations followed, and a government commission later ruled that tulip contracts could be annulled upon the payment of a fraction of the inflated price. The term "bubble" originated sometime in the late 1710's in Great Britain, and originally referred to the companies themselves and their inflated stock. The

South Sea Company was granted exclusive rights to trade with the Spanish colonies in South America in 1720, in return for financing the British government's war debt. Through a complex and fraudulent set of circumstances, shares of the company surged more than eight-fold in 1720, before collapsing in subsequent months and causing a severe economic crisis. Sir Isaac Newton was one of those ruined, losing the equivalent of GBP 2,4 billion, upon which he famously remarked: "I calculate the movement of stars but not the madness of men". Many other joint-stock companies in that era were making extravagant claims and promising excessive returns. These companies were nicknamed "bubble companies". Some later commentators have expanded the metaphor emphasizing the abrupt and sudden end, just as when physical bubbles burst. However, theories of financial crisis such as Debt Deflation by Irving Fisher and Financial Instability Hypothesis by Hyman Minsky, suggest instead that bubbles burst progressively.
Later infamous examples include the US bull market of the roaring twenties, the Japanese bubble economy in the 80's, the dot-com bubble at the turn of the century and the securitization bubble in the last decade. Acclaimed speculative bubbles, lesser in both notoriety and extend, have occurred in everything from uranium to rhodium, wheat, alpacas and ostrich eggs.

Bubbles have not only been studied through historical evidence, but also through controlled experiments. Smith et al. (1988) designed a set of experiments, in which an asset that paid a dividend with an expected value of 24 cents at the end of each of 15 periods (and were subsequently worthless) were traded through a computer network. According to classical economics, the asset should start trading near $3,60 (15 times $0,24) and decline by 24 cents each period. Instead they found that prices started well below the fundamental value and rose far above the expected return in dividends. The bubble subsequently crashed before the end of the experiment. This experiment has since been hundreds of times with similar results. The existence of bubbles and crashes in such a simple context opened up for the possibility of comparison between experiments and world markets, which together is taken as evidence of the existence of bubbles by most mainstream economists. There are, however, scholars that argue against the fact.

3.1.1 Mathematical definition

By illustrating the basic bubble mechanism by a simplified mathematical demonstration by Blanchard (1978), we offer a simple insight in the existence of bubbles, and also illustrate the relationship between fundamental price and the bubble price component. The process replicated here is form a rewrite by Caballé (2010).

In equilibrium, the price of an asset *p* at a given moment of time *t* satisfies the following equation:

$$u'(c_t) * p_t = \beta E_t\big(u'(c_{t+1})(d_{t+1} + p_{t+1})\big) \tag{14}$$

This equation states that the marginal costs at time equal to *t*, which appear on the left hand side, need to be equal to expected discounted marginal profits at time equal to *t+1*, which appear on the right hand side of the *Equation (15)*. Isolating the asset price at time equal *t*, we obtain:

$$p_t = \beta E_t\left(\frac{u'(c_{t+1})}{u'(c_t)}(d_{t+1} + p_{t+1})\right) \tag{15}$$

β is the discount factor and E_t is the mathematic expectation subject to all information at time equal to *t*. *d* is the dividend associated with the asset and is understood as the cash flow from the asset – not to be confused with dividend payments in the stock market in general, which is less than the total payoff to shareholders, i.e. earning per share.

To keep the demonstration simple, the following considerations are assumed:

There is risk neutrality, which implies that u' is constant.

There is no uncertainty, which implies that $E_t = 1$.

The dividend payments are constant, which means $d_t = d$.

$\beta = 1/R$ where $R \equiv 1+r$ is the interest rate, that we will also assume to be constant.

When these assumptions are applied to *Equation (15)*, we obtain the following simplified formula for the asset price at time equal to *t*:

$$p_t = \frac{d + p_{t+1}}{R} \tag{16}$$

And for time equal to *t+1*:

$$p_{t+1} = \frac{d + p_{t+2}}{R} \tag{17}$$

Combining *Equation (16)* and *(17)*, we obtain:

$$p_t = \frac{d + \frac{d + p_{t+2}}{R}}{R} = \frac{d}{R} + \frac{d}{R^2} + \frac{p_{t+2}}{R^2} \tag{18}$$

Repeating the same process for p_{t+2} and successively to infinity, we obtain:

$$p_t = \sum\nolimits_{s=1}^{\infty} \frac{d}{R^2} + \lim_{m\to\infty} \frac{p_{t+m}}{R^m} = \frac{d}{R-1} + \lim_{m\to\infty} \frac{p_{t+m}}{R^m} \tag{19}$$

In *Equation (19)*, $\lim_{m\to\infty} \frac{p_{t+m}}{R^m}$ is the bubble, because if it were equal to zero, then the asset price would be equal to its fundamental value, i.e. the present value of a perpetuity:

$$p_t = \frac{d}{r} \tag{20}$$

The bubble element appears whenever there are expectations of returns not based on future dividend payments, and is thus characterized by as an irrational price element added to the assets fundamental value. For further discussions of mathematical demonstrations of bubbles, we refer to Evans (1991).

3.1.2 Common characteristics

Common for all the bubbles mentioned in this section is, that a closer examination of their price trends reveal that, at least in principle, they more or less follow the four phases denoted by Rodrigue (*Figure 15*): stealth, awareness, mania and blow-off.

Figure 15: Four phases of a bubble

Source: Jean-Paul Rodrigue, Dept. of Global Studies & Geography, Hofstra University, New York. USA.

In the stealth phase, prices gradually increase as increasingly larger acquisitions are made, mostly unnoticed by the general population of players in the market. The category of investor seizing this opportunity tends to have better access to information and a higher capacity to understand that the fundamentals are well grounded and that this asset is likely to experience significant future valuations.
In the awareness phase, more investors start to realize the momentum, bringing in additional money and pushing prices higher. In liquid markets, there can be one or more short-lived sell off phases, as few investors cash in their profits.
The mania phase is where irrational behaviour becomes apparent. Both market participants and outside players are pouring money into the market in the expectation of future appreciation, which is why economic bubbles are also called speculative bubbles. A linear inference mentality sets in, where future prices are an almost guaranteed extrapolation of past price appreciation, which of course goes against any conventional wisdom. Too much money is chasing too few assets, causing assets to appreciate excessively beyond their fundamentals to an unsustainable level. Irrational behavior is gradually taking over as the market becomes more exuberant and unbiased opinions about the fundamentals become increasingly difficult to find. Prices are bid up with all financial means available, including leverage and debt.
The transition to the blow-off phase, the burst of the bubble, happens as confidence and expectations encounter a paradigm shift. Like a directionless herd many try to unload their assets to a greater fool, but takers are few as everyone is expecting further price declines. The house of cards collapses under its own weight and the bubble deflates. Many over-leveraged investors go bankrupt, triggering additional waves of sales, causing prices to drop at a rate much faster than the one that inflated the bubble. There is also a possibility that the valuation undershoots the long term mean, i.e. price drops below fundamental value, as investors flee the market (Kenan, 2011)

A history and analysis over four centuries and a wide variety of countries have found at least two consistent ingredients in bubbles: uncertainty and liquidity (Chancellor, 2000). In almost every bubble in history, there has been some kind of innovation or new insight which causes investors to debate the creation of new economic value. Even the famous 1630’s Dutch tulip mania adheres to this condition. A mosaic virus resulted in intricate multi-coloured breaking pattern and flame-like streaks on the petals of the most expensive tulips, the Semper Augustus. The tulip was itself a conspirator in the supply-squeeze that fuelled the speculation, because the bulb cannot be produced quickly; it takes 7–12 years to grow a flowering bulb from seed. Bulbs can produce both seeds and two or three “daughter offsets” annually. The "mother bulb" lasts a few years and properly cultivated, the offsets will become flowering bulbs after one to three years. The rare "breaking pattern" can only be reproduced through offsets, not seeds, as only the bulb is affected by the virus. Unfortunately, the virus also acted adversely on the bulb, weakening it and retarding propagation of offsets, so cultivating the most appealing varieties now took even longer. Needless to say, these tulip bulbs were quite an innovation, and the product was incredibly unpredictable. This uncertainty is usually compounded by a form of “lottery effect”, which creates an inevitable upside/downside imbalance that Henry Blodget recently framed as: “If you lose your bet, you lose 100%. If you in win your bet, you make 1000%.”

In every bubble, there are circumstances that cause excessive monetary liquidity in the financial system, such as lax or inappropriate lending standards. The expansion of leverage not only provides massive liquidity to fund the formation and proliferation of the bubble, but the leverage also sets up the covenants that unwind when the bubble ruptures and deflates. The irrationality lies in the absence of unbiased fundamental valuation, where future prices are taken as a course extrapolation of past price appreciation. If this is compartmentalised as truth, then logic dictates investors should borrow cheap money to maximize their returns. Axel A. Weber, the former president of the Deutsche Bundesbank, has argued that: "The past has shown that an overly generous provision of liquidity in global financial markets in connection with a very low level of interest rates promotes the formation of asset-price bubbles.” (Buchanan 2008).

3.1.3 Boom-bust cycles

Economic cycles, or business cycles, create a process of economic expansion and contraction that occurs repeatedly. Used in the indefinite sense, a business cycle is a period containing a single expansion and contraction in sequence. It often refers to the natural fluctuation of the economy between periods of growth and recession, but may also be used to describe cyclical industries. In 1860 the French economist Clement Juglar defined economic cycles as 7 to 11 years long, and later economist Joseph Schumpeter argued that a Juglar Cycle has four stages: expansion, crisis, recession, recovery.

Cyclical industries are industries that are highly sensitive to the business cycle, such that revenues are generally higher in periods of economic growth and lower in periods of economic recession. In this perspective, the term ‘business cycle’ can also be used to describe a specific industry or asset class. Shipping is classic example. The shipping industry accounts for approximately 90 percent of global trade by volume and is essential for connecting large sectors of the world's economy. In times of economic growth, world trade increases because of an increase in household consumption and increasing demand for raw materials to fuel the expansion. Conversely, during a recession, people are more careful about spending and fewer raw materials are needed. Shipping is characterized by boom-bust cycles, which are cycles where the expansions are rapid and the contractions are steep and severe. The cycles occur roughly every decade and the most recent super-cycle began in 2004 and peaked in 2008 before declining at the onset of the global financial crisis. The decline sparked an institutional and psychological amplified loss spiral, which turned into a precipitous drop in vessels prices (see section 3.2.5 on psychological amplification).

3.1.4 Interim conclusion

The term 'bubble' is hard to define and rarely is. As we have discussed, consistent overvaluation can occur in very different asset classes, and in spite of common characteristics, they often have different instigators and accelerants, are different in the magnitude of peaks and troughs and vary in length. The only true constant with all bubbles, is that they create excess demand. Once the bubble inevitably deflates, a consolidation has to occur to alleviate that excess. This was apparent in the dot-com bubble and the securitization bubble, as well as all the others. The result was deteriorating asset values and bankruptcies.

For the purpose of this paper, we will use a working definition of a bubble as an episode where irrational thinking or a friction causes asset prices within a specific market to rise above its fundamental price, higher than they would have in the absence of that friction or irrationality, and where the price level becomes such, that a rational observer with access to all available information would forecast a low long-term return on those assets.

With two major bubbles in less than a decade, in both cases supposedly catching policymakers off guard, many people question the tradecraft of political economists (citation). In each case, a number of people did correctly identify the bubble (Roubini, 2008). A posteriori this has led to conspiracy theories where governments, together with a small elite that controls the global finance sector, orchestrate, play into or at the very least turn a blind eye to bubble schemes, which generate a redistribution of wealth in society towards the ruling elite (Pettifor, 2014). We will not address these views in this study for two reasons.
First, economic or market bubbles are harder to define than one might assume. Boom and bust cycles exist in almost any business and industry, and the threshold between that and a bubble is only apparent in hindsight. A bubble is typically a retrospective of an excessive valuation of an asset class. It will always entail a boom –and a bust phase, which are just periods of the economic cycle.
Second, as with the boy who cried wolf, the truth is apt to be disbelieved. In every market there are always people claiming that prices are too high. That is what makes a market. As a result, the cry of "bubble" is far more often proven wrong than right.

Martin Stopford, managing director of Clarksons, the world's leading shipbroker, when asked in 2005 if there might there be a return to the overcapacity that characterized shipping in the 1970s, he said: "Shipping is not in a bubble but a "super-cycle". By the 1990s, the industry had finally shed the crushing burden of the huge oversupply there had been since the 1970s and it is unlikely to recreate it."

There is already a lot of research on why bubbles occur, a lot of it by behavioural finance scholars. It is our view, that the challenge is not the lack of good theories, but rather that we have too many such theories. Instead of rushing to develop a new theory of overvaluation, we will instead test and refine some of the theories, which already exist.

In the following, we review a number of behavioural biases, but emphasize three: 1) over extrapolation of past price changes, 2) belief manipulation and 3) psychological amplification. All of these psychology-based mechanisms have been extensively studied in behavioural finance and behavioural economics.

3.2 Behavioural finance and behavioural economics

3.2.1 Conventional Finance

As a starting point for our insertion into behavioural finance, we define "conventional" finance as the body of knowledge built on such pillars as the arbitrage principles of Modigliani and Millar, the capital asset pricing theory of Sharpe and Lintner, the portfolio construction principles of Markowitz, the option pricing theory of Merton, Black and Scholes and the efficient market hypothesis of Fama and French.

Modern finance is based on the premises of this school of knowledge as descriptive of the equilibrium that results from the interaction of individuals in markets (not to be confused with theory of the behaviour of individuals). It assumes that the representative investor in any market is rational in two ways; the investor makes unbiased future predictions and decisions according to the axioms of expected utility theory (Statman, 1995). Asset prices are determined by rational investors, and consequently achieved market equilibrium is rationality based. In this equilibrium, assets are priced according to the efficient market hypothesis, meaning that prices can be regarded as optimal estimates of the fundamental value, because they incorporate all available information at all times. It is the underlying basis of the efficient market hypothesis that as a whole, investors behave rationally, process all available information and maximize expected utility accurately. Assets are always priced rationally given what is known (bounded rationality), and because all information is contained in the equilibrium price, it is impossible to make an above average profit over time without taking excessive risk (Shiller, 1998).

Over time, there has been numerous studies pointing to market anomalies, that does not correspond with modern financial theory, such as abnormal price movements in connection with mergers, stock-splits, IPO's and spin-offs among others. The regular occurrence of these anomalies suggests that the principle of rational behaviour underlying the efficient market hypothesis is, if not wrong, probably incomplete (Olsen, 1998). This is perhaps most evident in the "winner's curse", which is a tendency for the winning bid in an auction to exceed the intrinsic value of whatever is purchased. The term originates from companies bidding for offshore drilling right in the Mexican Gulf and is described in detail in an article by Richard Thaler (1998). Rationality based theories assume that all bidders in an auction setting will come to the same valuation of the auctioned asset, because they all have access to the same information. In fact, what often happens is that the aggressiveness of the bidding and the number of bidders undermine the rational bidding process. Intrinsic value is of course subjective, but Thaler (Ibid.) also observes the phenomenon in the real estate market.

Supposedly, all the prospective homebuyers bidding for a house are rational and come to the same conclusion regarding the intrinsic value of the home from studying recent sales of comparative homes in the area. However, in much the same way that bubbles are created, buyers tend to be irrational and push prices beyond their true values.

These anomalies prompted academics to look elsewhere, to cognitive psychology, to explain the illogical and irrational behaviour that was empirically observed but for which modern finance did not have an explanation. Behavioural finance can thus be seen as a Kuhnian paradigm shift, in that it seeks to supplement conventional finance, within which scientific progress has thereto been made, by understanding and predicting systematic financial market implications of psychological decision processes. Rational asset prices only reflect utilitarian characteristics like risk, and not value-expressive characteristics like sentiment. Behavioural finance argues that value-expressive characteristics matter in both investor choices and asset prices (Statman, 1999). To sum up, modern finance seeks to explain the actions of homo economicus, the "economic man", whereas behavioural finance seeks to explain the actions of individuals.

The field of behavioural finance investigates whether certain economic phenomena are the result of irrational, or less than fully rational behaviour, of the agents in the system where the phenomena occurs. The field offers explanations on how people deviate from full rationality, and focus mainly on three areas of application: the behaviour of firm managers, the pricing of financial assets and the trading decisions and portfolio choice of investors. It is a probable assumption that shipping companies, with their finance departments, valuation and procurement specialists, are in fact "economic men". Tenets from behavioural finance clearly have a place in investigating boom-bust cycle patterns in the shipping industry, but can they offer a useful perspective? We suspect that they can. In next section, we will speculate about some of the ways behavioural biases may be helpful for understanding the investment behaviour in the containerized shipping market.

3.2.2 Heuristics

The concept of mania, as introduced earlier, stems from the first economic theories that attempted to explain the phenomenon. In this paragraph we will cover the most significant examples of such and later theories. It is fair to say that they are based upon the foundation laid by John Maynard Keynes in his famous work titled General theory of employment, interest and money (1973), where he challenges the notion that asset prices are based on mathematical calculations of expected value. According to Keynes, "people" are too ignorant to reliably estimate present value, which leads to short term speculation rather than long term enterprise, which in turn causes instability. This is exacerbated by successfully organised "liquid" investment markets. In the context of asset prices, Keynes talks about "animal spirits" as the spontaneous urge to action rather than inaction. When individuals are unable to rationally calculate expected value, animal spirits are the "springs of action". The term was originally used in early theories of physiology, accounting for muscular action directed by the brain. The French philosopher, mathematician and scientist, Descartes, believed blood was warmed in the heart before travelling through the aorta toward the brain. Animal spirits was the most animated and subtle portions of blood. "Brewed in the heart and filtered through the brain, animal spirits percolate down the hollow cavities of nerve fibres and causes muscles to move". Descartes believed this to be why people sometimes act against their own best judgement, guided by feelings and emotions instead of rational thought (Koppl, 1991). In financial markets, ignorance of the future leads investors to buy and sell on the basis of a "conventional valuation," which emerges from "the mass psychology of a large number of ignorant individuals" and it is "liable to change violently as the result of a sudden fluctuation of opinion". It is like a beauty contest in which "we devote our intelligences to anticipating what average opinion expects the average opinion to be" (Keynes, 1973).

Besides Maynard Keynes and later Richard Thaler, cognitive psychologists Daniel Kahneman and Amos Tversky are some of the most notable contributors to behavioural finance. The pair focused much of their research on heuristics that causes individuals to engage in unanticipated irrational behaviour. Heuristics refer to the "use of experience and practical efforts to answer questions or to improve performance". Basically it means the process by which individuals find things out for themselves, which is often by a trial and error approach, which leads to "rules of thumb". Because both the extent of information and the speed with which it travels has increased exponentially, life for decision makers in any market has become more challenging. This implies increased use of heuristics as an almost inevitable approach (Fromlet, 2001). Theories about asset market overvaluation in behavioural finance literature can be categorized based on whether they focus on investor beliefs or investor preferences.

On one side (i.e. beliefs) there are three main theories. The first argue that overvaluation is caused by strong investor disagreement about an asset's future prospects coupled with short-sale constraints. The logic is that there are very bearish and very bullish investors, but because of short-sale constraints, the price of the asset will only reflect the views of the bullish; the bearish will stay out of the market and the asset will become overvalued (Miller, 1977; Hong and Stein, 2007). A similar explanation is that under the same circumstances, the asset's price will be higher than its holder's valuation of future cash flow, because these holders believe they can resell to more optimistic investors in the near future. (Harrison and Kreps, 1978; Scheinkman and Xiong, 2003). This is also called the 'greater fools theory', and is perhaps most evident in the tulip mania described earlier.
Another belief-based theory of overvaluation is that investors extrapolate recent price changes too far into the future (Barberis, Shleifer, Vishny, 1998; Greenwood and Hanson, 2010). This is also called the 'recency bias'. An example is the survey, which Bloomberg conducts among market strategists on a weekly basis. The

survey asks for their recommended portfolio weightings of stocks, bonds and cash. The peak recommended stock weighting came just after the peak of the internet bubble in early 2001, while the lowest recommended weighting came just after the lows of the financial crisis. Kahneman and Tversky's (1974) representativeness heuristic motivate this assumption. According to this heuristic, investors expect very small data samples to reflect the properties of the parent population. As a result, they draw unjustifiably strong inferences from these samples, which can lead to over extrapolation.

The third belief-based theory is that people are overconfident and consistently overestimate the precision of their forecasts (Daniel et al., 1998). According to this theory, investors who research and analyse information, in an effort to estimate the fundamental value of an asset, become overconfident about the usefulness of this information. If they uncover favourable information about the asset, their overconfidence about how reliable the information is leads them to push the price of the asset up too high. On one hand, overconfidence is a powerful feature of human cognition. Without it, military commanders would hesitate at key moments when decisiveness was essential. At the same time, it causes faulty and irrational assessments, like in a study where 94% of college professors claimed that their research was above average.

Other theories of overvaluation are preference-based, like the 'house money' effect, where investors who have experienced gains by holding an asset become less risk averse. They are essentially less concerned about the future, because any eventual loss will be cushioned somewhat by the prior gains. This reduced risk aversion, cause them to be even more bullish and push prices up even further (Thaler and Johnson, 1990). The house money effect is an example of mental accounting where investors mentally keep their winnings in artificially separate "accounts". Thaler and Johnson (Ibid.) argue that the house money effect is consistent with prospect theory because of 'hedonic editing', which states that investors are not uniform in their tolerance for risk, but rather that it depends on the situation.

Of all these theories, the one most useful for understanding the behaviour of the shipping industry is probably the second type of belief-based model. The theory argues that investors over-extrapolate the past when making forecasts about the future, possible because of the representativeness heuristic. In 2003 shipping rates rose sharply. The boom was a result of fast-growing world trade, much of it due to China's astonishing rate of growth. This created a huge appetite for raw materials in the country, and ever more manufactured goods to ship back to foreign markets. In 2004 the rate of growth of global trade in goods, many of them carried by sea at some point, was 9%, compared with 5% in 2003 and 3,5% in 2002 (Economist Intelligence Unit). If we apply the theory to buyers of ships, then during 2003-2008, when forecasting future growth in vessel prices, buyers over-extrapolated recent demand growth. This led them to overpay for their new vessels and to take out loans with excessively high loan-to-value ratios.

3.2.3 Risk-reward imbalance

In 2005 alone, the world's shipyards saw their order books expand by one-third. At the same time, the rate of growth of world trade in goods was forecasted to slow down, albeit to a still respectable 6,6% in 2005 and 7,0% in 2006 (Economist Intelligence Unit) As a result, an armada of new ships was joining the world's fleets just as the rate of growth in world trade seemed to be slowing. The more slowly growing trade was obviously vulnerable to any slowdown in economic activity in Europe or the United States. If growth and trade were to stumble while shipping lines were piling up extra capacity, the result would be empty holds, plunging shipping rates and rapidly sinking profits. This is exactly the scenario that unfolded in 1981, when a global recession and the US coal miners' strike led to a collapse in time charter rates. It takes between 12-24 months from the time an order for a new vessel is placed to the delivery date, which means that vessel capacity fluctuations often lags demand fluctuations (see *Figure 37*).

How can we understand the excessive ordering of new vessels in this market? On one hand, it makes perfect economic sense to scale up capacity in order to meet a rising demand, and container shipping was far better placed than bulk shipping. China's export boom was still doing nicely, and the big ports on the US west-coast were still inefficient and congested, which meant shipping capacity was lying idle. Since vessels were earning a return that was higher than their funding cost, it was a profitable investment. The problem with this explanation is the significant associated risk. If economic activity in Europe or the US were to drop, demand would drop precipitously. It costs about USD 1.000 a day to keep a ship anchored at Singapore port, and on top of that owners have to maintain a full crew of 25-30 people on average, pay hundreds of thousands of dollars in insurance cost annually and maintain engines and machinery (BBC World). All this is needed for a ship to maintain its class, which is equivalent to a clean bill of health. Being taken ‘out of class’ means a ship cannot trade or earn any money, and cannot be insured for voyage on the open sea. At the same time, many ships have been bought with multi-million dollar loans that needs to be serviced. Given that many shipping companies were highly leveraged, often with short-term debt, this could have severe consequences. In retrospect, previous business cycles illustrate a familiar pattern, and the slowing world trade in 2005-2006 indicate a trend. Why then, did shipping companies continue to increase their exposure in spite of this growing risk?

There are perhaps three coarse answers to this: Bad incentives, bad models and bad luck. ‘Bad incentives’ posits that the previously recognized ‘economic men’ – shipping valuation and procurement specialists – were aware of the increasing risk-reward imbalance, but that they chose to ignore it because their performance is measured short-term and their compensation and recognition is tied largely to the size of the deals they structure. This is a well-known dilemma from other industries, that by not being compensated on the long term performance of the deals they are making, economic actors are not forced to face the consequences of the risks they are taking (Acharya et al., 2009). It is perhaps most evident in the case of the people responsible at the mortgage desks of banks in the years leading up to the recent financial crisis.

The second explanation of why shipping companies did not react to the increasing risk-reward imbalance can be labelled ‘bad models’. According to this view, because of faulty reasoning, shipping companies were genuinely unaware that shipping was nearing the peak of a super-cycle. An example is that the models they used to value their assets incorporated the faulty too-far-into-the-future extrapolation of past price increase, and therefore did not reveal any alarming risk. The ‘bad models’ view is implicitly assuming, that in the later years of the shipping boom, a rational individual with the right incentives would have known that the risk-reward balance has shifted.

The third explanation disputes this. According to the ‘bad luck’ view, a rational individual, even with the right incentives, would not have assigned a high probability to the precipitous drop in demand (Vassalou, 2011). As a causality of the financial crisis, the imploding market was a state of the world that a rational observer would have deemed highly unlikely ex ante.

All three of these explanations are possible, and certainly defendable, but we approach the ‘bad luck’ view with some scepticism. At the peak, ships that historically were leased for USD 30.000 a day were being leased for USD 120.000 – 200.000 a day, world trade was slowing, new ships were pouring into the market and shipyards still had booming order books (Greenwood and Hanson, 2014). If a rational shipping company, and per extensions the trained professionals working there, had carefully and thoroughly analysed the state of the industry, it seems likely that it would have set off a few alarm bells. It is the same argument that no one could foresee the global crisis before it happened, when in fact, there are ample evidence that that the poor performance of subprime-linked securities, which ignited the kindle, was predictable through careful analysis in the run-up to the crisis (McLean and Nocera, 2010).

The ‘bad incentives’ and ‘bad models’ explanations are more plausible, but even they seem somewhat scant and not quite satisfactory. After all, as we have already discussed, the professional valuation and procurement experts working at shipping companies are very competent and highly intelligent people. How plausible is it really that they would led slipshod reasoning mislead them as the ‘bad models’ view argue? Also, how plausible is it that the same people would knowingly expose their employer and the broader industry to excessive risk, simply because of bad incentives; a pad on the back, a toast at the annual barbecue and a larger Christmas bonus? One of the fundamental building blocks of social psychology is that generally people do not just want money and respect from others, they also want to respect themselves and to feel good about themselves. That is why whistle-blowers are willing to risk their job and career and face public ousting and yearlong litigation. It is difficult to feel good about yourself if you are knowingly doing something that is potentially ruinous to others. According to this logic, if the people responsible for new vessel purchases were aware of the increasing risk to the firm, they would limit the scale of their activities even if they could make more money and gain more short term recognition by increasing it further.

But if these explanations do not tell the whole story, how can we then understand why shipping companies continued to order new vessels in spite of the growing risk? One alternative hypothesis is that the people responsible were vaguely aware that the business model of continuous purchases in a seemingly saturated market entailed serious risks, but that they manipulated their beliefs.

3.2.4 Cognitive dissonance

Belief manipulation is essentially deluding oneself into neglecting the risk and overplaying the reward, thinking it is not that risky after all. Social psychology explains this with the concept of cognitive dissonance. Cognitive dissonance refers to a situation that causes mental stress and discomfort because of conflicting attitudes, beliefs or behaviours, like when people take action that conflict with their positive self-image. The theory proposes a powerful motive to maintain cognitive consistency, which can give rise to irrational and sometimes maladaptive behaviour (Kunda, 1999). In other words, to avoid the feeling of discomfort, people manipulate their beliefs to feel better about themselves – to achieve consonance (i.e. agreement). For example, when people smoke (behaviour) and they know that smoking causes cancer (cognition). To reduce the dissonance they feel about smoking, they can either quit smoking, which is hard, or manipulate their beliefs and convince themselves that smoking is not that risky after all. We see this all the time that smokers will argue, irrationally, that they know an old person who is very healthy in spite of having smoked her entire life. To put this into context, let us say a senior analyst at a shipping company begins to sense that the tide is turning, and that she is part of a malpractice that could pose serious risk to her employer. This will create an uncomfortable dissonance between her positive self-image as an upstanding person whose work is valuable to the company. To remove this dissonance, she can go against the consensus and let her superiors know that she feels the direction the company is going is wrong and that she has dire expectations for the future. However, this presents her with a difficult dilemma. If she goes to her superior and she turns out to be right, she will not be commended for doing her job. After all, this is expected of her. If she goes to her superior and she turns out to be wrong, the company might pass on a lucrative opportunity to join in the spoils, and she will probably be passed over for promotion. Instead, she can manipulate her beliefs, telling herself that the current course of action is not that risky after all. She might convince herself that if everyone else sees clothes on the emperor, he must be clothed, and she will stop scratching the lacquer. At first she may have suspected that the market was turning, but she was not sure, and now she will never confirm her suspicion. Congeniality bias, also known as confirmation bias, refers to instances where people underrate the importance of contradictory information or maintain their beliefs – what they want to believe – despite conflicting information (Rassin, 2008). In time, the recognition can become so strong, that it almost resembles denial. This role of belief manipulation is not a new concept, but has been widely considered in connection with the recent economic crisis. We recommend Benabou (2009) for a formalization of ideas related to those we present here.

3.2.5 Psychological amplification

In times of economic downturn, when the supply of ships exceeds the demand, and operating revenue drops below operating costs, ‘lay-up’ is the go-to choice until the freight and charter markets improve. It means taking a ship ‘out of class’ for anything from a short to a longer period of time (hot lay-up/cold lay-up). It is distinct from dry-docking for repairs or idling while waiting for cargo or orders from a charterer. Cold lay-up in particular is attractive, because it can save a ship owner up to 60% of daily operating costs, besides some insurance and other costs. The disadvantages are the cost of deactivation and reactivation and potential deterioration of the condition and value of the ship (in addition to this, the ship owner might miss the start of any recovery in the market due to the time lag in reactivating a ship and mobilizing a crew).

There is an institutional amplification mechanism at work during market conditions such as this. Since many vessels were funded by cheap credit during the boom, many companies were highly leveraged. If a company’s assets declined in value, the company would have to sell one or more vessels in order to deleverage. The law of supply and demand dictates that this will push down the value of vessels of other companies as well, forcing them into sales of their own, thereby pushing the price down even further, and so on.

These loss spirals are probably important in explaining the dramatically steep drop in ship prices during the bust. However, psychological amplifications mechanisms might also have played a role, specifically mechanisms related to loss aversion and ambiguity aversion.

The idea that ambiguity aversion plays a role in fuelling loss spirals is not ours (see for instance Easley and O’Hara, 2010) In short; the argument is that ship owners, experiencing losses in their asset holdings, experienced an increase in ambiguity aversion, which led them to reduce their asset holdings, thereby pushing the prices down even further. Ambiguity aversion is also known as uncertainty aversion and is a preference for known risks over unknown risks. It is exemplified in the proverb: “Better the devil you know, than the devil you don’t”. There is a subtle distinction between risk aversion and ambiguity aversion. Where risk aversion is defined by the preference between a risky alternative and its expected value, ambiguity aversion is defined by the preference between risky and ambiguous alternatives, after controlling for preferences over risk. Kelsey and le Roux (2015) provided evidence that ambiguity influences behaviour in a coordination game, using an experimental test of the influence of ambiguity on behaviour in a Battle of Sexes game. A real world consequence of increased ambiguity aversion is the increased demand for insurance because the general public are averse to the unknown events that will affect their lives and property (Alary, Treich, and Gollier 2010).

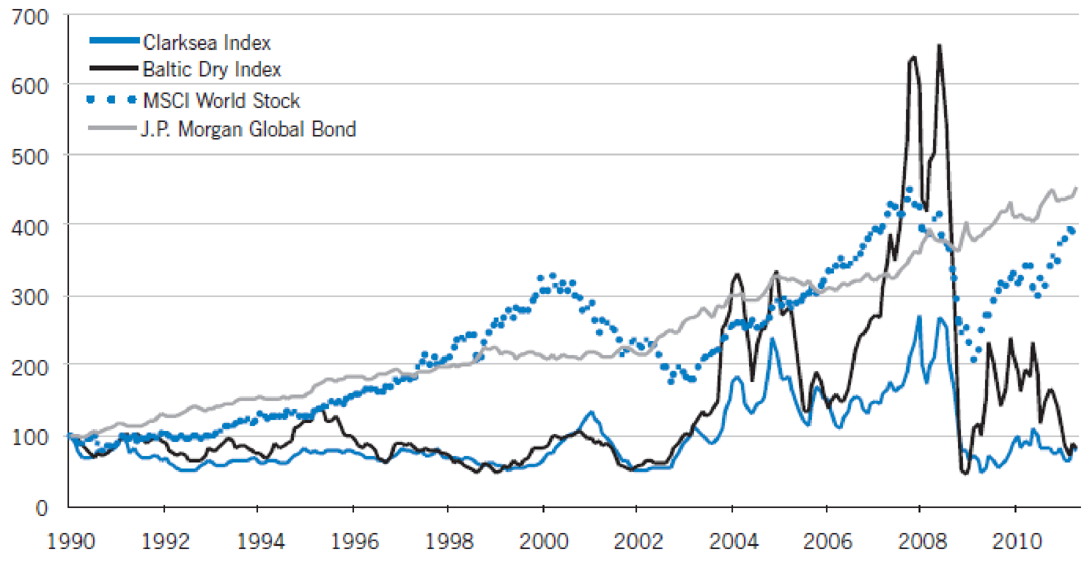
Heath and Tversky (1991) present an interesting theory on ambiguity aversion, labelled the ‘competency hypothesis’, which proposes that people can be either ambiguity averse or ambiguity seeking, depending on how competent they feel at analyzing the information available. According to this theory, if people feel competent at analyzing a situation, they will be ambiguity seeking and if they do not feel competent at analyzing the situation they will feel ambiguity avers. Heath and Tversky (1991) and Fox and Tversky (1995) found that they could alter subjects degree of ambiguity aversion by manipulating their feelings of competence, for instance by comparing the situation being analyzed to a less complex situation or by telling subjects that a seemingly more able group was analyzing the same situation. Among voluminous supporting research is an experiment where Fox and Tversky tell a group of subjects, who were undergraduate students at San Jose State, that the situation they were analyzing was also being studied by a group of graduate students from Stanford. The news, albeit a bluff, significantly increased the students' ambiguity aversion.

Even more familiar to economists than ambiguity aversion is loss aversion: Kahneman and Tversky's (1979) observation that people are twice as sensitive to losses as they are to gains of the same magnitude. While conventional finance considers this completely irrational, it is a very important concept in marketing. Just think of the difference between avoiding a USD 5 surcharge and getting a USD 5 discount – there is none. Something that economists are less aware of is that the degree of loss aversion changes over time depending on the experienced losses and gains Thaler and Johnson (1990). When people experience a loss, their utility function becomes more asymmetrical and they become more loss avers. They will subsequently refuse to take gambles that they otherwise would have, had they not experienced the loss. Clearly changes in loss aversion could have worsened the fall in vessel prices. The initial decline entailed painful losses, which made ship owners more loss averse, causing them to reduce their asset holdings.

4 Hypotheses building

In 1983, anticipating a recovery from the global recession, many ship owners ordered new vessels. According to Martin Stopford, author of Maritime Economics: "If so many owners had not had the same idea, this would have been a successful strategy." As it turned out, a heavy delivery of vessels worldwide choked the increase in shipping rates. Shipping companies scrambled to order new vessels again in the swell of 2003-2008. That led to a glut of ships competing in the market a few years later, accompanied by a decline in fees going into the hands of owners in the following trough when the market imploded in early 2009.

Figure 16: Freight rates and the global stock -and bond markets



Source: Albertijn et al., 2011

Why, despite a repeating boom-bust cycle in the shipping industry, did investors seem to make the same mistake over time? Perhaps because there is a lag between ordering and building a ship or perhaps for psychological reasons (behavioural biases).

What ship owners ought to ask themselves when facing changing market conditions, is how they should respond given how they expect all of their competitors to respond. Because the optimal equilibrium response in a market as competitive as shipping is incredibly complex, it is not farfetched to assume that owners instead relate to the much simpler questions of how they should response, assuming no one else reacts – so a status quo. This mental substitution leads investors to neglect the extent of the mean reversion of earnings brought on by their competitors supply response. Kahneman (2011) suggests that this praxis of investors overestimating their own skill and speed in responding to common observable demand shocks and underestimating the response by their competitors, is particularly dramatic when decision feedback is delayed, such as with extended lead time due to time-to-build delays as in shipping. Mental substitution is another heuristic (see section 3.2.2) which is perhaps most eloquently accounted for by Daniel Kahneman: "The target question is the assessment you intend to produce. The heuristic question is the simpler question that you answer instead. The technical definition of heuristic is a simple procedure that helps find adequate, though often imperfect, answers to difficult questions." The word heuristic, by the way, comes from the same root as eureka.

Competition neglect appears irrational by definition, but it can also be seen as a creating of bounded rationality, in which investors with limited cognitive resources attempt to forecast the market using simplified models instead of more sophisticated dynamic supply-demand models. Glaeser (2013) and Gabaix

(2014) have proposed this kind of reasoning in other industries. Even though data on ship orders are available (e.g. from Clarksons Research, which we use in our calculations), and shipping firms are supposedly aware of the development in the order book, they may still underestimate the response of future orders to demand shocks. This is consistent with the ‘bad models’ view, on which we elaborate in section 3.2.4. As we explain, the bad models view is implicitly assuming that a rational individual, with the right incentives, would have more accurately forecasted the market – a rational individual here being one that does not rely on “the mass psychology of a large number of ignorant (bounded rational red.) individuals” (Keynes, 1973).

Camrer and Lovallo (1999) take this line of thought even further, suggesting that investors may not make full use of the available data. They relate competition neglect to ‘inside view’ forecasting: “An ‘inside view’ forecast is generated by focussing on the abilities of a particular group …. In contrast, an ‘outside view’ ignores special details of the case at hand, constructs a class of similar cases to the current one, and guesses where the current case lie in that class …. The inside view tells a colourful story; the outside view recites statistics. In the inside view, there is no special role for anticipation of the number of competitors or their abilities”.

The idea of competition neglect is relatively modern, but we view it as a specific instance of more general biases, which have been amply emphasized in prior research. For a general introduction, please refer to section 3.2.

For at least two reasons, belief manipulation, or cognitive dissonance (see section 3.2.4) plays particularly well into the shipping boom. The first reason is that whether future supply will outstrip demand hinges on both endogenous investment behaviour and exogenous market factors like world trade, and as such is very complex. Given the considerable intricacies involved, it would be difficult to disprove the claim that the then current boom would not last. This may have made it easier for the people involved to delude themselves about the risk of an impending bust. The second reason why it might have been easier for people to hold distorted beliefs about the shipping market is that there was a seductive argument to justify their beliefs. Global economic growth was fuelled by China with no end in sight, which meant an increasing need for global trade. The representativeness heuristic make this argument seem even more plausible, since according to that heuristic, people have a natural tendency to believe that past trend will continue into the future.
We do not view the belief manipulation hypothesis as an alternative to the ‘bad incentives’ or ‘ bad model’ view, but rather as a foundation or the bad models view that makes it that much more plausible. Through both lenses, vessel traders are unaware of the increasing risk-reward imbalance. Belief manipulation offers the explanation that they are unaware because they choose to be.

The idea of ambiguity aversion that we present in section 3.2.5 and the basic evidence for it (the Ellsberg paradox) are common knowledge to most economic men. However, literature on how ambiguity can change over time, such as the described 'competency hypothesis' by Heath and Tversky (1991), is much less known despite its potential economic relevance. If we view the shipping cycle through the lens of the competency theory, we get another perspective on the sharp decline in vessel prices following the peak in jun-2005. Once ship owners incurred initial losses in their asset holdings, they felt less competent at analyzing these assets – especially because these losses coincided with a confusing development in the world market because of the global financial crisis. This increased their ambiguity aversion, leading them to sell more assets, which further lowered prices. To put it in laymen terms, when prices suddenly started dropping fast, and the analyst teams working for the shipping companies did not anticipate this, they felt much less competent at their ability to anticipate what was coming next, which increased their ambiguity aversion. Interestingly, this also offers an explanation for the overvaluation in the boom. When the asset class was performing well and generating high returns, analysts may have felt more competent at analyzing the situation which made them ambiguity seeking, leading to more purchases and further price increases. In general, the competence hypothesis can be useful in understanding the high return volatility of the shipping industry.

This perspective of increasingly asymmetrical utility functions as risk preference changes over time (Thaler and Johnson, 1990), too sheds light on the overvaluation in the boom phase of the recent cycle, since year after year of high returns would have lessened ship owners loss aversion. This line of thinking further explains why ship owners downplayed the increasing risk-reward imbalance nearing the peak of the shipping boom. Almost five years of consecutive growth in earnings led them to take gambles that they otherwise would not have. This is potentially amplified by the 'house money' effect, which we described earlier, were investors become less concerned about the future, because any eventual loss will be cushioned somewhat by the prior gains.

Finally, Kahneman and Tversky's (1974) representativeness heuristic, as presented in section 3.2.2, shows that investors are prone to 'recency bias', which is another term for extrapolative expectations. The theory is widely recognized, and has been proven through numerous case studies, where subjects over-extrapolate recent values of an exogenous cash flow process, which leads to mispricing of the claims on those cash flows. Interestingly, since vessels are usually purchased with outside financing, the same argument means the people providing this outside financing were also over-extrapolating. Therefore, the argument would be that overvaluation is made possible because of an oversupply of low interest credit. If future prices are taken as a course extrapolation of past price appreciation, then logic dictates that investors should borrow cheap and increase their leverage to maximize returns.

To sum it up, we propose that prices and investment react more aggressively to demand shocks when competition neglect is severe, or when firms over extrapolate the persistence of that demand shock. These dynamics are reminiscent of those in the cobweb theory described in *Figure 37*. When demand is high, lease rates and prices will be high, which attracts investors, i.e. ship owners will want to invest. However, when those firms neglect the competition, they each underestimate the response of their competitors, which leads them to overinvest. The same firms are then surprised by the level of industry investment, which pushes down lease rate below expectations, which in turn results in low future returns. Assuming an absence of competition neglect, firms accurately forecast endogenous supply response, but still over extrapolate demand, which then leads to low future returns because demand shocks revert more quickly than anticipated. The intuition that competition neglect becomes stronger when demand is more inelastic follows from the logic of the cobweb theorem, which states that "investments overreact more when supply is more elastic; and a given amount of 'overinvestment' has a larger effect on future earnings, and subsequently returns, when demand is more inelastic".

Assume that $\lambda \in [0,1]$ measures competition awareness and $1 - \lambda$ thus measures competition neglect. If λ = 1, shipping firms have rational expectations as to how their competitors will respond to common market shocks. Conversely, if λ < 1 then firms underestimate the magnitude of the response. Also, imagine that ϕ_0 measures the true persistence of demand shocks, and ϕ_i measure persistence perceived by individual firms. This means that if $\phi_0 < \phi_i$ then firms over-extrapolate demand, and $\phi_i - \phi_0$ measures by how much. In relation to this, the cobweb describes the limiting case where firms completely neglect the competition (λ = 0) and over extrapolate demand radically (ϕ_i=1). In this case, ship prices are simply the perpetuity value of current earnings.
We hypothesize that ship owners neglect the competition (λ < 1) and over-extrapolate demand ($\phi_0 < \phi_i$).

5 Valuation

This paper is based on two different models of how to evaluate the price of an asset, a second hand vessel. The *mark-to-market* or just *market approach* takes its stand in the market and uses the market to evaluate ex-ante what the price should be today. Baseline is then, that the comparable assets, which make the impetus for the analysis of the asset should be priced correctly. However, the question of whether the market price of an already completed transaction and fundamental or intrinsic values are the same follows a long-lasting financial debate (Albertijn et al, 2015). This is further amplified in crises or just in general industries with high volatility, since different expectations may occur. Still the market approach assume that asset pricing is correct on average, meaning that mistakes can be made for a single asset, but that the comparable assets are on average priced correctly.

Further, it is an assumption that the law of one price holds, meaning that similar assets are sold at the same price. Were this not the case, the market approach, as described here, would fall short, since it is the very foundation of the model.

The fundamental value of an asset, in this paper second hand vessel, is based on the expected future financial benefits of investing in the asset. The future financial benefits, is typically equivalent with the generated net cash flow from the investment, where risk is taken into account. The most applied method for this is the *discounted cash flow approach*. The DCF-approach, unlike the market approach, accounts for the possibility, that the whole industry mistakes the expectations of the proper price. This is reflected in the method, since it uses the expected possible ex-post outcomes to evaluate the expected asset price. The future perspective, instead of retrospective analysis should eliminate the possibility exposure of an already mistaken sector, but of course this still require that all other parameters are estimated correctly for the model to be complete

Both models require efficient markets, with many willing buyers and sellers and cash available for the transaction, to be complete. This means further that the price of the asset is what a knowledgeable and independent buyer is willing to pay to acquire the asset from an equally well informed seller. Market imperfections would affect the models. If for instance there is a tendency to overinvestment problems in the sector due to distress costs in a market downturn, then the mark-to-market approach would tend to underestimate the asset value. Or maybe the DCF-approach would overestimate the asset price if the market is not liquid.

Since 2009 the standard DCF approach, has been developed into the Long Term Asset Value (LTAV) method by Hamburg Ship Evaluation Standard, which basically uses the conceptual form of the DCF approach, but with standard assumption for the input. By conceptualizing the input, e.g. the discount factor, the LTAV ensures a stronger base for the ability to compare different evaluations. This is done through the Hamburg Ship Evaluation Standard (HSES) which defines certain methods for the calculations with LTAV.

The two approaches, the mark-to-market and the LTAV approach, may come to different results for the same vessel. Differences may occur from the different views on market efficiency (Albertijn et al, 2015). As already stated the LTAV method accounts for general market mistakes, but is very dependent on the methodology concerning its parameters. Mark-to-market is dependent on a market which is priced correctly on average

5.1 Methodology

The framework for this paper is to analyse the historical second hand container vessel prices for the purpose of evaluating if market prices is affected by only the fundamental value of the second hand vessel, or if other factors affects the market prices of the vessels. The analysis is made by applying the mark-to-market and LTAV model, from the best possible accessible data, and then ex-ante compare the predicted price from the models with the actual traded prices on the market.

The reason for using two models is that the shortcomings of one model should be compensated by the other model. Should the market miss something in the market approach, then the fundamental value calculated for LTAV should still be correct and vice versa. Imprecise input to the LTAV should not affect the market approach, which should still be able to predict the market prices within a reasonable range. The analysis will therefore be based on the overlay from the models, where both models are taken into account.

Deviations occur when the historical market prices differ from the vessel prices predicted by the models. It is not unexpected that a *residual* from a single predicted price and actual price is different from zero. Otherwise the models would be complete and be able to foresee vessel prices perfectly. For a period with more observations, the expected mean residual should not vary significantly from zero, otherwise a systematic variation for a longer period could mean that other factors than those accounted for in the two models are influencing the second hand vessel prices.

The *residual analysis* is made from the same reference vessel for both the market approach and the LTAV method. The values calculated as the residuals between the models' predicted prices and the actual prices from the reference second hand container vessel can be explained by either the models' incapability to comprehend the market conditions (and further the vessels fundamental value) or fluctuations in the actual prices, emerged from e.g. irrational market behaviourism.

5.2 Discounted cash flow approach

5.2.1 Long Term Asset Value

The Discounted Cash Flow (DCF) approach is also known as Long Term Asset Valuation (LTAV) in the shipping industry. It is basically the widely used method in corporate finance for valuation of everything from investment projects, companies or assets, by discounting expected future Free Cash Flows (FCF) to account for time value of money. The DCF approach computes the Net Present Value (NPV) of a vessel on the basis of the sum of all expected future FCF, both incoming and outgoing (i.e. what is left for debt and equity holders), and the residual salvage value (scrap value).

In other words, the method is independent of market disturbances and perceptions of worth, and better recognizes the vessels long-term, sustainable earnings potential. Especially in 'disturbed' markets, it is a prudent regulative for when functioning markets overvalues or undervalues the price of vessels, and a further indicator for the value retention.

The Hamburg Shipbrokers' Association (Vereinigung Hamburger Schiffsmakler und Schiffsagenten e.V., VHSS) established the Hamburg Ship Evaluation Standard (HSES), also known as the LTAV, in an effort to provide a uniform set of criteria for the discounted cash flow approach, and had Pricewaterhouse Coopers

(PwC) approve the method so it could be used for banking purposes. The HSES uses a discount rate determined independently by PwC, to allow for comparability of different valuations, and defines a disturbed market as follows: A disturbed market exists when at least two of the following five scenarios apply:

- An unusually low number of vessels for sale in comparison to the overall fleet within one category of vessel, over a period of three months or more, indicating a severe imbalance between willing sellers and willing buyers.
- Transactions in which either buyer or seller are knowingly under constraint or in urgent need to conclude a deal due to personal or corporate distress, since prices do not reflect vessels characteristics.
- A 30% difference between current transaction prices and the Long Term Asset Value lasting for at least three consecutive months.
- An unusually low number of market participants, based on total number of parties trailing a three-month period, signalling an illiquid market.
- Absence of essential, regular market conditions (e.g. unavailable debt financing for a large number of market participants).

In particular, the LTAV is computed as follows:

$$LTAV = \sum_{t=1}^{T} \frac{(C_t - OPEX_t)}{(1 + WACC)^t} + \frac{RV_T}{(1 + WACC)^T} \tag{21}$$

where the future FCF in a future period t is obtained by subtracting the expected operating expense (OPEX) from the charter revenue (C). In addition, there is a residual value (RV) or salvage value, and (T), which is the remaining period until the end of the expected economic useful life of the vessel, which is normally 20-25 years (Stopford, 2009).

HSES uses the following input in the model: The charter revenue, or Time Charter (TC) rate, is derived using current indices for t=1 and based on the 10 year (or shorter) average TC rate for the given vessel type for t=2 until t=T. Annual earnings are calculated on 360 running days, except for every five years when only 345 days are counted because of class renewal, which is required inspection of the vessels hull, machinery, electrical plant and any special equipment classed. The operating expense is calculated as the 10 year (or shorter) average OPEX.

The residual value can be determined by the scrap value at the end of the expected economic useful life of the vessel. It is also important to subtract cost of disposal (e.g. commissions and cost of voyage). Scrap value can be determined by multiplying light displacement tonnage with the expected scrap price at the end of the vessels economic useful life, meaning it should reflect price increases resulting from inflation. Light displacement tonnage is the weight of the ship (equal to the water it displaces) excluding content (cargo, fuel, water, ballast, stores and crew).

HSES uses two different methods for calculating the scrap value. Method A is used for vessels up to 15 years of age and method B is used for vessels older than 15 years.

A. Using an investment horizon until the vessel has reached 20 years of age, the residual value is determined by the scrap value (light displacement*10-year average scrap value) multiplied by a pre-determined coefficient, which is 3,7 for container ships.
B. Using an investment horizon until the vessel has reached 25 years of age, the residual value is determined by the 10-year average scrap value.
   For the vessels 21st -25th year, the average TC rate is reduced for container vessels by 15%.

The DCF approach is the most academically rigorous method available, and is widely accepted for determining the value of assets, vessels included. However, determining appropriate inputs for the model can heavily impact the resulting value of the vessel. The most crucial input is perhaps the charter revenue, which in the LTAV is based primarily on a 10-year average TC rate. The main quarrel with the LTAV is that relying on 10-year averages for the projection of freight revenues is dependent on the assumption that history repeats itself. It is a bit like driving a car while only looking at the rear-view mirror. Projections could more accurately be based on assumptions of: future market conditions of tonnage supply, tonnage demand (trade, trade patterns and world economic conditions), as well as chartering strategy (sequence of short-term charters vs. long-term charters) and of course also adjusted for inflation (Shinas et al., 2015).

5.2.2 Weighted Average Cost of Capital

The discounting method used is exponential discounting, which values future cash flows as: "how much money would have to be invested currently, at a given rate of return, to yield the cash flow in future”, and the discount rate is the appropriate Weighted Average Cost of Capital (WACC). WACC represents the minimum return a company must earn on an existing asset base to satisfy its capital providers (owners and creditors). In short, it is the rate that the company is expected to pay on average to finance its assets. The cost of capital is computed as follows:

$$WACC = \frac{E}{D+E} * r_E + \frac{D}{D+E} * r_D(1 - t_c) \tag{22}$$

Where r_D is the cost of debt, r_E is the cost of equity and t_c is the corporate tax rate, which makes $(1-t_c)$ the tax shield, i.e. the benefit from deducting interest expenses from taxable income. This makes the second part of the equation the after-tax cost of debt. Precisely because interest is a tax-deductible expense, increased leverage will result in a lower cost of capital, despite an increase to the cost of equity due to an increasing residual risk to equity holders.

However, most of the worlds key shipping industries operates with tax regimes were the tax payable is based on the tonnage of a vessel. With a few differences (Dutch model vs. Greek model), tonnage tax regimes base the taxable operating profit of a vessel on the net tonnage and not on the actual operating results. The profit is calculated from the registered tonnage, multiplied by a fixed amount of deemed profit per tonne per sailing day. Countries that have tonnage taxation include: Belgium, Bulgaria, Curaçao & St. Martin, Cyprus, Denmark, Finland, France, Germany, Greece, India, Ireland, Italy, Japan, Malta, the Netherlands, Norway, Poland, South Africa, South Korea, Spain, Taiwan, the UK and the US. For more information, see pwc.com/transport for "Corporate taxation of the shipping industry around the globe".

For the most parts, tonnage taxation applies only to the shipping activities of the shipping company. The non-qualifying shipping income is subject to regular Corporate Income Tax (CIT) rates. Tax regimes are implemented to stimulate investment because the shipping industry is of national importance, as therefore the fixed amount is very favourable.

Table 11: Amount of taxable profit per day per 1.000 net tons (Dutch regime)

EUR 8,00	up to 1.000 net tons
EUR 6,00	for the excess up to 10.000
EUR 4,00	for the excess up to 25.000
EUR 2,00	for the excess over 25.000

Source: PwC Analysis, pwc.com/industrysectors

For instance, for a 5-year-old cargo ship, with a net tonnage of 18.000 that is operational all year, the taxable profit is 1 x EUR 8 + 9 x EUR 6 + 8 x EUR 4 = EUR 94 per day x 365 = EUR 34.310 per year. Based on a CIT rate of 25%, this amounts to just EUR 8.578. Sometime the computation is as simple as that, and sometimes less so. Many countries offer corporate tax incentives other than, or in addition to, tonnage tax. The result is that under certain circumstances a very low effective tax rate of less than 1% can be achieved. For that reason, because the effective tax rate is so low and because taxation is independent of the earned profits, it is reasonable not to take any tax benefit of debt into account. With $t_c = 0$, the WACC becomes as follows:

$$WACC = \frac{E}{D+E} * r_E + \frac{D}{D+E} * r_D \tag{23}$$

It is important to note that the formula still accounts for the effects of varying degrees of financial leverage, because the cost of equity and debt are weighted by the relative proportions. In the wake of the trade crisis turbulence of 2009 saw containership values plunge by as much 70% in less than six months, bankers have become much stricter regarding margin requirements, and vessels are now typically financed with 50-70% debt as opposed to the very high leverage before the crisis (Clarksons Shiping Intelligence Network). For the present valuation model, the cost of capital is weighed with 70% debt and 30% equity. According to Drobetz et al. (2013), it is a rational assumption that, with many vessels on the balance sheet, a vessel's risks are equal to those of the company's other assets (i.e. business risk), and that the vessels support the same degree of financial leverage as the overall company, for the total life of the vessel. The Modigliani-Miller theorem, or capital-irrelevance principle, states that in a world without taxes, assuming an efficient market without bankruptcy cost, agency cost or asymmetric information, the value of a firm is unaffected by how the firm is financed. According to Modigliani and Miller's second proposition, increased financial leverage leads to a higher required return on equity, because equity holders must be compensated for the increased residual risk, and in a world without taxes this offsets any effects of changes in the weights (Modigliani and Miller, 1958).

$$r_E(levered) = r_E(unlevered) + \frac{D}{E}(r_E(unlevered) - r_D) \tag{24}$$

Following this argument, and not taking into account other market imperfections, the no-tax WACC depends only on business risk. So even though the leverage of a vessel decreases over time, as the loan is paid back, the WACC remains constant. The result is that the value of a vessel is independent of its capital structure. Suppose a shipping company is considering a purchase of either vessel U or vessel L. Instead of purchasing the levered vessel L, the company could purchase the unlevered vessel U lever it to the same extend as vessel L (take out a loan). The resulting ROI would be the same, which means the price of vessel L must be the same as the price of vessel U minus the money borrowed, which is the value of vessel L's debt.

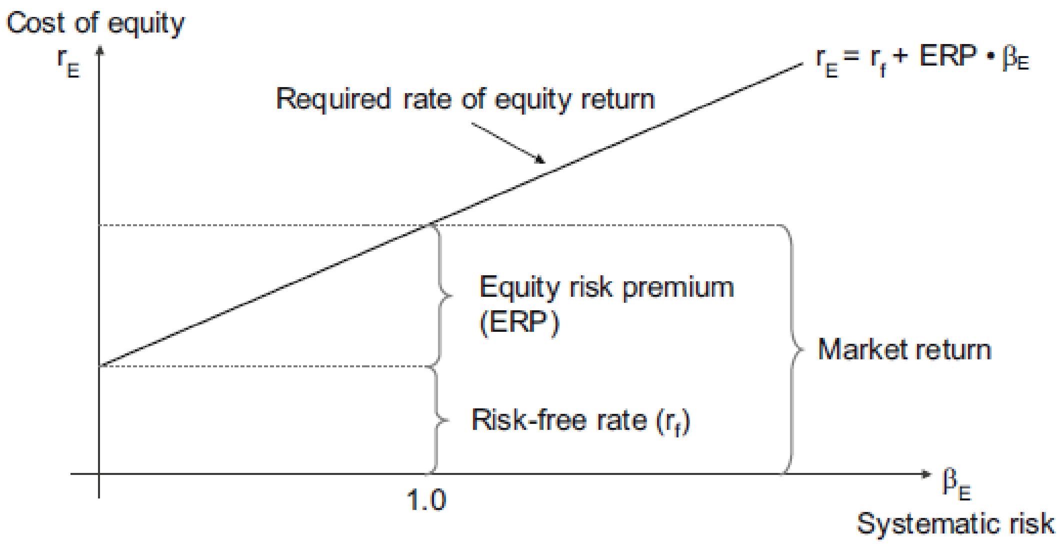
5.2.2.1 Return on debt

The return on debt, which is the interest rate on the loan used to finance the vessel, is variable, and based on one of the interbank offered rates (usually LIBOR) plus a credit spread (risk-premium). The credit spread depends on many factors, such as the six C's assessment method: Character, Capacity, Capital, Conditions, Collateral and Company (Grammenos, 2010). The spread used in LTAV by HSES is a statistical average of 1,374%. The spread, which represents a significant part of the bank's gross income from the loan, is fixed in advance, but the LIBOR is renewed periodically (usually every three to six months). This structure allows the bank to pass on the interest rate risk to the ship owner, whose cost of servicing the loan fluctuates with the LIBOR

5.2.2.2 Return on equity

The return on equity is based on the widely accepted theory based Capital Asset Pricing Model (CAPM). Based on this model, there is a linear relationship between the equity return required by the owners and the corresponding non-diversifiable (i.e. systematic) risk expressed by beta (β_E) (see *Figure 17*).

Figure 17: Linear relationship between risk and return in the Capital Asset Pricing Model



Source: Sharpe, 1964

The components of the cost of equity are: The risk-free interest rate (r_f) and a risk-premium because equity holders must be compensated for the increased residual risk caused by the fact that debt holders have first claim to any assets. The risk-premium comes from multiplying a general market –or equity risk premium (ERP) with the equity beta, which is the correlation with the market:

$$r_E = r_f + ERP * \beta_E \tag{25}$$

The risk-free rate is the rate of return on an investment that can be earned without any risk in the capital market. For vessel valuation purposes, the time horizon is usually long, so in absence of a duration matched rate, a long-term rate is preferred. Completely risk-free investments do not exit, so we use government bonds with the highest possible credit rating as an approximation ("Aaa" from Moody's and "AAA" from Standard

& Poor's and Fitch). For developed industrial nations, this is assumed to be a (quasi) risk-free investment alternative although a negligible small default risk remains.

The ERP is the difference between the expected return on an investment in the market portfolio and the risk-free rate. There are three different approaches to estimating ERPs: 1) the survey approach, where the answer depends on who and what you ask, 2) the historical premium approach (average historical excess returns on investments in stocks compared to government bonds), where results differ depending on how you slice the data and 3) the implied premium, where the result is a function of the model you use and the assumptions you make about the future.

In every approach lie different assumptions about market efficiency. If we believe markets to be efficient in the aggregate, or at least if we cannot forecast overall market movements, then the current implied ERP is the most logical choice. If on the other hand we believe that the market, in the aggregate, can be significantly undervalued or overvalued, then the historical ERP or average implied ERP is a better choice. If we have no faith in markets whatsoever, survey ERPs is the better alternative.

The myriad of different specific ways to calculate the ERPs and their implications is outside the scope of this paper, but for our specific purpose, we can make some important considerations. There is no one approach to estimating equity risk premiums that will work for all analyses, and consensus premiums, estimated by averaging across approaches, does not make sense, since they represent different views of the world. A historical analysis revealed the highest correlation between the current implied ERP and the implied premium the following year, indicating the highest predictive power. For a much more detailed discussion of the subject, we recommend "Equity Risk Premiums (ERP): Determinants, Estimation and Implications – the 2015 Edition" by Aswath Damodaran from Stern School of Business.

Beta measures the systematic risk, which is theoretically the sensitivity of the asset's returns to the market portfolio's returns. To put it more concretely, beta is the covariance of the asset's returns with the market portfolio's returns, divided by the market portfolio's variance of returns:

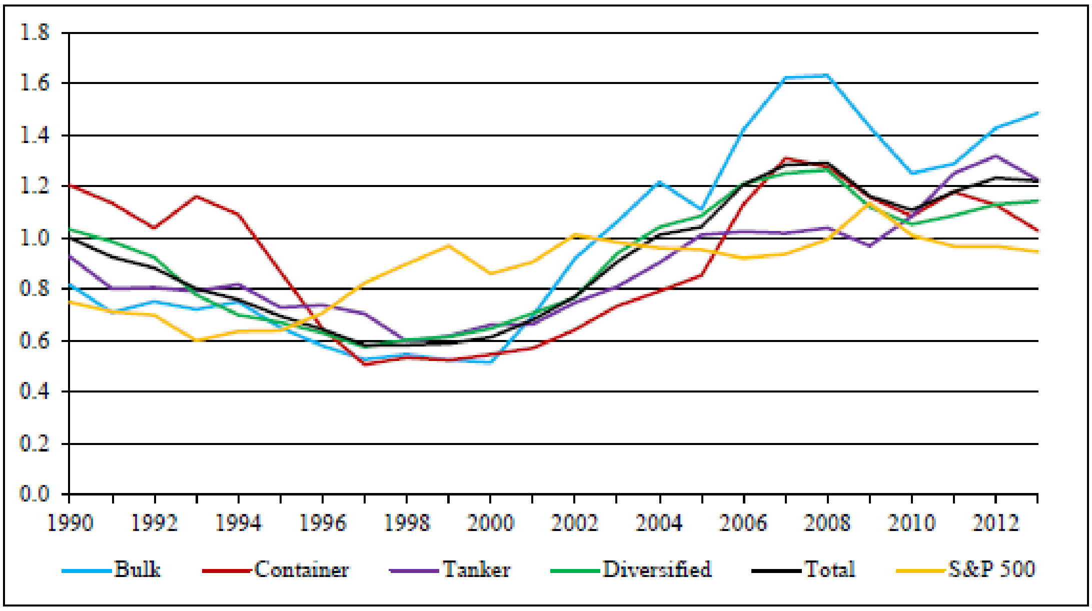
$$\beta_i = \frac{Cov(r_i, r_m)}{Var(r_m)} \tag{26}$$

The Asset Pricing Theory (APT) assumes that all investors are well diversified, so that the only risk investors perceive is the non-diversifiable risk, i.e. market risk. A company's stock market beta can be estimated using Ordinary Least Squares (OLS) regression analysis with the company's stock return as the dependent and the market return as the explanatory variable (expressed by one of the big indices like S&P500). Similarly, the beta for a specific vessel can be estimated based on capital market data for peer group companies listed on the stock exchange, with a comparable market risk to that of the vessel. The estimated beta coefficient indicates the average percentage change in the company's stock price, in response to a 1% change in the market index. This means that the asset has a beta higher than 1, it reacts, on average, disproportionately high to market fluctuation, and conversely, if the asset has a beta lower than one, it react disproportionately low.

The equity beta is usually assumed to depend on three factors: the cyclicality of a company's operations (business risk), its financial leverage and its operating leverage (i.e., the ratio of fixed to total costs). Because shipping is characterized by highly cyclical cash flows, high financial leverage and high operating leverage (Drobetz et al., 2013), we expect the shipping industry to have a high financial leverage. We intuitively expect that firms in the shipping industry exhibit above average systemic risk characteristics.

Contrasting this common held conjecture is a series of studies conducted by Kavussanos and Marcoulis (Drobetz et al., 2015), exploring the level of systematic risk in the shipping industry. Using OLS frameworks as described above, these studies document betas close to one for their samples of shipping companies, which is at odds with our economic expectations. An empirical analyses of 150 globally-listed shipping companies from 1991 to 2015 found that systematic risk levels of shipping companies fluctuated considerably over the investigated sample period. The industry annual beta averages varied between 0,583 and 1,292.

Figure 18: Average annual beta estimates by segment over time



Source: Drobetz et al., 2014

In the case where beta fluctuates over time like this, OLS estimates will only provide an average indication of risk levels in the industry. In fact, the study documents that average betas over the entire sample period have magnitudes around unity, supportive of prior evidence that earlier moderate time-invariant betas estimations are the result of time-varying risk levels (Ibid.).

Because the DCF approach is oriented towards an estimation of the vessels long-term earning potential, capital budgeting relying on OLS-based cost of equity estimates may lead to suboptimal outcomes.

5.2.3 Historical analysis

5.2.3.1 Input variables

The purpose of the historical analysis is to compute the estimated value of the same reference vessel, aged 5, 10 and 15 years respectively, using the DCF approach, from 1996-2015. Subtracting this from the actual values of a similar reference vessel, leave us with a residual value, which if above zero indicates a tendency towards overvaluation and vice versa – according to the model. Because we want to test for irrationality, for each year from 1996-2015, we will sit in the chair of a ship owner (or prospected buyer) and calculate the value with the information available. For most variables, this means trailing 10-year arithmetic averages.

Figure 19: Specification for our chosen 1-2000 teu container reference vessel.

Specification	
Dwt/Ldt	12,171/3,895
LOA/MB/MD/Draft	149/22.7/11.3/7.8
BHP/Speed/Consumption	20535/22/63.5
Built	1999
TEU/Gear	1216/2*35
Survey (Special)	2014

Source: Drewry Research "Ship Operating Costs Annual Review and Forecast 2012/13" (2012). Reports. Book 5.

In the following, we will account for each variable and corresponding references and assumptions. We will then discuss our findings and conclude with a discussion of the biases, limitations and shortcomings of the model.

$$NPV = \sum_{t=1}^{T} \frac{(C_t - OPEX_t)}{(1+WACC)^t} + \frac{RV_T}{(1+WACC)^T} \tag{27}$$

- t = Years (t_1 current year)
- T = Remaining years until age 20 years which is the assumed full economic life of a 1-2000 teu container vessel (HSES).

$$C_t = TC_t * (1+i_t)^t * ED * u * (1-f) \tag{28}$$

- TC_t = 6-12 month Time Charter rate ($/day for 1.000 teu geared container reference vessel, which is the closest we can get to our reference vessel with the available data)
  (building up to a trailing 10-yr average from 2000 and forward [data going back to 1990 from Clarkson Research].
- i_t = US inflation rate.
  To simplify the calculations, an annual inflation rate of 2% is used throughout the analysis. This roughly corresponds to a 10-yr trailing average from 1996 and forward [data going back to 1986 from Bureau of Labour Statistics].

- ED = Earning Days when not undergoing maintenance, inspection and surveys, i.e. available for chartering.
  Assumed to be a constant 358 days/year except for 343 days/year every five years due to the Special Survey. “Certificate of Class for Hull and Machinery” is the basis for underwriters to insure the ship. For the Certificate of Class to be valid, it requires Intermediate Surveys (IS) as well as a Special Survey (SS) every five years, the latter which is a far more thorough inspection of the ship that requires dry-docking (BIMCO).
- u = Utilization rate (booked days as a percent of Earning Days).
  Assumed to be a constant 95% (HSES).
- f = Sum of commission and management Fee when chartering out.
  Assumed to be a constant commission 2,5% and management fee 4% (HSES).

$$OPEX_t = OpCost_t * (1 + i_t)^t * RD - S * (1 + i_t)^t \tag{29}$$

- $OpCost_t$ = Operational Cost for excluding dry-docking ($/day for 1-2000 teu container reference vessel [teu/dwt/ldt = 1.216/12.171/3.896 same as our reference vessel]) adjusted for age according to the below *Table 12*.
  10-yr trailing average from 2000 and forward [data going back to 1990 from Drewry Research].

Table 12: Operational Cost adjusted for age

Actual monthly cost			Age adjustment		Weight adjustment	
		Weight	<=5-yr	>=15-yr	Weight (<=5-yr)	Weight (>=15-yr)
Manning	63418	45%	0%	0%	0,00%	0,00%
Insurance	13373	9%	10%	-5%	0,95%	-0,47%
Stores	8619	6%	-10%	10%	-0,61%	0,61%
Spares	10710	8%	-10%	10%	-0,76%	0,76%
Lubrecating oils	19207	14%	-5%	5%	-0,68%	0,68%
Repair and maintenance	12300	9%	-10%	5%	-0,87%	0,44%
Management and Adm	13504	10%	0%	0%	0,00%	0,00%
Total	**141131**	**100%**			**-1,97%**	**2,01%**

Source: Drewry Research "Ship Operating Costs Annual Review and Forecast 2012/13" (2012). Reports. Book 5.

- RD = Running Days are assumed to be a constant 365 days/year.
- S = Surveys.
  In 2012 the IS was USD 377.000 and the SS USD 602.000 (Drewry Research). To obtain survey

costs for the preceding years we assumed similar values and adjusted yearly using the US Consumer Price Index. Conventional practice for most commercial vessels is to work around an interval of approximately 30 months. This corresponds with the five-yearly special survey together with an interim periodic survey. Treating these outgoings solely on a cash flow basis would distort annual budgets and hinder commercial management needs to assess a representative daily operating expense. Normal practice is to find a mechanism for spreading these costs over the cycle, retaining these expenses within the operating cost budget (and P&L account) and treating it as an apportionment, which is what we have done here. In practice that means every vessel will incur annual cost equivalent of one fifth of the sum of both surveys taken from the year of the calculations and adjusted for inflation. Using this technique, the annual survey cost was USD 202.130 in 2015 and USD 133.806 in 1996.

$$RV_T = LDT * SP * \partial * (1 + i_t)^T \tag{30}$$

- LDT = Light Displacement Tonnage is 3.896 for our reference vessel.
- DP = Scrap Price for a 1-2000 teu container reference vessel ($/ldt average of prices from Bangladesh, India and the Far East)
  10-yr trailing average from 2003 and forward. In recent years, Clarkson provides an estimate of the scrap value. Scrap price is highly correlated with nominal steel prices, and thus when we are missing data on scrap price we estimate it from a projection of scrap value on steel prices taken as the average composite delivered price per metric ton of No. 1 heavy melting steel scrap, calculated from prices per long ton published monthly by American Metal Market.
- ∂ = A coefficient for specific vessel types (3,7 for container vessels) because the Residual Value of a vessel after its full economic life exceeds the scrap value.
  The coefficient for a container vessel is based on proven statistical data of market transactions for 20-year-old vessels respective scrap prices (HSES).

$$WACC_t = {}^{E}/_{V} * (r_f + ERP * \beta_E) + {}^{D}/_{V} * (LIBOR + SPREAD) + RP \tag{31}$$

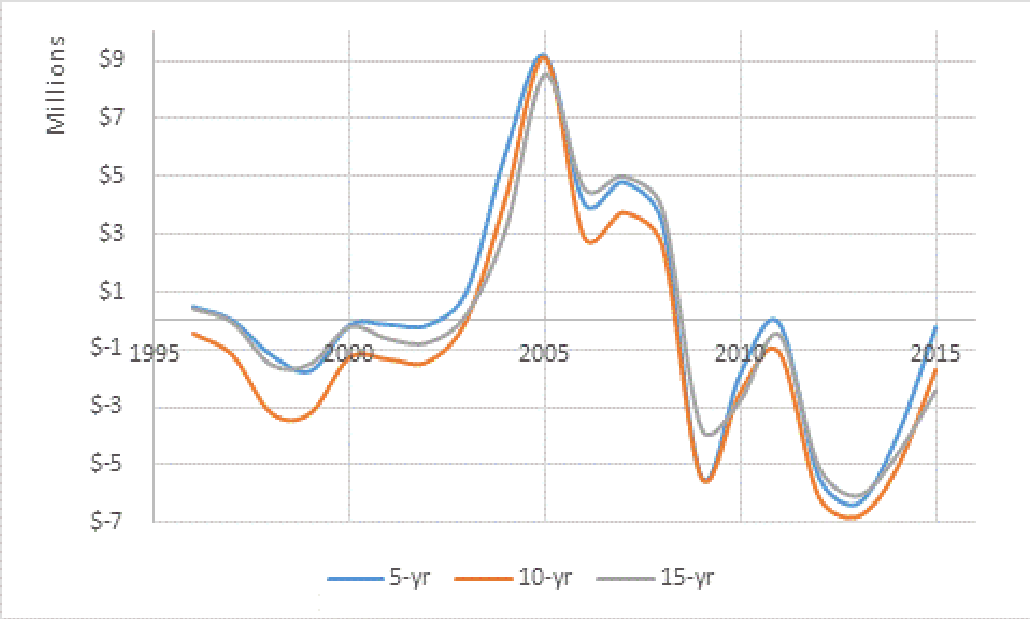
- E/V = Equity ratio is assumed to be a constant 70% (HSES).
- r_f = As a proxy for the risk-free rate the US treasury bond (T-Bond) was used.
  10-yr trailing average from 1996 and forward [data going back to 1986 from Damodaran Research].

- ERP = Implied Equity Risk Premium (see section 5.1.2.2).
  10-yr trailing average from 1996 and forward [data going back to 1986 from Damodaran Research].
- $\beta_E =$ Equity Beta.
  10-yr trailing average from 2000 and forward [data going back to 1991 from Drobetz et al. 2015]. The resulting beta (or asset beta, which is the leverage adjusted equity beta) is only accurate for valuing a vessel with the same business risk characteristics as the company. Vessels with different risk characteristics compared to the average vessel on the balance sheet must be evaluated by using unique betas and hence unique WACCs. Failure to comply with this can lead to severe WACC-fallacy, i.e. hurdle rates that are too high or too low for a given vessel. This is outside the scope of our general WACC computation, but we refer to Krüger et al. (2015) for an in depth analysis of this issue.
- LIBOR = London InterBank Offered Rate.
  10-yr trailing average from 1998 and forward [data going back to 1989 from Clarkson Research].
- SPREAD = The credit spread is measured as a statistical average and taken as a constant of 1,374% (HSES).
- RP = To reflect an overall conservative approach consistent with the LTAV method, a 1% Risk Premium is added.

5.2.3.2 Residual values

The actual Second Hand (SH) prices used for comparison concerns a 1.000 / 1.100 teu container reference vessel and data ranges from 1996-2015 (Clarkson Research). Putting it all together, we get the following mapping of the residual values.

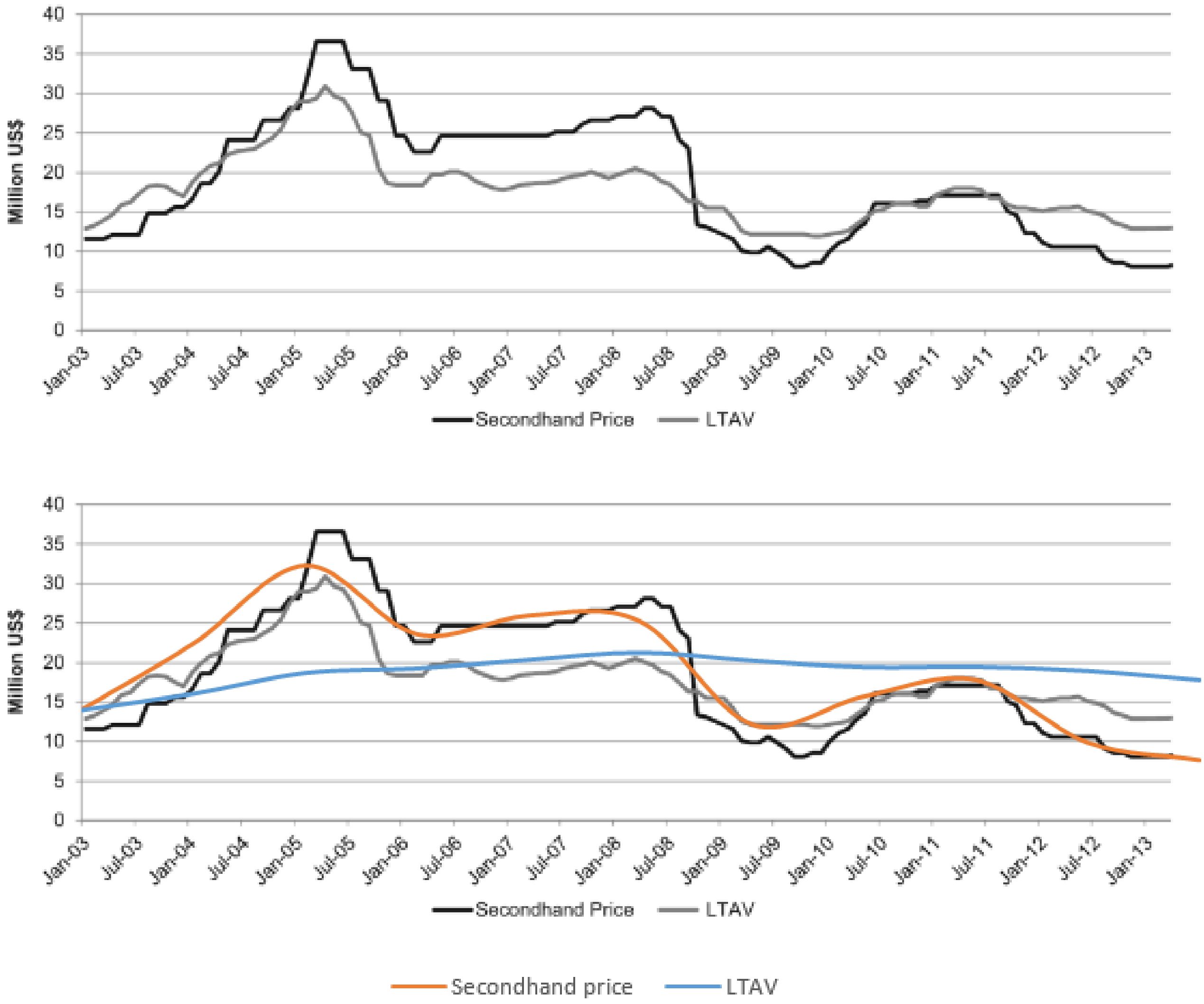
Figure 20: Residual values when comparing the estimated values to actual values from 1996-2015



Source: Residual values calculated by subtracting estimated SH prices from actual SH prices, authors calculations

We do not expect the Residual Value to be zero, because that would mean that the model have exactly calculated the SH prices the last 20 years, including any institutional or behavioural biases. We do, however, expect to see a peak from 2003-2008, signifying an overvaluation of assets during the shipping boom. It is also not surprising that assets become undervalued in the subsequent bust phase for then to gravitate towards the mean (se section 4.1.2). What is a little surprising is that the model suggests that asset prices, at least for handy size container vessels depicted here, have already 'rebounded' and is close to the mean. The results differ slightly compared to *Figure 21* below, which compares actual SH prices and theoretical LTAVs for a 10-year old 1.700 teu geared container vessel and is calculated by PwC on the request of HSES. It is however important to notice that the alternation of over versus under valuation of vessels follow more or less the same timeline in the two graphs, i.e. undervalued until 2003, overvalued between 2005 and 2008 before vessels become undervalued again – even the short-lived spike in 2011 recurs.

Figure 21: Historical comparison of second-hand prices and theoretical LTAVs for a 10-year old 1.700 TEU geared container vessel



Note: The overlay is the authors own calculations based on data from Clarksons Research

Source: Clarksons Shipping Intelligence Network, PwC Analysis, authors calculations

It is important to note that our model computed vessel values for a smaller 1000 / 1100 teu reference vessel, although we claim it to be representative of the 1-2000 teu handy size segment. The reader will notice that the traded prices match up pretty well, but that our DCF (LTAV) calculation is much smoother and less volatile. PwC does not stipulate their methods of calculation, which is monthly (we have chosen to depict ours yearly here), and The Hamburg Ship Evaluation Standard do not disclose specific detail of the LTAV calculation to non-members (paying membership), but published information list the following discount rates (see *Table 13* for discount rates dated July 1st 2009).

For comparison, the discount rate used in our computation in 2009 was 6,61% for both 5, 10 and 15 year old container vessels. The average of those three numbers in the below table is 7,04%.

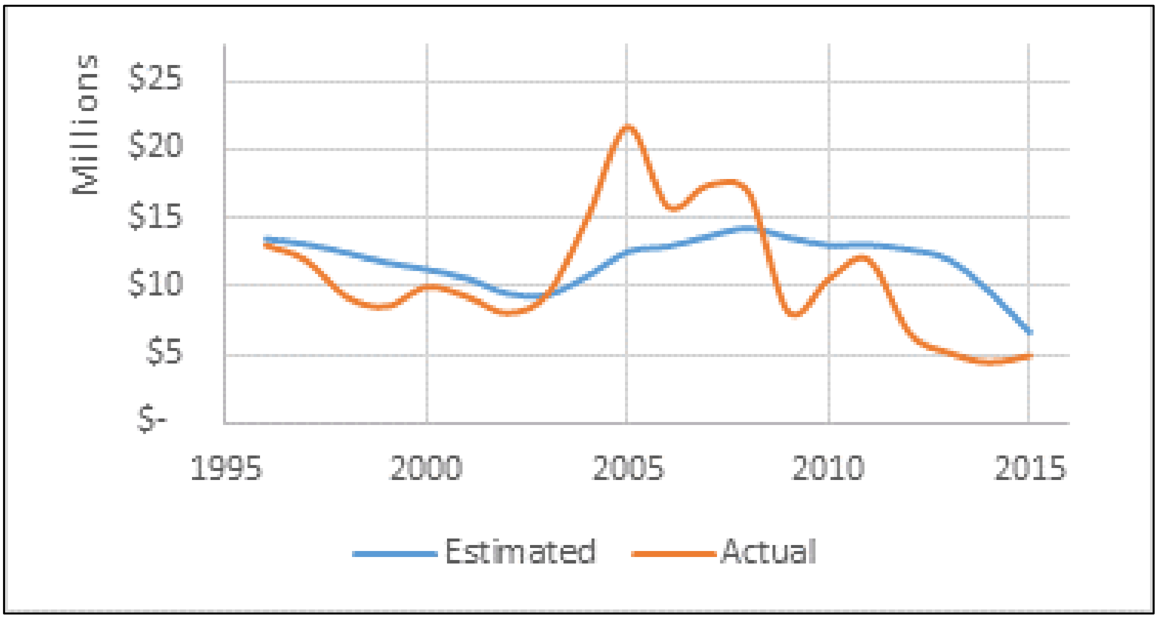
Table 13: VHSS Discount Rate for different vessel age and type

Year \ Ship Type	5	10	15	20
Bulker	6.7824	7.6846	8.1544	8.4054
Container	6.2824	7.1846	7.6544	7.9054
Tanker	6.2824	7.1846	7.6544	7.9054

Source: Vereinigung Hamburger Schiffsmakler und Schiffsagenten e.V. (VHSS)

To further investigate the origin of the residual value when comparing the SH prices estimated by the model to the actual traded price, we go up one level and turn our attention to the estimated prices compared to actual prices in absolute terms in *Figure 22*. In order to compare all three of them side by side, the graphs are somewhat shrunk. Nevertheless, it is obvious that in all three cases, the estimated DCF values resemble a smooth representation of the actual traded values. On the face of it, it does seem like a prudent tool for baseline valuation, compared to desktop analysis of trying to predict the swells and troughs that are evident, especially in the period 2003-2015. For this period in time at least, the DCF approach seems to approximate a rough mean value.

Figure 22: DCF estimated prices compared to actual prices for 10-yr old vessels in absolute terms



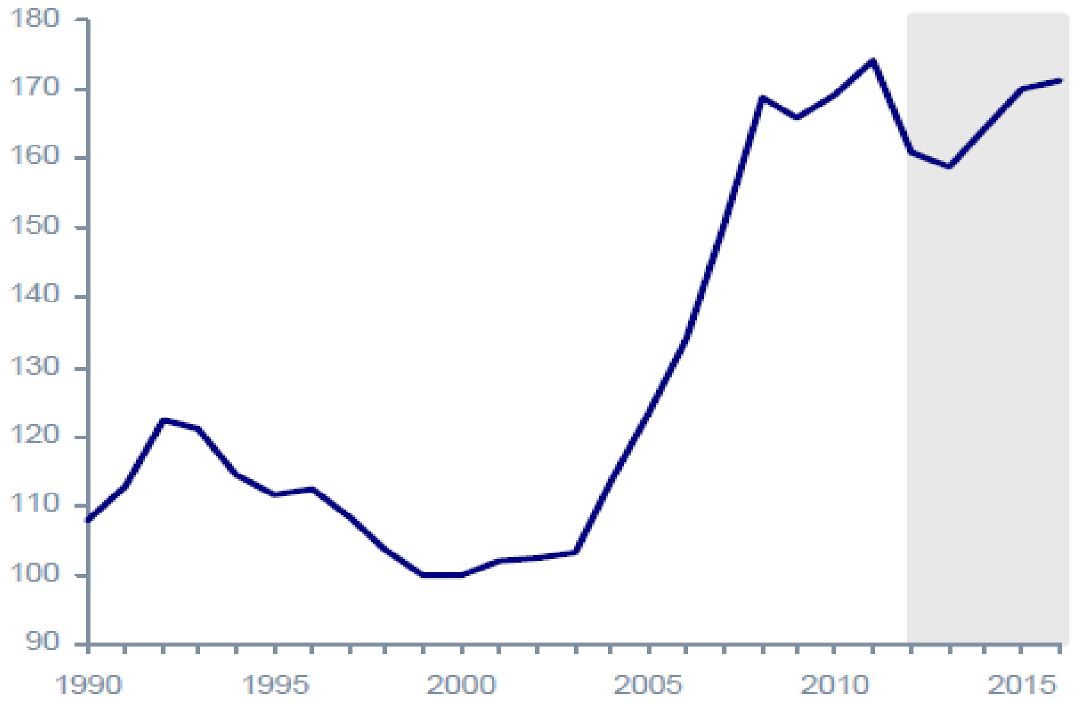
Source: Clarksons Research, authors calculation

Besides the scrap prices and charter revenue, the OPEX is the most important variable in determining the value of a vessel, because it is instrumental in determining the EBIAT. The methodology behind the OPEX data gathered by Drewry Research and used throughout this section is primarily direct contact and feedback from ship owners and managers (surveys), data extracted from financial statements of stock listed shipping companies and input from industry specialists, experts in each of the main expense heads.

The data is based on the following assumptions:

- Manning costs are based on representative, international crew of ITF - approved status.
- Insurance is based on Hull & Machinery (H&M) and Protection & Indemnity (P&I) cover only. Key assumptions include a reputable manager and fleet, fully in class and classed by an International Association of Classification Societies (IACS) member.
- Repair/maintenance assumes a ship of 5-9 years old, but all other costs are based on a 10 year old vessel.
- Dry docking expenses have been amortised over the appropriate period.

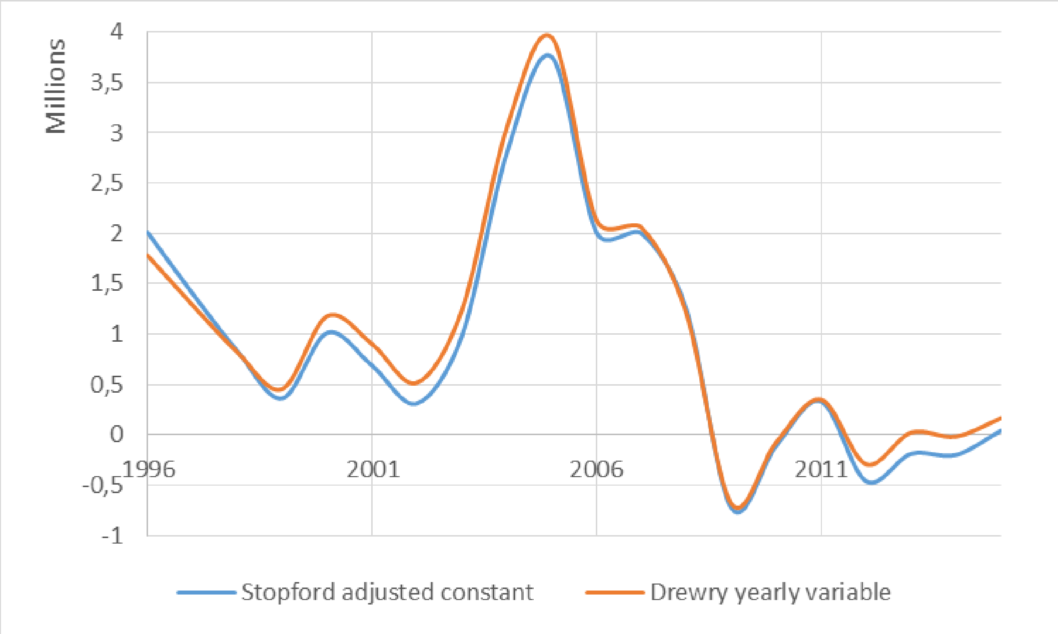
Figure 23: Evolution of total operating costs (2000=100)



Source: Drewry Maritime Research

From Drewry's "Ship Operating Costs Annual Review and Forecast 2012/13" we have the exact cost for a reference vessel 2015 (see *Figure 19* for detailed specifications) representative of the handy size (1-2000 teu segment) from 2002-2012 and a forecast from 2013-2015. For the period 1996-2011 we have relied on the evolution of general operating costs shown in *Figure 23*, which represent the entire maritime commerce fleet but is assumed to be highly correlated with the handy size container segment. We feel this approach ensures the highest validity and stays true to the available data. However, another approach of simply taking OpCost for this segments as a daily cost estimated to be USD 5.000 per day in 2009 dollars (based on table 8.4 in Stopford 2009) is adopted by other researchers (Alizadeh and Nomikos, 2006; Stopford, 2009) and used in case studies of the shipping industry (Stafford et al., 2002; Esty and Sheen, 2011). When the 'Stopford constant, is adjusted using the US CPI with 2009=100, we get the below comparison between the annual EBIAT, based on the OPEX derived from Drewry's Maritime Research as described earlier, and the annual EBIAT based on the Stopford adjusted constant OPEX.

Figure 24: Annual EBIAT (FCFE) from owning a handysize container vessel



Note: The EBIAT depicted here is calculated based on a 10-yr old vessel. However, the relative difference between the cash flows for five and 15 year old vessels are remarkably similar.

Source: Clarksons Research, authors calculations

Despite the striking correlation (99,38%), the values are in fact different with as much as USD 256.418 annually, which is a big chunk of change when viewed relative to the cash flow itself (20,68% short), and probably also to the ship owner because it is essentially money out of her pocket. We feel confident that our data are more valid, but take some comfort in knowing they are highly correlated with a 'second best' approach supported by literature.

5.2.4 Example computation

For any real present day vessel purchase, obviously the variables in the model would be different. The operational expense concerning the specific vessel would be made known to the buyer, and said buyer would have a more accurate estimation of their cost of capital. For instance, Maersk have access to cheaper capital (lower credit spread) than most shipping companies, partly due to its size, but also because the shipping division of Maersk is not separated from the entire company, which means a lenders diversify their risk. Regarding the FCF; the vessel quite possibly already has an existing charter fixed to a charterer with a reliable credit rating (in which case the existing charter should be considered until its completion). For any short time horizon preceding an existing charter or in its place, shippers can use detailed analysis of the current and expected market situations, especially taking fleet development (market supply) and economic outlook (market demand) into account, to forecast time charter rates. Forward freight agreements can also provide further indications for the future development of the charter rates in the near future. Finally, projections of future charter rates for the detailed planning period can be retrieved from research companies, e.g. Maritime Strategies International (MSI), Clarksons Research, Drewry Shipping Consultants, and Marsoft. As can be seen in the below table, in the current market, this I at best a ‘guesstimate’ (actual TC rates retrieved from Clarksons Research, for the same reference vessel, are USD/day 7.313, 8.842 and 7.000 for 2014, 2015 and 2016 (jan) respectively).

Table 14: Charter rate forecast for a 1,700 TEU (geared) container vessel as of 30 June 2013

Charter Rates (US$/day)	Actual 2013	Forecast 2014	2015	2016	2017
Market-Implied Forecast (Clarkson)*	7,250	7,800	9,000	10,300	n/a
Research Forecast (MSI)	7,250	7,100	9,000	11,200	13,300

*based on charter contracts with different duration (1 year T/C: 7,250 US$/day, 3 year T/C: 8,400 US$/day)

Source: Schinas et al. 2015

Due to increasing operating costs observed in the past and expected in the future, an orientation toward figures in the past when forecasting future operating costs is very questionable, contrary to the long-term forecast of charter revenues, which can reasonably adjust linearly to a 10-year historical average by year four (Schinas et al. 2015).

Instead of using the statistical average of 1,374% provided by HSES, we refer to Reuters Pricing Service (RPS) or similar authoritative estimates; RPS has eight evaluators responsible for pricing approximately 20,000 investment grade corporate bonds, who obtain the spreads from brokers and traders at various firms. Most shipping financiers do not offer loans with a maturity longer than five years anymore because of the current crisis, which is considerably shorter than those that characterized the pre-crisis period (Albertijn et al., 2011). The shipping industry is characterized by relatively low credit ratings, reflecting the high current non-systemic risk. Take for instance CMA CGM, the French container transportation company and third largest shipping company in the world, that is rated by B1 by Moody’s. For our general cost of capital computation, we use the Ba2/BB rated spread for 5 years to maturity, which is estimated at 3,43%.

Table 15: Reuters corporate spreads for asset-heavy companies

Rating	1 yr	2 yr	3 yr	4 yr	5 yr	6 yr	7 yr	8 yr	9 yr	10 yr	12 yr	15 yr	20 yr	25 yr	30 yr
Aaa/AAA	21	26	38	45	53	55	61	65	70	76	84	99	122	127	121
Aa2/AA	30	32	42	53	65	72	83	95	108	121	137	149	153	146	114
A2/A	43	58	71	79	88	92	102	115	131	147	165	175	175	162	141
Baa2/BBB	96	111	132	144	153	160	178	204	230	253	277	280	269	240	200
Ba2/BB	172	272	331	346	343	335	336	341	349	361	-	386	364	304	-
US Treasury Yield	0.23	0.61	0.89	-	1.36	-	1.74	-	-	2.04	-	-	2.48	-	2.87

Note: Spread values represent basis points (bps) over a US Treasury security of the same maturity, or the closest matching maturity.

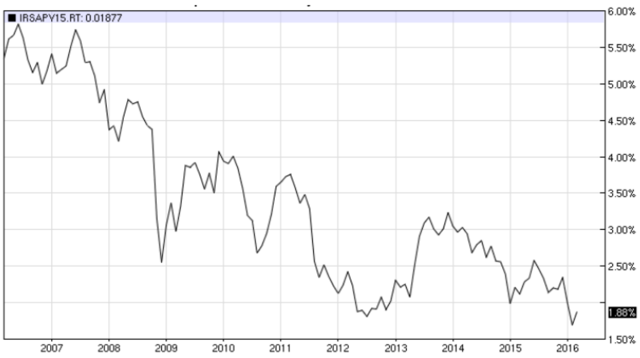
Source: Reuters Pricing Service (RPS), retrieved Thursday, March 24th 2016

The spread, which represents a significant part of the bank's gross income from the loan, is fixed in advance, but the LIBOR is renewed periodically (usually every three to six months). This structure allows the bank to pass on the interest rate risk to the ship owner, whose cost of servicing the loan fluctuates with the LIBOR. If un-hedged, it prevents the ship owner from calculating the future interest payments with any certainty. Therefore, when determining the cost of debt, it is common to refer to the interest rate swap markets. The interest rate swap is the spread that is paid on a swap in addition to the fixed interest rate to receive payments based on a floating rate.

It follows, that the cost of debt can be defined as the interest rate on the loan (USD LIBOR 12 months (1,231%)[6] plus a 3,430% credit spread to the bank) plus the 15-year USD interest rate swap fee (1,850%), resulting in 6,511%.

Figure 25: Dollar interest rate swaps for various years to maturity and line chart for swap 15-years

Interest Rate Swap 1 Year	0.80%
Interest Rate Swap 2 Years	0.96%
Interest Rate Swap 3 Years	1.10%
Interest Rate Swap 4 Years	1.23%
Interest Rate Swap 5 Years	1.32%
Interest Rate Swap 7 Years	1.52%
Interest Rate Swap 10 Years	1.74%
Interest Rate Swap 15 Years	1.85%
Interest Rate Swap 30 Years	2.16%



Note: Retrieved Thursday, March 24th, 2016

[6] Retrieved Thursday, March 24th 2016 from ICE Benchmark Administration

As a result of the discussion and estimation of the individual determinants, the cost of equity is computed as r_E = 2,27% (r_f) + 5,780% (ERP)*0,925 (β_E) = 8,708%. For the determination of the WACC, the cost of capital is again weighed with 70% debt and 30% equity and added a 1% risk-premium to reflect an overall conservative valuation approach because of current market conditions. This brings the current discount rate to a total of: 70% (D/V)*6,511% (r_D)+30% (E/V)*8,708% (r_E)+1% = 8,170%.

Calculating the value of the Asian Gyro 1.032 teu container vessel built in 2001 and sold in 2015 (same example as in the mark-to-market model), we compute a value of **USD 5,62 million** (see Table 16 for detailed calculations). This value is slightly more than the actual realised price of USD 5,50 and the mark-to-market estimated price of USD 5,36. The higher estimate reflects well the tendency of the DCF approach to disregard disturbed market condition in favour of the namesake long term asset value. In fact, the negative residual is slightly less than would be expected, indicating that there might be special circumstances regarding the vessel that boasts its market value. A closer look at the specialist details reveal that the *Asian Gyro* was a Japanese ship with a MAN engine (high quality), but with only 100 reefer plugs and without any cargo gear. Any of these, and other, elements, such as general condition, fixed charter etc. also influences the price. Unfortunately, the data we have obtained from Clarksons Research do not differentiate between geared or gearless until 2011 (a quite significant factor considering the lack of sufficient lifting equipment in many third-world countries).

Table 16: DCF sample computation for Asian Gyro

Vessel name: Haian Time (Ex: Asian Gyro)

Sold	Built	Age	Size	Index	Price
(Date)	(Year)	(Years)	(TEU)	(CTRI)	($ millions)
2015-sep	**2001**	**14**	**1032**	**53,5**	**5,5**

Earning Days	358	maximum # of available charter days in a typical year
	343	maximum # of available charter days in years with dry-docking (class renewal)
Utilization rate	95%	booked days as a percent of total available Earning Days
Historical TC rate	$ 7.838	10-year historical average monthly timecharter rate
Fees and commissions	6,50%	ship management fee and freight commission as a percent of gross TC rates per day
Daily operating expenses	$ 5.570	includes general and adm. costs, insurance, crew, operating expenses and dry-docking provisions
Inflation rate	2,00%	affects the timecharter rate, operating expences and scrap value
Tax rate	0%	assumes a non-tax paying owner
Cost of capital (WACC)	8,17%	used to calculate the present value factor

Model year	Calendar Year	Ship age (years)	Earning Days (a)	Actual booked days (b)	Gross TC rates per day	Net annual TC revenue (c)	Annual operating expense (d)	EBIAT (f)	Scrap value (g)	Free cash flow (h)	Present value factor	Present value
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(10)	(11)	(12)	(13)	(14)
1	2016	15	358	340	$ 7.995	$ 2.541.455	$ 2.073.779	$ 467.676		$ 467.676	0,924	$ 432.353
2	2017	16	343	326	$ 8.154	$ 2.485.543	$ 2.115.254	$ 370.289		$ 370.289	0,855	$ 316.466
3	2018	17	358	340	$ 8.317	$ 2.644.130	$ 2.157.559	$ 486.571		$ 486.571	0,790	$ 384.437
4	2019	18	358	340	$ 8.484	$ 2.697.013	$ 2.200.711	$ 496.302		$ 496.302	0,730	$ 362.509
5	2020	19	358	340	$ 8.654	$ 2.750.953	$ 2.244.725	$ 506.228		$ 506.228	0,675	$ 341.831
6	2021	20	358	340	$ 8.827	$ 2.805.972	$ 2.289.619	$ 516.353	$ 5.544.672	$ 6.061.025	0,624	$ 3.783.599
											Total	**$ 5.621.196**

Footnotes:

a) Vessels require extensive maintenance, inspection and surveys every five years (dry-docking and class renewal), which reduces the number of available charter days.

b) # of booked days = total available Earning Days x (1 - utilization rate).

c) Equals gross daily TC rates x # of booked days x (1 - fees and commission rate).

d) Dry-docking provisions are recognized every five years and Intermediate Surveys are assumed to be an annual expense (see section 5.1.3 for details).

f) Earnings before interest and after tax (EBIAT) calculation ignores depreciation, a 'non-cash charge' because there are no taxes.

g) Scrap value equals 3.895 ldt x $348/ton (10-yr historical average scrap price) x a vessel specific coefficient of 3,7

h) FCF equals EBIAT + depriciation - increases in NWC - capital expenditures. Assumes minimal cap. exp. and investments in NWC

Source: Multiple data sources, authors calculations

5.3 Mark-to-market

5.3.1 Introducing the principle

When market participants are buying and selling container vessel, the price of the transaction is decided by what the sellers and the buyer's acceptance of the trade is. One way to evaluate the acceptable price for the trade is to look at former recently made trades; this is called the *market approach.* The market is used by analysing earlier trades, and then compared with the asset vessel of the actual trade.

The market approach requires an appropriate number of historical trades, comparable with the vessel evaluated for the transaction, at perfect a 1-to-1 match. The 1-to-1 match would mean that the transaction would be priced just like the former trade, since the market approach uses former transactions to price a similar asset. It is just not realistic to expect the exact match when dealing with container vessels. The variations are simply too many, and the number of historical trades to few. Instead, the comparison has to be made on a set of significant parameters, which is assumed to have substantial effect on the price of the asset and is comparable from the market trades to the assessed vessel.

When selecting the comparable container vessels, the goal is to make the best possible fit from the market population to the actual transaction, variations like technology, gear, compatible routes or cargo should be minimized when collecting the sample from the market. When the sample of market trades is set, the significant parameters can be evaluated. Adland and Koekebakker (2007) finds that within Handy size bulk carriers there are three main factors, concerning second hand prices; size (dead weight tonnage), age and the state of the freight market. These parameters are found from an analysis of 1.850 second-hand sales form a 10-year period.

The factors from the analysis of the bulk carrier segment, is assumed to be significant within the container segment of seaborne shipping as well. The container vessels age is a proxy for the remaining years the asset should be able to operate, and should be negatively correlated with the price of the vessel, since a higher age will reduce the years the asset can make a revenue. Also the operating costs are expected to be less for a newer ship than it is for an old ship, since the maintenance and repair costs are likely to be higher for an old vessel. Furthermore, technological improvements will devaluate through time, when new technology makes the "old" technology less worth.

The size (capacity of TEU) of the container vessel is of course one of the main factors when evaluating the price; the number of TEU carried by the vessel generates the revenue, and should be positive correlated with the asset price. Likewise the freight rates should have a positive causality with the vessel price, since this also is a parameter, which has a positive relation with the expected revenue.

The last 20 transactions of second hand trades are illustrated in *Table 17*, the table shows the age of the vessel on the date of the trade, the size in TEU and the actual traded price in $ millions. The TEU range is as described earlier from 1000-2000 TEU. As a proxy for the freight market, the Containership Time Charter Rates index has been used, the index is anticipated to state the market conditions and move along if the market equilibrium changes due to shifts in supply or demand. For a less volatile exposure, a one year moving average has been calculated of the Containership Time Charter Rates index.

Table 17 Dataset of first 20 observations of the second hand sales

Count	Name	Sold	Built	Age	Size	1 year MA	Price
1	Nordic Philip	12-01-2016	2010	6	1.036	52,5	11,00
2	Nordic Stani	12-01-2016	2010	6	1.036	52,5	11,00
3	Independent Venture	22-12-2015	1993	22	1.468	52,9	2,00
4	Aspiration	09-12-2015	2005	10	1.050	52,9	7,20
5	Admiration	25-11-2015	2007	8	1.054	53,3	7,00
6	Credo	09-10-2015	1996	19	1.728	53,5	6,20
7	Sanya	30-09-2015	1999	16	1.560	53,5	7,00
8	Sky Evolution	15-09-2015	1996	19	1.120	53,5	4,00
9	Kaptan Aytac A	08-09-2015	2001	14	1.157	53,5	6,90
10	Asian Gyro	02-09-2015	2001	14	1.032	53,5	5,50
11	El Toro	01-09-2015	2006	9	1.080	53,5	6,50
12	Soga	28-08-2015	1998	17	1.157	53,2	5,00
13	Paola	29-06-2015	2005	10	1.080	51,4	4,40
14	Dolphin Strait	22-06-2015	2003	12	1.118	51,4	4,50
15	Sounion	11-06-2015	1996	19	1.064	51,4	2,00
16	Alexandra N	09-06-2015	1997	18	1.728	51,4	4,00
17	Ability	08-06-2015	2006	9	1.054	51,4	8,00
18	Otterhound	02-06-2015	2003	12	1.118	51,4	4,82
19	Vision	02-06-2015	2006	9	1.118	51,4	4,60
20	Ayutthaya Bridge	28-04-2015	2007	8	1.708	48,8	12,20

Source: Clarksons Shipping Intelligence Network (Timeseries 16891, “Second hand sales”)

An example of how to price a container vessel from the *Table 17* could be an investor who wants to estimate the price of a random vessel from the table in january-2016. It could be No. 10 *Asian Gyro*. The *Asian Gyro* is at the time of the sale 15 years old[7] and has a capacity of 1.032 TEU. If the investor wants to find a price from similar transactions he has to compare *Asian Gyro* with former transactions. Comparison on age makes No. 7 *Sanya* or no. 9 *Kaptan Aytac A* the best option since the age for both of them is deviating by 1 from our dependent vessel but still the best option. *Sanya* benefits from being a most recent transaction, which makes the influence of the market conditions less volatile. But the difference between the two should be insignificant, and the average price of the vessels seems the best possible solution due to the insufficient data. If instead a match on size is used, then no. 15 *Sounion* makes a satisfactory match since the TEU range is approximately the same as Asian Gyro. But *Sounion* is a four year older vessel at the time of the trades, which should not be neglected when estimating the price of the valued asset. The estimation of the price, exemplified by these two comparisons, makes the price span for a trade with no. 10 to lie between 2 and 6,95 m $. The full dataset of resent second hand trades within this segment of 1000-2000 TEU includes 94 trades and if all of them were taken into account, then the possibility of a better match would be enhanced. But the example describes well the shortcomings of the approach so far. The average price of the second hand trades in the table is 5,41 m $, so even with shortcomings, the estimated price range seems more realistic even if the old age and small size are taken into account.

For analysis or decision making a less broad range for the price estimation would be preferred. For this purpose the former univariate comparison could be developed into a multivariate regression analysis, where the predicting input are as already stated (age, size and freight). The dependent variable is the price. The independent variables can be analysed as linear or non-linear with respect to the dependent output. There will be made a linear assumption in the following analysis. This is done initially, but adequacy of the assumption is further analysed through the explanatory power of the statistic results, and with exposition of the p-values and significance level.

Instead of choosing a match in *Table 17* when trying to price the container vessel, the full dataset of 94 observations will be analysed for making a more significant model for price predicting of second hand container vessels.

The following model is evaluated for the purpose:

$$VP_i = \alpha + \beta_1 * Age_i + \beta_2 * Size_i + \beta_3 * Freight_i + \varepsilon_i \tag{32}$$

[7] one year older than summarized in the table, since a year has passed at new transaction date

VP_i is the vessel price where i refers to each individual transaction from the full data set. Age_i denotes the age of the vessel at the time of the transaction, measured in years, this variable is analysed as a integer. $Size_i$ is the capacity of the vessel measured in TEU, and $Freight_i$ is as mentioned a one year moving average, measured on monthly observations of the Containership Time Charter Rates index. α is the intercept and a constant parameter in the model. β_1 β_2 and $\beta_3$is the sensitivity of the price, where β_1 refers to the sensitivity from Age_i, β_2 the models sensitivity from the size and last β_3 denotes the sensitivity from $Freight_i$. ε_i is the error term, and for each observations denotes the distance the observations price is from the estimated price from the model.

The regression of the model is made using ordinary least square (OLS regression), which is a linear multivariate model, to estimate the parameters α β_1 β_2 and β_3. This is done by minimizing the sum of the squared ε_i from all the observations. The Gausss-Markov theorem (Chipman 2011), states that OLS gives the *best linear unbiased estimators*[8] meaning that this method is making the most accurate predicting overall[9], but it also requires both homoscedasticity and serially uncorrelated errors, else the OLS is no longer BLUE. This will be tested further later on. *Table 18* shows output from the regression

Table 18 Coefficients from regression

	Coeff
α	4,3078
β_1	-0,5350
β_2	0,0025
β_3	0,1110

Source for data regression: Clarksons Shipping Intelligence Network (Timeseries 16891, “Second hand sales”)

[8] Referred to as BLUE in litterature
[9] Minimizing the variance

5.3.2 Statistical statement

The model has been evaluated from a level of significance of 5% and the output from excel is shown in *Table 19*. Notable data from the regression statistic is the p-value for the regression equal to $1{,}64 * 10^{-26}$, which is far below the applied significance level. This is essential, since a value above the level of significance would imply a model without correlation. R^2, the coefficient of determination is 0,7437. This value describes how well the variation in the vessel prices, can be explained by the variation in age, size and freight (Bøye 2009). This is also an indicator of how well the model predicts the vessel price. The value of 0,7437, means that 74,37 % of the variation in VP comes from variation in the tree explanatory variables.

$$R^2 = \frac{Explained\ variation}{Total\ variation} \tag{33}$$

The problem with R^2 is, that it does not take into account the amount of independent variable in the regression; therefore the adjusted R^2 in the multivariate analysis should be considered as well. The adjusted R^2 diminishes the degrees of freedom when adding a new explanatory variable, which points to a parsimonious model. An adjusted R^2 value in 0,7351 is an indicator of a model, that is quite accurate, but still makes room for stochastic variation. The high adjusted R^2 and R^2 values and the low p-value for the regression, is also a consequence of the fact that the extreme outliers have been removed from the regression. This is commonly done when other factors than those used in the regression could have significant impact on the price. A more qualitative analysis of the container vessels (maybe as dummy variables in the regression) could have adjusted for this. However, it is not considered that it would make a big difference for the analysis aggregated with the fact that these data's availability is bad; it makes the exclusion of the extreme outliers the best option for the model.

Table 19 Regression output from excel

Regression statistics	
Mult R	0,8624
R^2	0,7437
Adj R^2	0,7351
Std. Err	1,3464
Obs	94

ANAVA

	df	*SS*	*MS*	*F*	*P-value*
Regression	3	473,3665054382	157,7888	87,0423770638	1,64E-26
Residuals	90	163,1503601142	1,8128		
I alt	93	636,5168655523			

	Coeff	*Std. Err*	*t-stat*	*P-value*	*Low 95%*	*Upp 95%*
α	4,3078	2,6524	1,6241	0,1079	-0,9617	9,5772
β_1	-0,5350	0,0343	-15,6093	2,41494E-27	-0,6031	-0,4670
β_2	0,0025	0,0005	4,9388	3,6011E-06	0,0015	0,0035
β_3	0,1110	0,0483	2,2967	0,0240	0,0150	0,2069

Output from regression data analysis excel

Data for regression; Clarksons Shipping Intelligence Network (Timeseries 16891, “Second hand sales”)

Table 19 shows that all the individual t-tests of the slopes of the input are under the applied level of significance, meaning that all the parameters are adding explanatory value to the model.

This is further supported by the correlationmatrix in *Table 20*, because the low correlation coefficient between the independent values lessens the colinearity problem. This is true because colinearity affects the regression coefficients and makes them less accurate because more of the independent variables are having the same impact (or exact opposite) on the dependant variable. If both size[10] and dead weight tonnage[11] were added as independent variables, the correlation coefficient close to one *Table 20* would make them have about the same impact on the model and blur the result. Intuitively size and dwt are coherent, but even though age, size and the index not obviously are correlated *Table 20* shows that age and size are correlated with 0,1342.

[10] Defined as measured in TEU
[11] DWT

Table 20 Correlation matrix from regression

	Age	Size	1 year MA
Age	1		
Size	0,1342	1	
1 year MA	-0,1076	-0,2880	1

Source: Clarksons Shipping Intelligence Network, authors calculations

Table 21 Correlation matrix with size and dwt

	Size	*Dwt*
Size	1	
Dwt	0,9764	1

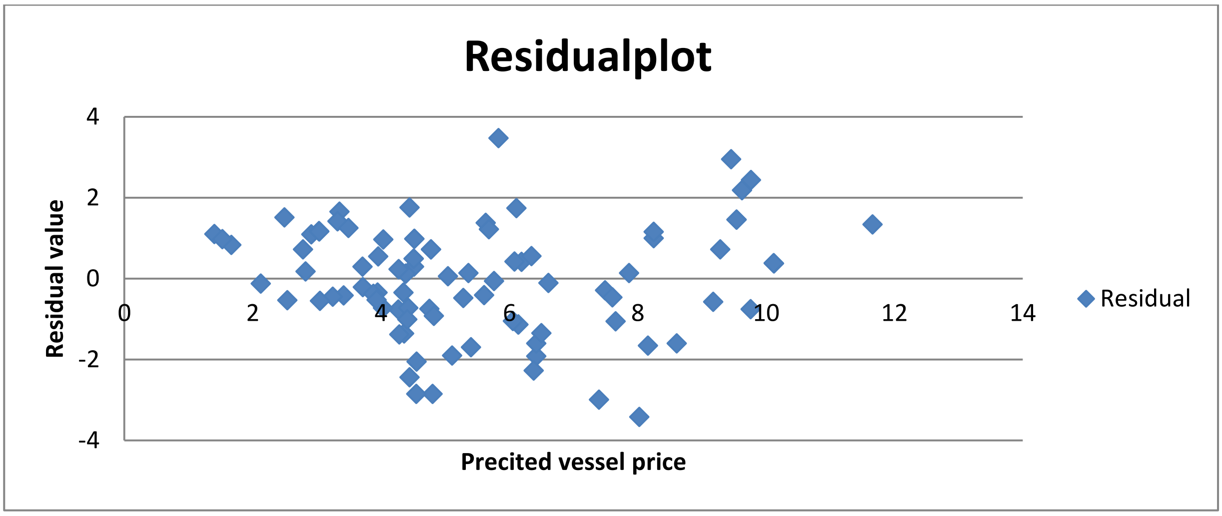
Source: Clarksons Shipping Intelligence Network, authors calculations

The correlation between age and size is still low enough to avoid further notice.

To evaluate the presumption of the model, the test of heteroscedasticity is done by evaluating the residuals. A residual is the difference between vessel price and the predicted vessel price for an observation, and these should in a perfect model vary randomly around zero.

The residual plot from *Figure 26* shows the residuals from the regression. It should be noticed that the plot only approximately is distributed randomly. There is a tendency of a hopper shape, which can be evidence of deficiencies in the regression. Other parameters could be affecting the price, or the preconception of linearity is not consistent. But there is also a natural cause that the residuals in the lower price range only are above zero. When the model predicts the low value, it does not take the scrap value into account. This means that at some point the model consequently will predict values that are beneath the actual traded values, since the age effect will be zero when the scrap value is reached.

Figure 26 Residual plot from the regression output



Clarksons Shipping Intelligence Network (Timeseries 16891, "Second hand sales")

5.3.3 Application of the model

Based on the regression the model for the expected price of the second hand vessel will be

$$\widehat{VP}_i = 4{,}3078 - 0{,}5350 * Age_i + 0{,}0025 * Size_i + 0{,}1110 * Freight_i \tag{34}$$

As seen in *Equation (34)* the causalities are as expected. Higher age has negative effect on the predicted vessel price, while an increase in size makes the expected price higher. As already mentioned the age influences the remaining lifespan of the asset, while the size influences the possible income. The market condition is also having a positive impact on the vessel price as expected since better market conditions are favourable for the market participants.

If the vessel price for no. 10 *Asian Gyro* should be predicted as previously, the independent parameters for the vessel from *Table 17* should be used to calculate the expected vessel price from the regression analysis.

$$\widehat{VP}_{Asian\ Gyro} = \alpha + \beta_1 * Age_{Asian\ Gyro} + \beta_2 * Size_{Asian\ Gyro} + \beta_3 * Freight_{Asian\ Gyro} \tag{35}$$

Using the OLS data from the regression the vessel price is calculated in equation *(36)* and data from Asia Gyro

No	Name	Sold (Date)	Built (Year)	Age (Years)	Size (TEU)	Index (CTRI)	Price ($ millions)
10	Asian Gyro	2015-sep-02	2001	14(+1)[12]	1.032	52,5[13]	5,50

[12] One year older in January 2016
[13] Adjusted to the one year moving average in January 2016

the predicted value can be calculated:

$$\widehat{VP}_{Asian\ Gyro} = 4{,}3078 - 0{,}5350 * 15 + 0{,}0025 * 1032 + 0{,}1110 * 52{,}5 \Leftrightarrow \tag{36}$$

$$= 4{,}826\ m\ \$$$

Equation (36) shows that if the investor wants to predict the price in january-2016 for the container vessel named *Asian Gyro*, like he did earlier, but now with the regression model, the expected value of *Asian Gyro* is 4.826.300 $. This value is within the range of 2 to 6,95 m $, but is a far more accurate result and takes more variables into account. This is as would be expected since the new calculated prediction is within the range of the previous price span.

If the prediction of the price instead were made at the time of the last known trade (sep-2015), the vessel price from the model would be calculated by:

$$\widehat{VP}_{Asian\ Gyro} = 4{,}3078 - 0{,}5350 * 14 + 0{,}0025 * 1032 + 0{,}1110 * 53{,}5 \tag{37}$$

$$= 5{,}3611\ m\ \$$$

This estimated price differs from the actual traded price on 5,500 m $. That means that the difference between the forecast vessel price and the actual transaction price, is 0,14 m $, or said with the terms of the regression, the $\varepsilon_i = 0{,}1389$. The value of the error term should preferable be 0, but the R-squared value is not 100 and therefore some of the variation in the dependent variable is not measurable from the independent factors in the model. This should not be surprising since aspects like the condition of the vessel in general of course has an impact on the vessel price, but is not included in the model. The OLS regression method used as done in this section, benefits from being quantitative because it makes it easy to use, but meanwhile has a shortcoming in that it neglects those qualitative and more subjective parameters can affect the container vessel price.

The OLS model has an assumption that the explanatory variables are independent, which means that they should not be correlated with each other. Otherwise it creates multi colinearity problems. All of this makes the precision less accurate and will have a negative effect on the model’s prediction power if not considered

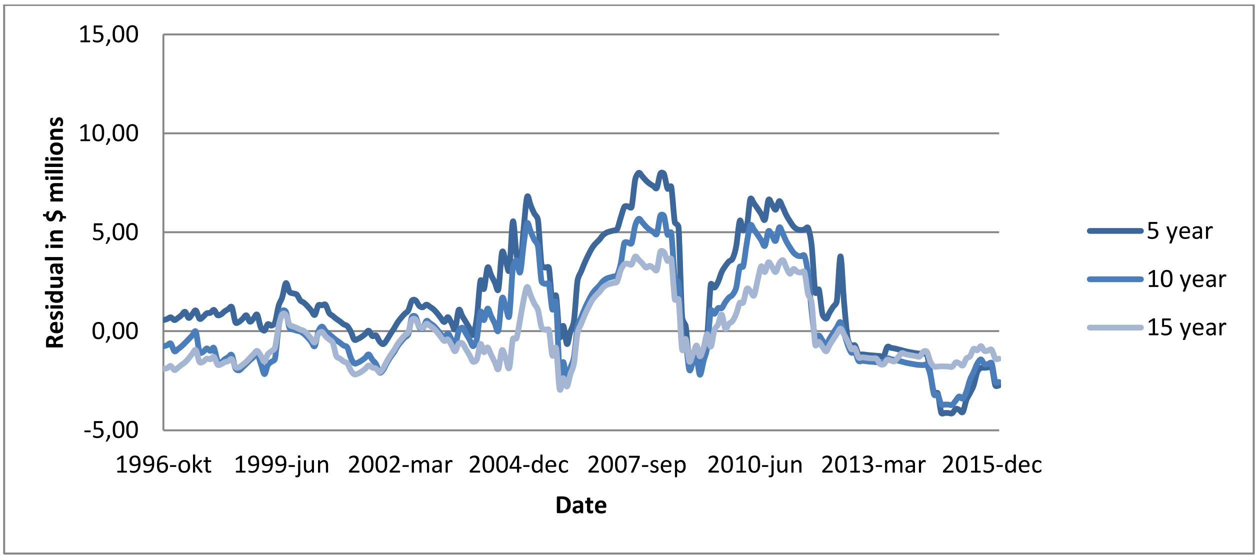
5.3.4 Residual values

The mark-to-market model is normally used to evaluate market prices on the present market, but for analysis purpose they will be considered as relevant. The input as independent variables in the regression analysis should make the model comparable even over a wider time series. This is anticipated since the index is one of the independent variables and therefore should be usable as a proxy for the market changes over time.

For studying purpose the residuals from the regression analysis will be further examined ex-ante. This is done because a constant stable variation for a longer period could indicate that other factors are having a significant impact on the model in a given period of time or maybe another view on one of the parameters already included in the model.

To evaluate the prices ex-ante the model has been used on an historical dataset, the data are trades from a reference container vessel on 1000/1100 TEU, which is used as representative of the handy size segment on 1000-2000 TEU. The dataset includes 3 series of data, respectively for vessels with 5, 10 and 15 years of age. As earlier stated, the residual is the error term from a given observations expected value to the actual traded price.

Figure 27 Residuals from reference vessels



Source: Clarksons Shipping Intelligence Network (Timeseries 56915, 91015 and 56934 - "Second hand sales")

Figure 27 shows the variation from the prices predicted by the model and the prices disclosed at Clarksons for the reference vessel. The values in the graph show that there is a tendency to 2-3 periods where the market prices are significantly higher than the regression would predict. These, not negligible deviations, will be further analysed later on.

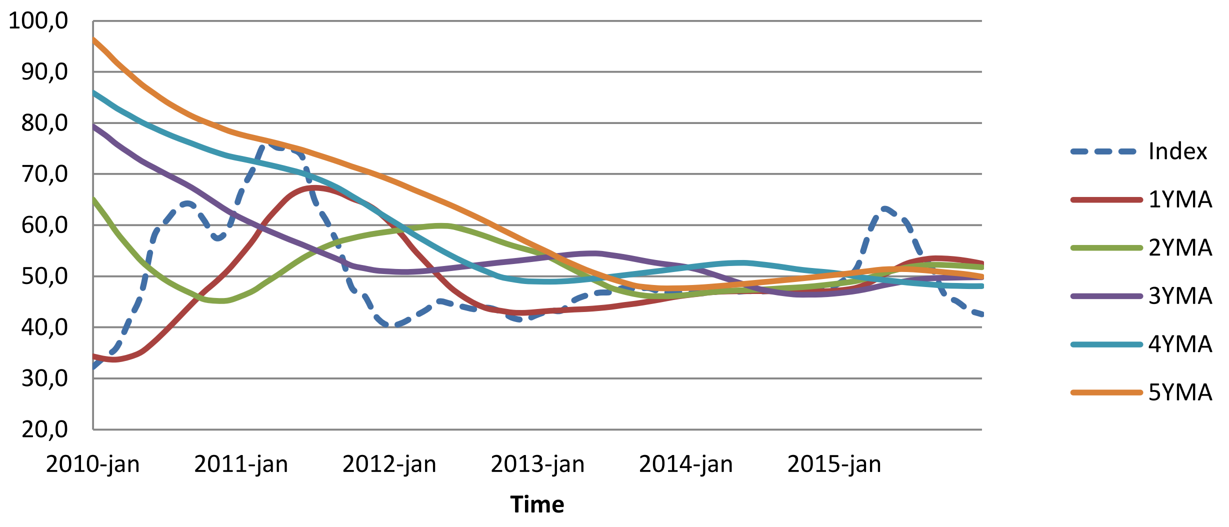
5.3.5 Testing other models

Further testing has been made to evaluate other options even though the initial model is significant. This is done to study the possibility to make a model, which better fits the purpose of evaluating a second hand vessel price.

The first thing which is tested is another approach to the index as explanatory variable. Initially a one year moving average[14] was used to make the fluctuations lower than if the input was not measured as an average.

In the following the 1YMA will be substituted with 2-5YMA and the index itself.

Figure 28 Moving average and the index



Source: Clarksons; authors own calculations

As seen in *Figure 28* there is quite a difference between the methods, the reason for this being that the very high index before 2010 is being weighted in the average, and of course more of the peak is influencing the longer time series.

[14] 1YMA

The best alternative to the 1YMA is the 4YMA which is shown in *Table 22*

Table 22 Regression output from excel 4YMA

Regression statistics	
Mult R	0,8556
R^2	0,7320
Adj R^2	0,7231
Std. Err	1,3768
Obs	94

ANAVA

	df	*SS*	*MS*	*F*	*P-Value*
Regression	3	465,9254	155,3085	81,9370	1,21E-25
Residual	90	170,5915	1,8955		
Total	93	636,5169			

	Coeff	*Std. Err*	*t-stat*	*P-value*	*Low 95%*	*Upp 95%*
α	4,7333	5,1457	0,9199	0,3601	-5,4896	14,9562
Age	-0,5515	0,0364	-15,1506	1,702E-26	-0,6238	-0,4792
Size	0,0020	0,0005	3,8460	0,0002	0,0010	0,0031
4YMA	0,1143	0,1081	1,0578	0,2930	-0,1004	0,3290

Output from regression data analysis excel

Source: Data for regression; Clarksons Shipping Intelligence Network (Timeseries 16891, “Second hand sales”)

It is shown that the P-value diminishes compared with the initial model (*Table 19*) which implies a less significant model, and because the observations and degrees of freedom are the same as before, it is causal that the adjusted R^2 decreases as well.

Output from 5YMA is actually making a more significant model as the output from *Table 23* display, but the model states a negative ratio of the vessel price when the index increases. This is not plausible, since a high index value states a market with conditions that makes the preconditions for the earning better than when the index is low.

Table 23 Regression output from excel 5YMA

Regression statistics	
Mult R	0,8640
R^2	0,7465
Adj R^2	0,7381
Std. Err	1,3389
Obs	94

ANAVA

	df	*SS*	*MS*	*F*	*P-Value*
Regression	3	475,1793	158,3931	88,3575	9,94E-27
Residual	90	161,3375	1,7926		
Total	93	636,5169			

	Coeff	*Std. Err*	*t-stat*	*P-value*	*Low 95%*	*Upp 95%*
α	23,1891	5,2571	4,4110	0,0000	12,7449	33,6333
Age	-0,5566	0,0346	-16,0996	3,09E-28	-0,6252	-0,4879
Size	0,0020	0,0005	3,9426	0,0002	0,0010	0,0030
5YMA	-0,2521	0,1001	-2,5190	0,0135	-0,4509	-0,0533

Note: Output from regression data analysis excel

Source: Data for regression; Clarksons Shipping Intelligence Network (Timeseries 16891, "Second hand sales")

2YMA and 3YMA are making less descriptive models, and therefore the data from these models are not considered as relevant for further analysis in this paper.

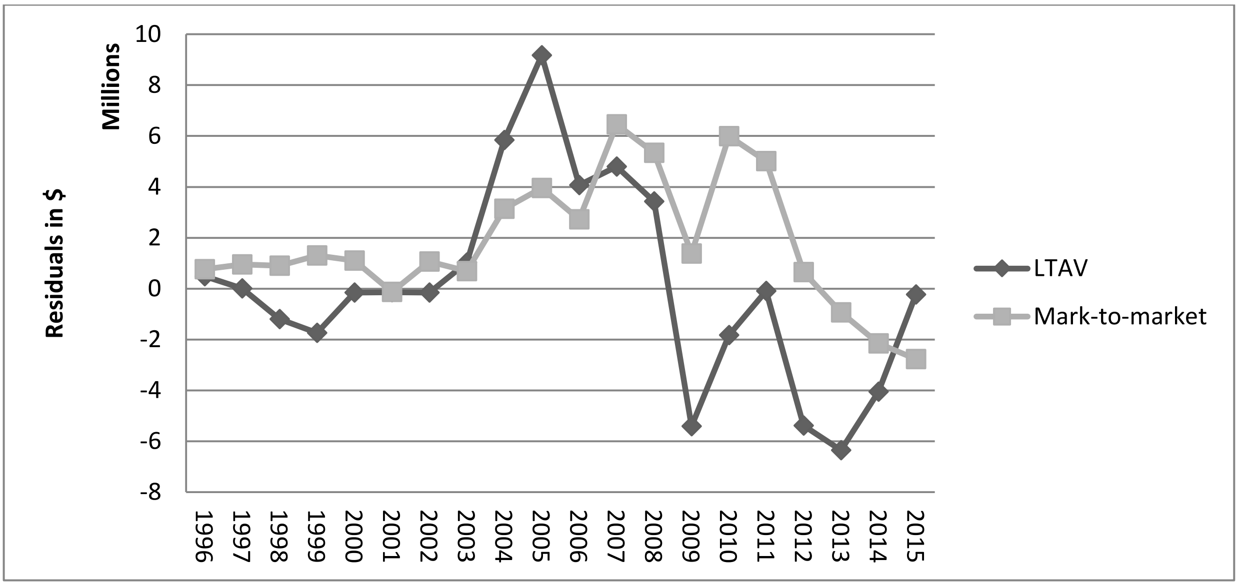
The interim conclusion is therefore that the 1YMA gives the best model since 5YMA must be influenced by other factors and gives an implausible model. 4YMA is less significant and therefore implies a model where less of the variation in the vessel price is accounted for from the variation in the independent variables.

5.4 Interpreting the residuals

The deviations from the models predicted values and the actual traded prices are illustrated in Figure 29, and are calculated by subtracting the models predicted price from the actual traded prices, meaning that a positive residual value is an expression of market prices that exceeds the predictions and vice versa.

Figure 29 shows that the initiating period from 1996 to 2003 of the analyses fluctuates approximately around zero for both models, which is causally with models which correspond to the market prices. The LTAV seems to over evaluate what the market prices should have been, compared to actual transactions but still within a reasonable range. The market approach underestimates a little, meaning that the actual market prices for the reference vessel of the analysis is a little higher than the model's predicted price of a vessel with the same proportions.

Figure 29 Residuals from LTAV and mark-to-market



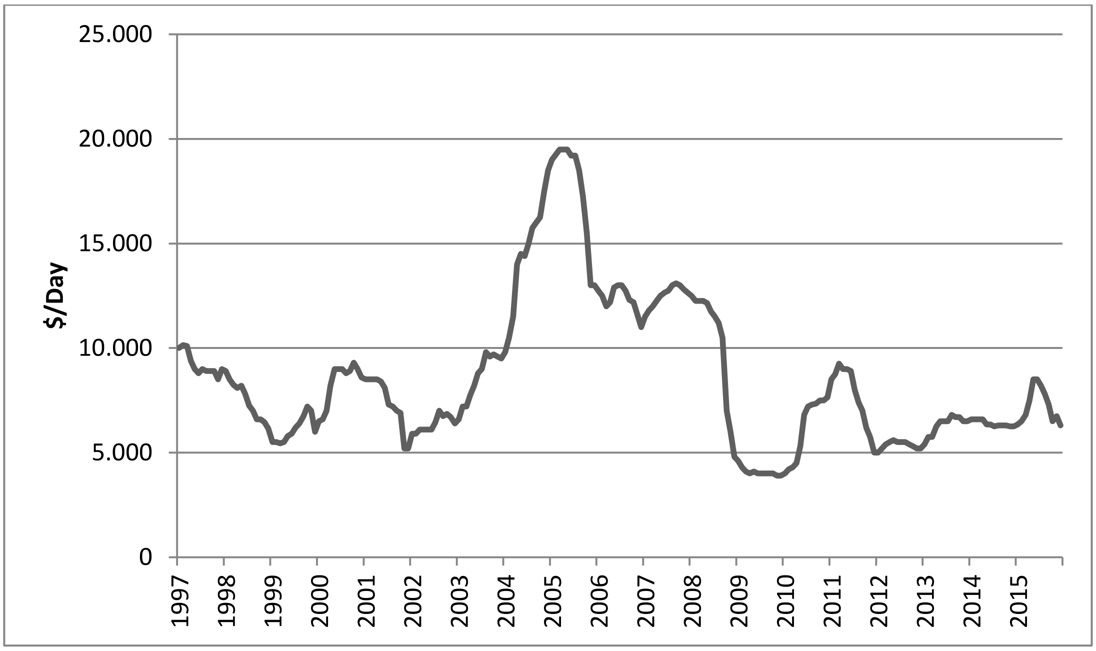
Source: Clarkson Resarch, authors own calculations

From 2004 until 2008 the market prices seem to escalate compared to prices perceived by both LTAV and the market approach. This may be an indication of either shortcoming of both models mutually, or irrational behaviour from the market participants. If considering the mark-to-market model mostly the I_i parameter can be subject to the inconstant inclusion of the state of the market in the model. The regression is made with the best possible data accessible, but the trades for the regression is composed by the most actual trades at the time of the regression, and therefore it may be that the regression input is not enough to make the model able to accommodate these market fluctuations. Though it should be noticed that both the period before 2003 and after 2012 seem less volatile and far less systemic. Recalling the primary bias for the mark-to-market approach, it is that it has a limitation that makes it vulnerable for general market mispricing. If the regression or just ordinary comparison is made from prices that are already mispriced, the market approach will continue the mispricing, because the presumption of a market which should be priced correctly on average is not fulfilled.

The residuals in *Figure 29* from the market approach can therefore be an expression of a model constructed under condition with a general imbalanced pricing, with a market average not equal to the actual intrinsic value of the vessels.

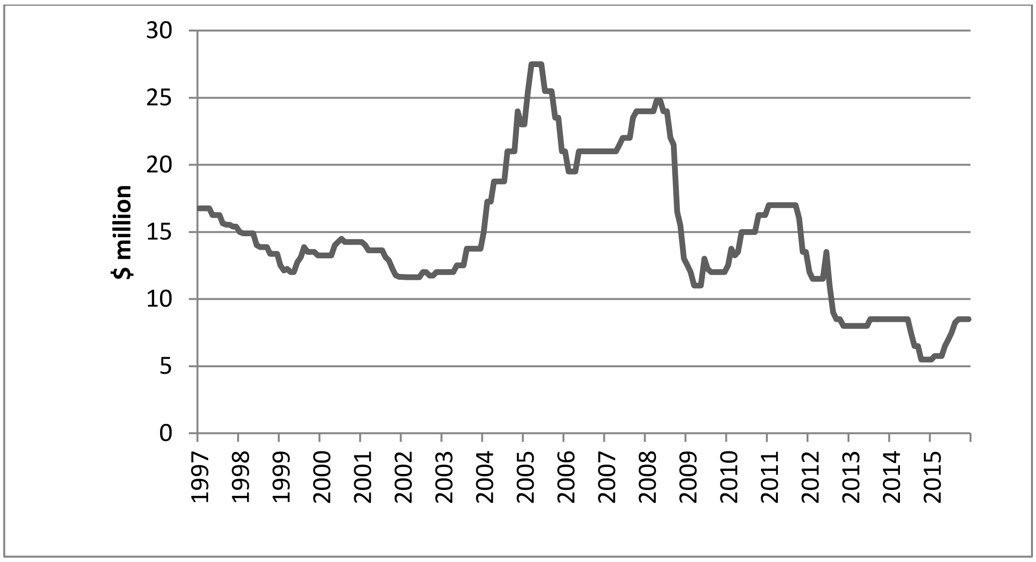
Residuals from LTAV vary a little from those already outlined from mark-to-market. It has a much steeper curve at the peak in 2004 and 2005, which is a countenance of a model not as sensitive to market fluctuations, as maybe the mark-to-market model. The 10 year average method from LTAV, makes the weighing equal regardless the point of time, within the 10 year period. The consequent of this is that current market fluctuations, is not having that big impact on the value estimated from the LTAV model.

Figure 30 timecharter rates handysize 1000 TEU container vessel



Source: Clarkson Research (Timeseries 16835)

Figure 31 secondhand price 1000/1100 TEU 5 year old containervessel



Source: Clarkson Research (Timeseries 56915)

Comparing the residuals for the LTAV method in *Figure 29* with the second hand prices from *Figure 31* does show that the fluctuations in the residuals is similar to the curve of the second hand prices. This is an expression of a slow reacting LTAV model compared with a market which clearly reacts faster on the variability in the time charter rates (*Figure 30*) than the LTAV. The reason for the similarity of *Figure 29* and *Figure 31* is that LTAV only slowly incorporate the changes from the increasing time charter rates, and on short sight almost stay the same, while market second hand prices seems very dependent of the concrete time charter rate.

Viewed isolated the models seem to periodically fail the purpose of predicting the vessel price, compared with the actual traded market prices. This is mainly apparent from 2004-2014, where fluctuations in the seaborne trades (see *Figure 6*) and also the time charter rates seem more pronounced than normal. The analysis of the residuals would definitely be intensified if the historical analysis started earlier, because past reactions to market volatility, would either strengthen or exclude the assertions drawn from the analysis, but unfortunately the analysis has been limited by the data provided. Still though, the models do not seem to predict the fundamental value of the vessel in isolated terms, since the difference between market prices and predicted vessel prices from the models is not approximately zero, and neither zero on average for the period. This criticism requires that the market is efficient, and by that meaning that the market prices are consistent with the expected intrinsic value and fundamental value of the vessel traded. If only the market approach or the LTAV model had these notable and systematically variations in the residuals, the shortcomings of the models would be assumed to be plausible explanations of the models inability to foresee the intrinsic value of the vessels

It is not the case that only one of the models seems inadequate. It is the case that both models simultaneously create residuals with more significant fluctuation than expected. This makes it reasonable to assume that maybe the fundamental value is not directly derived by market prices in a given period. The reason for this presumption is that even though both models have vulnerabilities to certain exposures, it seems unlikely that the mark-to-market model falls under the condition of a generally mispriced market at the same time as the LTAV model is failing due to bad input in the model.

Based on this, it is assumed likely that the fundamental value of the second hand vessel is different from market prices in the period and it cannot be excluded, that other factors are affecting the actual market prices, for the second hand container vessel

Figure 32 predicted vessel price of reference second hand vessel, 5 year old and 1000/1100 TEU

Source: Clarkson Research, authors own calculations

As *Figure 32* shows, that the vessel prices from the two models are not the same. Mark-to-market fluctuates more than prices from LTAV. As already described this is a consequence of the 10 year trailing average of several inputs that flatten out the LTAV. Contrary to this the mark-to-market model includes the actual market conditions in the regression.

For the purpose of analysing whether the market prices or the models differ from the fundamental value of the vessel, a more in depth analysis of earnings, prices and investments is necessary. The combination of LTAV and mark-to-market, the two most common methods for vessel valuation, indicates that the second hand prices in a period from 2004-2014 deviates from the intrinsic value. Since the two models do not come up with the same results, further analysis is essential for the purpose of better predicting the prices prospectively and in order to determine possible reasons for the deviations from the market prices to the fundamental values.

6 Earnings, Prices and Investments

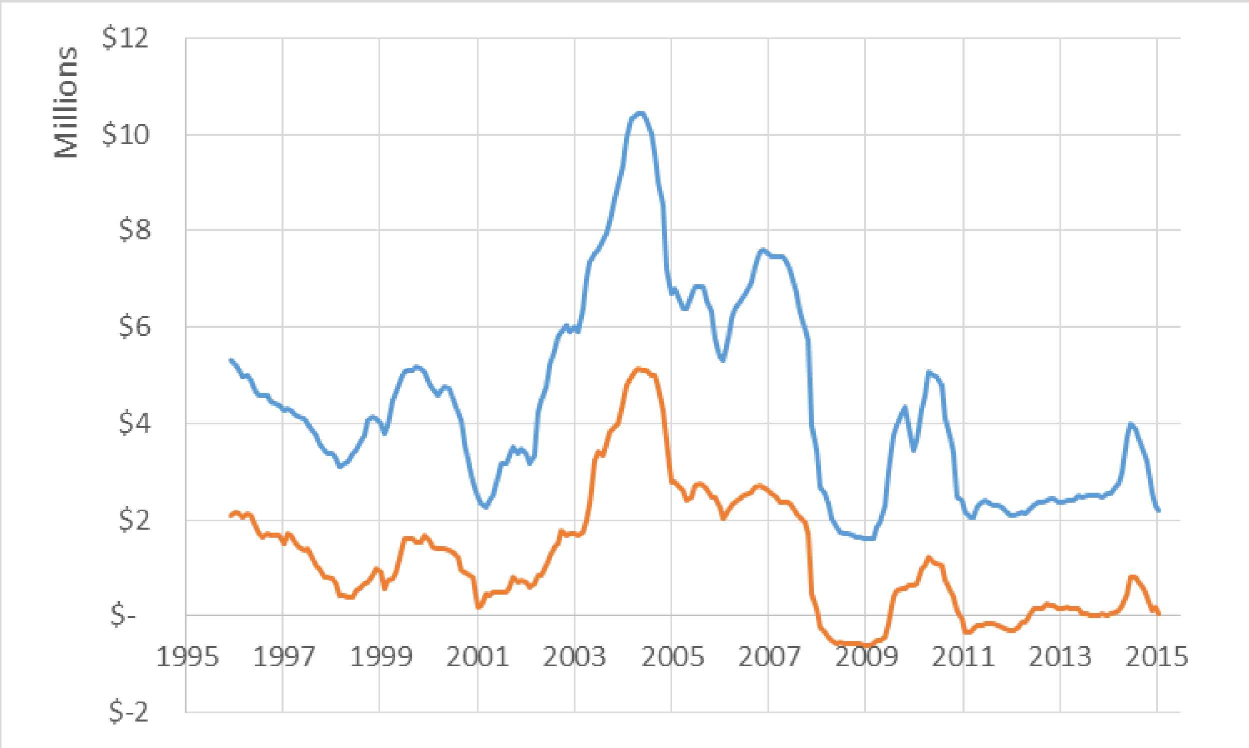
6.1 Earnings and prices

Our analysis focuses on a five year old second hand handy size container vessel (1-1999 teu) as previously introduced. We analyse used prices instead of new prices because the buyer then has immediate access to the ship and its rental income, i.e. time charter. Thus a buyer could be justified in paying a higher price for a used than for a new ship when current lease rates are high. Such a dynamic did indeed occur in 2007-2008 (Kalouptsidi, 2014). According to Stopford (2009), because there is little adverse selection in this market there is a large common time series component of prices that is shared across different size and age ships. We assume the owner earns the lease rate for 355 days a year, which is similar to the 358 days a years and 343 every fifth years as assumed in the DCF approach, simply spread out evenly over the years. The vessel is docked (and dry-docked) the remaining 10 days a year for maintenance and class renewal. The OpCost paid by the ship owner is assumed to be the factual USD/day 4.985 in December 2009 (Drewry Research) and Survey cost the factual USD/anno 195.800 in December 2012 (Ibid.). The Survey cost comes from an intermediate survey of USD 377.000 every five years and the special survey of USD 602.000 every five years, offset by 2,5 years, so each survey occurs every five years. This assumption is exactly the same as in the DCF approach, just spread out evenly over the years (we are no longer constrained to cash flows when calculating earnings). As before, we assume that the ship owner signs consecutive 12-month lease contracts. Real earnings are therefore:

$$\Pi_t = 355 * TC_t - (365 * OpCost_t + SurveyCost_t) \tag{38}$$

Where daily TC rate and OpCost and annual SurveyCost are all expressed in constant 2015-dec USD adjusted using historical CPI-U data for the preceding and subsequent months for the time period 1996-okt to 2015-dec. Although this estimate of ship earnings is an estimation, it is quite accurate. The OpCost which we know to be USD/day 4.985 in 2009-dec is very close to the estimated USD/day 5.000 suggested by Stopford (2009). We refer to section 5.2.3.1 where we describe the validity of this method in greater detail. Compared to the cash flow computation under the DCF approach we have left out the utilization rate and the commission and management fee. It makes intuitive sense to leave out the utilization rate because the ship owner is indifferent to the utilization as long as she receives a 12-month charter lease every year. We exclude commission and management fee because we asses this to belong to SG&A overhead and not earnings. Also, the fee is assumed to vary over time and within individual firms. This estimation of earnings is surprisingly accurate when compared to Clarksons Average Containership Earnings for the entire fleet as depicted in *Figure 33*. The correlation between the two time series is 0,97. As we expect, the average earnings are higher in absolute terms than the earnings for the handy size segment. This makes intuitive sense because of scale economy: a ship that carries twice the amount of teu incurs less than double the maintenance cost and requires less than double the crew count etc.

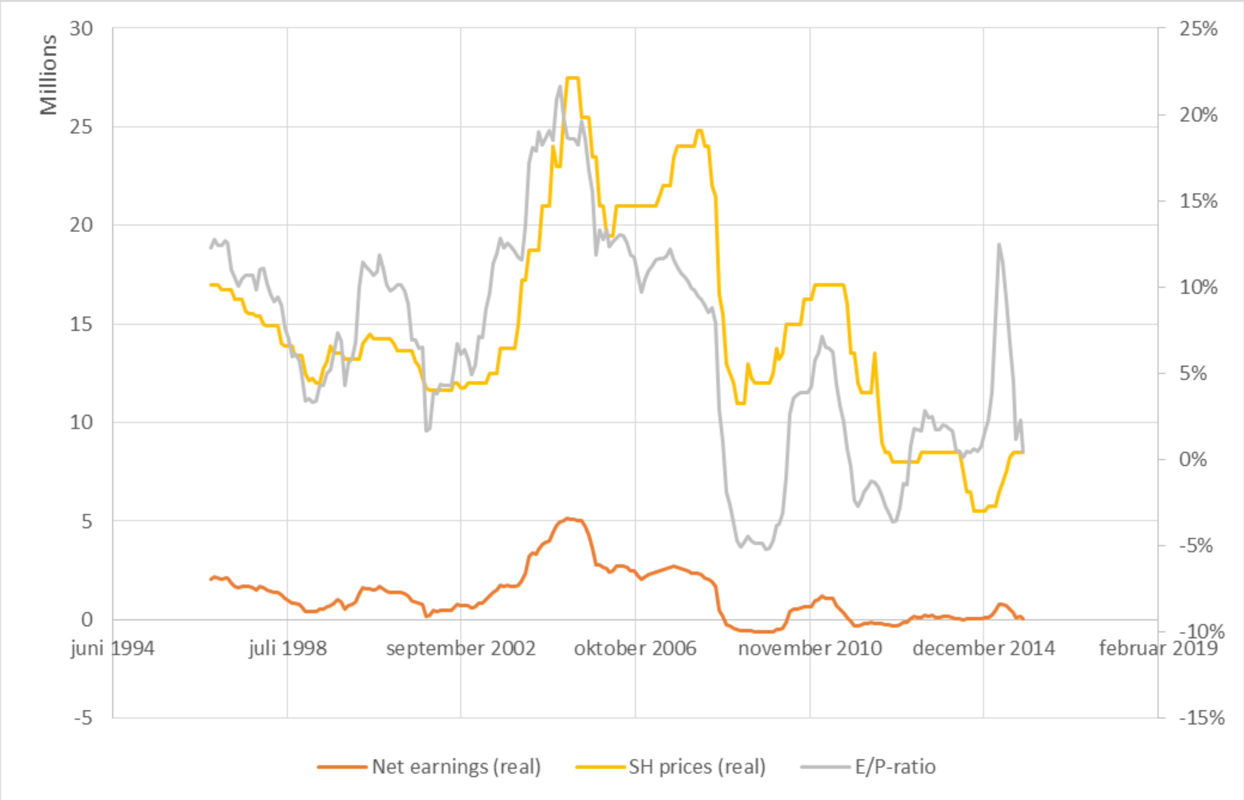
Figure 33: Estimated earnings compared to actual average earnings for the entire fleet



Source: Clarksons Research, authors calculations

Real ship earnings, as shown in Figure 34, are highly volatile, with a monthly standard deviation for annual earnings exhibiting a standard deviation of USD 1,33 million compared to a mean of USD 1,22 million. *Figure 34* also shows that earnings are mean reverting. To illustrate this, the 1-month autocorrelation of our computed earnings series is 0,99, the 12-month autocorrelation is 0,62 and the 24-month is 0,28. The autocorrelation with a 36 month lag is only 0,19 and turns slightly negative (-0,18) at a 48 month lag (four years). A study conducted by Greenwood and Hansen (2014) using a longer time series (1976-2010) and focussing on the bulk industry, suggest an even more rapid mean reversion of less than two years (compared to less than four for our sample).

Figure 34: Real earnings and second hand prices for a five year old vessel



Source: Clarksons Research, authors calculations

We can also see that real price closely tracks real earnings throughout our period of analysis (1996-2015). The correlation between the two time series are in fact 0,84 in levels. Interestingly, although earnings and prices are highly correlated, the ratio of earnings to price is far from constant. When earnings are high, so are prices, but prices do not rise proportionately. This is exactly what we would expect to see if firms understand that real earnings are mean reverting.

Using our computed net earnings and second hand ship prices based on recent transactions and pooling of brokers (Clarksons Research), we can calculate the holding period return for an investment in a box ship. For instance, the one-year holding period return on a ship equals the 12-month change in the second hand price, plus the net earnings accruing to the owner (who signed a 12-month charter immediately after purchasing the ship), relative to the initial used price. In *Equation (39)*, (t) is measured in 12-month periods, so annually, but for every month.

$$R_{t+k} = \frac{P_{t+k} * (1 - Depreciation_{t+k}) - P_t + \Pi_t}{P_t} \tag{39}$$

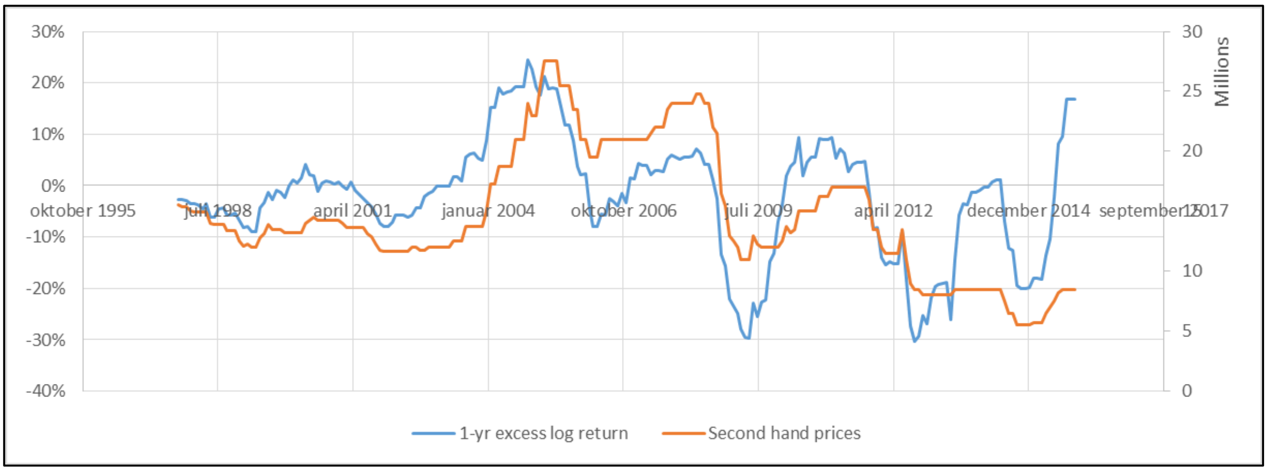
Depreciation refers to economic depreciation: obviously, after 12 month, a five year old vessel is now a slightly less valuable six year old vessel with one less year left of its economic life. Because we do not have data on the prices of 6 year old vessels, we assume that the annual depreciation cost equals 5% of the initial market price of the ship, reflecting a 20-year average economic life as previously stated (1/20 = 5%). To verify data reliability, we depreciated a five year old vessel five years into the future (t=5) and compared the estimated price of a 10-year old vessel with the actual price of a 10-year old vessel (Clarksons Research). While the two prices differed in absolute terms and the ratio varied across our time series, we found the correlation to be 0,99. Also, when solving for the depreciation rate that minimizes the sum of squared residuals between the estimated and the actual price, we get 5,0018%, which indicates that our assumption of 5% is very reasonable. Because depreciation is assumed to be a constant fraction of the initial price of the ship, it only affects the average return on the ship and has no effect on any forecasting results.

For every month that our data range permits, we compute the price of a five year old vessel at time using this method. As in most asset-pricing studies, we forecast excess returns as opposed to raw returns, because raw returns may fluctuate due to movements in the riskless interest rate. We define the excess return as follows:

$$rx_{t+k} = \log(1 + R_{t+k}) - \log(R_{f,t+k}) \tag{40}$$

Because we assume that a ship owner signs a new 12-month charter every year, we can compute multiyear cumulative excess returns by summing 1-year log excess returns.

Figure 35: Log excess return on a five year reference vessel for 1-3 year holding periods



	N	Mean	Median	Std. dev	Min	Max
rx(t+1)	219	-0,022	-0,012	0,115	-0,304	0,245
rx(t+2)	207	-0,043	-0,049	0,166	-0,357	0,379
rx(t+3)	195	-0,058	-0,073	0,206	-0,524	0,388

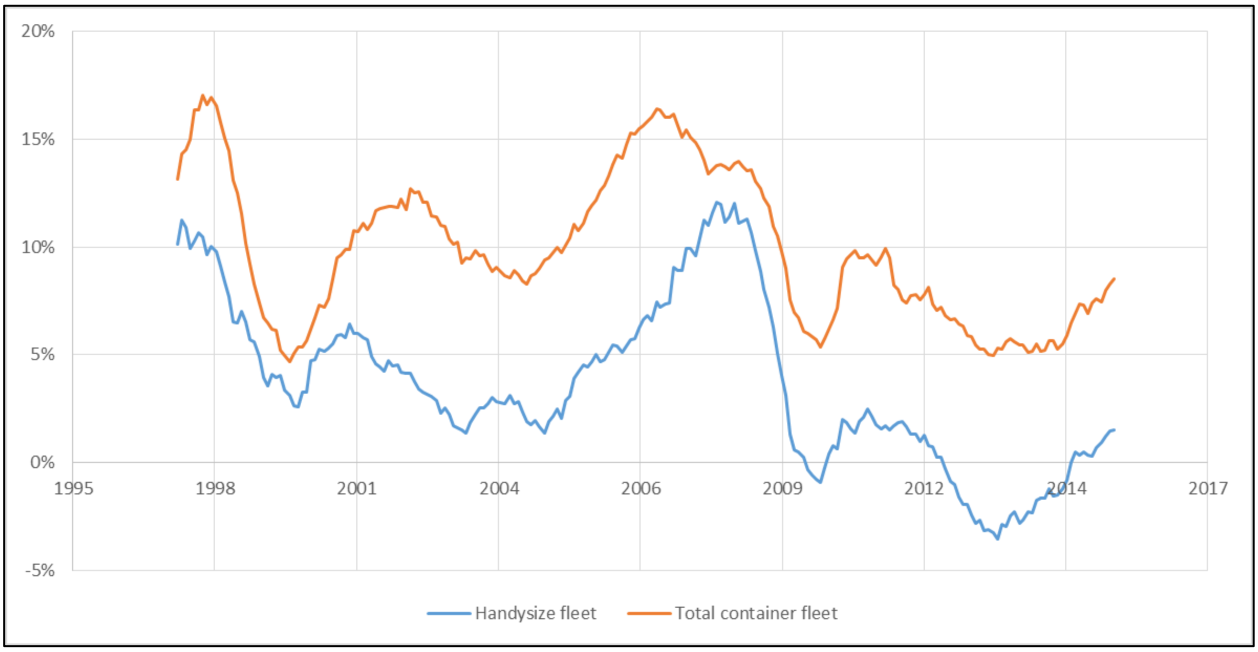
Source: Clarksons Research, authors calculations

Figure 35 shows that one year holding period returns in our period of analysis are incredibly volatile, with an average of -2,19% and a standard deviation of 11,46%. When we compare our return series up to 2008 with the annual "return on shipping investments" series computed by Stopford (2009), we get a correlation of 0,86, which is acceptable all things considered.

6.2 Investment plans

Different size container vessels are close substitutes due to the homogenous service they provide. Consequently, there is a high degree of time series correlation between earnings, prices and investment across ship sizes. For instance, if we define net supply change as the 12-month relative change in capacity (i.e. $NetSupplyChange_{t+1} = (Deliveries_t - Demolitions_t)/Fleet\ size_t$, where Fleet size refers to the size of the handy size and total container fleet respectively, both measured in teu, there is a 0,94 correlation between handy size and total fleet development. *Figure 36* shows the net supply change relative to fleet size. Even though the handy size segment is somewhat set apart from the general container fleet because of the small size and subsequent nature of related voyages, it still more or less follows the general trend.

Figure 36: Net supply change relative to fleet size for handysize segment and total fleet respectively



Source: Clarksons Research, authors calculations

Demolitions are tied to fleet aging. As ships become older, the maintenance costs rise, and eventually they must be scrapped. However, the demolition of an old ship can of course be postponed if lease rates are high and accelerated if lease rates are low. Qua that logic, the demolitions term partially reflects active disinvestment decisions by ship owners.

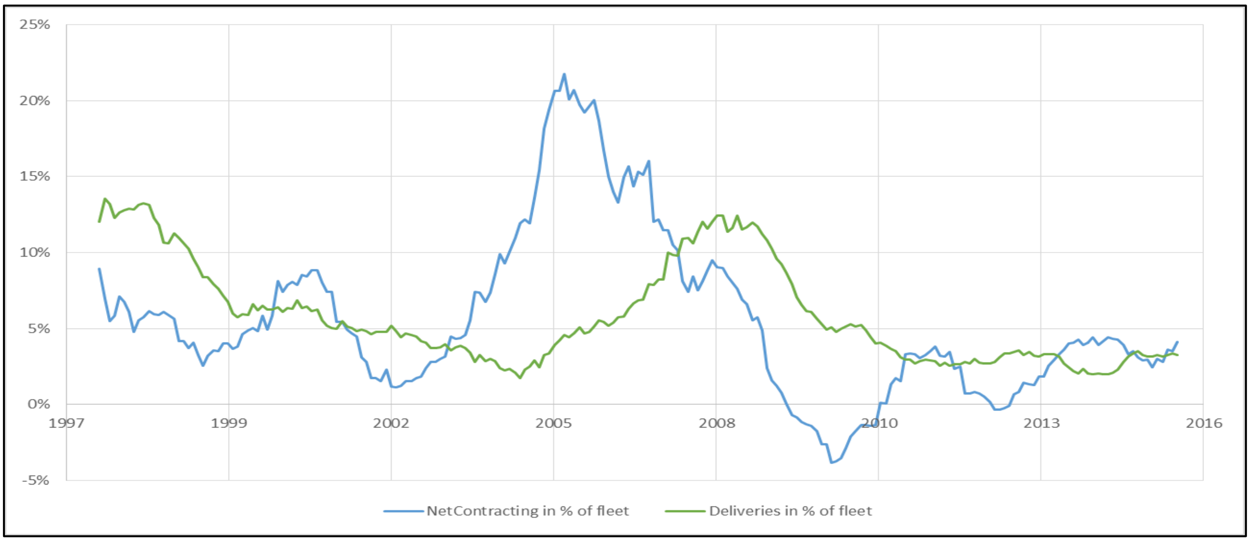
At the industry level, investment is the purchase of new vessels and not the resale of used ships. For our chosen period of analysis, Clarksons Research provides data on the industry wide order book, which is a general ledger of sorts, which mimics orders at shipyards around the world. The order book evolves as follows:

$$Orders_{t+1} = Orders_t + Contracting_t - Deliveries_t - Cancellations_t \qquad (41)$$

Hence, the change in the order book in year (t) equals new orders (Contracting), less ships delivered in that year (Deliveries), less previous orders that were cancelled (Cancellations). We continue to measure everything in teu. Based on *Equation (41)* we determine the measure for investment plans as the net contracting activity (i.e. contracting less cancellations) over the past 12 month relative to fleet size. As expected, investment is also extremely volatile. At its peak, annual net contracting amounted to 22% of the existing stock of handy size ships. The deliveries term in *Equation (41)* represents the realization of past investment plans. Once ordered, an average cargo vessel typically takes 18-36 months to build and deliver.

Despite the relatively small size of a 1-1999 teu container vessel compared to the market average, the lead time is not proportionately short, because the added work in for instance a Panamax box ship is mostly just an extension of the hull, which is not the most time consuming construction work (Stopford, 2009). Without having examined it more closely, we intuitively expect lead time to be longer in peak contracting periods, because shipyard capacity is relatively fixed in the short run.

Figure 37: Contracting and deliveries of new handysize vessels relative to fleet size



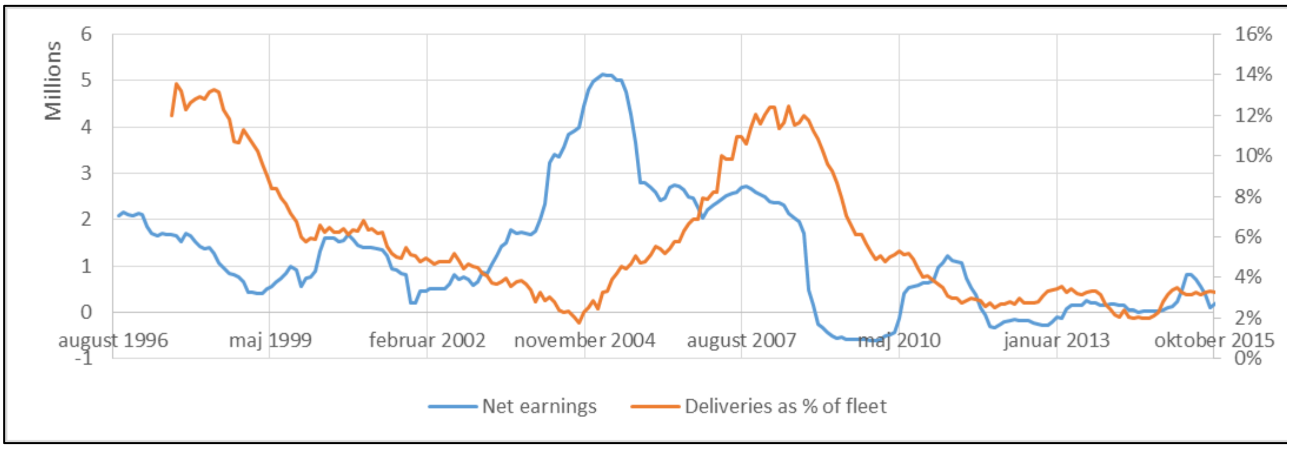
Source: Clarksons Research, authors calculations

It is evident from Figure 37 that there is a lead time between contracting and delivery of a new vessel, and that this lead time increases when more ship are ordered as we expected. Because capacity is fixed short term, a sudden spike in the demand for new ships will cause an extension of the average lead time. The key take away here is that the bulk of the new ships ordered in the peak of 2005, was not delivered until 2008 when the market crashed.

In Nicholas Kaldor's "cobweb" model of industry cycles, firms choose the quantity to produce based on the naive assumption that there will be "zero supply response, so that earnings will always be the same" as they were in a particular time period. The cobweb model is based on a time lag between supply and demand decisions, such as you may find in real estate, agriculture or indeed shipping, and describes cyclical supply and demand in a market where the amount produced must be chosen before prices are observed.

The dilemma becomes even more apparent when we compare net earnings to deliveries in *Figure 38*. Here we see that deliveries bottomed out when earnings peaked, which means that fleet growth was at its lowest (during the period of analysis) when the demand for new ships was at its highest because of the high net earnings. Those same high earnings caused a spike in net contracting, but the resulting increase in capacity was not realized until years later when the cycle had turned. Even though this pattern is of the handy size segment, the same dynamics played out for the industry at large, which is a big reason for the current overcapacity in the market.

Figure 38: Net earnings and deliveries in % of fleet for handysize segment



Source: Clarksons Research, authors calculations

6.3 Suggestive present value calculation

To further investigate the relationship between current net earnings, prices, investments and subsequent returns, we perform a simple present value calculation that suggests prices are far too volatile given the degree of mean reversion in earnings. If we consider a benchmark in which discount rates are constant, we can evaluate the apparent volatility in second hand ship prices, by comparing it to the actual time series of second hand prices (Shiller, 1981). For this model we will use 7,3% as the discount rate, which is the sample average of the weighted average cost of capital used in the DCF approach (see 5.2.2).

As before, we assume that a buyer of a five year old vessel receives the current lease rate (time charter) less operating expenses for 12 months following the purchase, and then continuously signs a new 12-month lease every year for the following three years. We estimate the earnings for the consecutive years based on the time series autocorrelation of earnings for the full sample (see Figure 39). Using this method, the ship owner will earn 0,62 times the current earnings plus 0,38 times the sample average from months 12 to 24, 0,28 times the current earnings plus 0,72 times the sample average in months 24 to 36 and 0,19 times the current earnings plus 0,81 times the sample average during months 36 to 48, after which she will just earn the sample average of earnings. All values are measured in 2015 USD.

Figure 39: Summary statistics for real net earnings (1-1900 teu handysize vessel)

N	Mean	Meidan	Std. dev.	ACF(k=1)	ACF(k=12)	ACF(k=24)	ACF(k=36)	ACF(k=48)
231	$ 1.220.422	$ 857.107	$ 1.329.810	0,992	0,618	0,282	0,188	-0,181

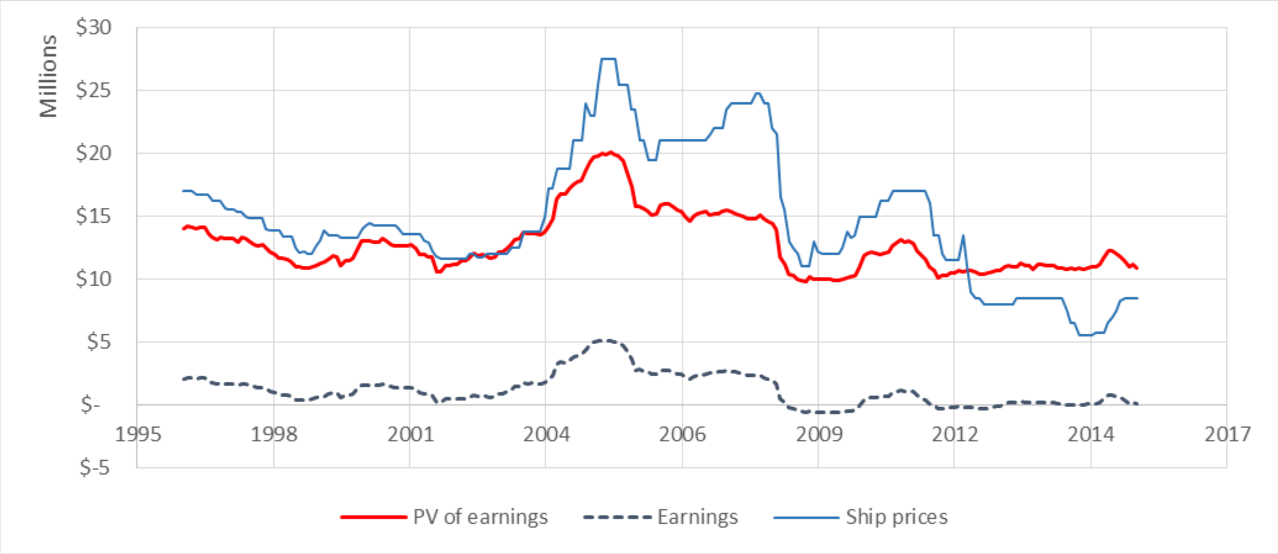
Source: Clarksons Research, authors calculations

After this initial four year period, we assume the buyer receives the sample average net earnings of USD 1,22 million each year. This is reasonable since there is no correlation between current earnings and those after four years. Because there is a tendency for older ships to lease at lower rates (Stopford, 2009), we reduce earnings by 15% once the ship is 15 years old. We continue to assume that containerships have an economic life of 20 years. Hence, a five year old ship will be scrapped after 15 years, and the owner will receive a scrap value. The scrap value is based on recent data from Clarksons Research and estimations from a projection of scrap value on steel prices. This yield the following present value calculation:

$$PV_t = \frac{\Pi_t}{1+r} + \frac{\widehat{\Pi}_{t+1}}{(1+r)^2} + \frac{\widehat{\Pi}_{t+2}}{(1+r)^3} + \frac{\widehat{\Pi}_{t+3}}{(1+r)^4} + \frac{\overline{\Pi}}{r} * \frac{\left(1 - \frac{1}{(1+r)^6}\right)}{(1+r)^4}$$
$$+0,85 * \frac{\overline{\Pi}}{r} * \frac{\left(1 - \frac{1}{(1+r)^5}\right)}{(1+r)^{10}} + \frac{Scrap_{t+15}}{(1+r)^{15}} \qquad (42)$$

Figure 40 shows that the model-implied present value of the cash flows from a container vessel is considerably less volatile than actual market prices. Consistent with Schiller (1981) and subsequent work of Campbell (1991) on the excess volatility of asset prices, the standard deviation of the model-implied present values is USD 2,56 million compared with a standard deviation of USD 5,19 million for second hand prices. The mean is USD 12,84 million for the model-implied present values and USD 14,77 million for the market values.

Figure 40: Model-implied present value versus market price of a second hand ship



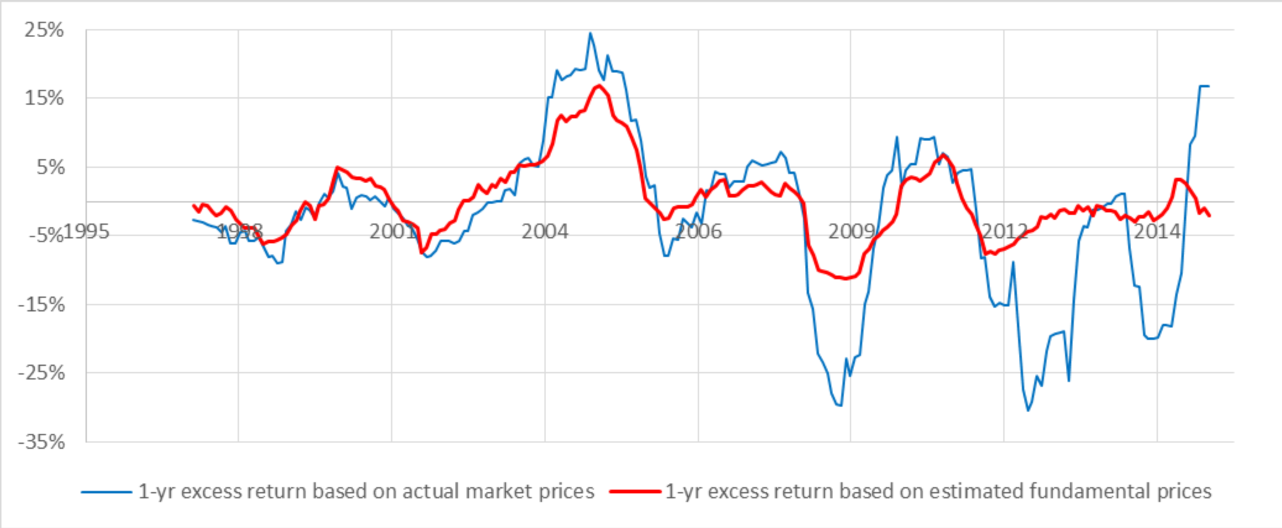
Source: Clarksons Research, authors calculations

The discrepancy mainly stems from the fact that this present value calculation is not as responsive to changes in current earnings, which are expected to be almost completely reverted away three years later. This is in sharp contrast to actual market prices, which is extremely responsive to current earnings, almost to a ridiculous extent. When earnings increase, market prices increase relatively more and vice versa. A quick univariate regression of the relative increase of market prices compared to real earnings reveal a statistically significant coefficient of 1,26%. This is not much, but all things considered it is still too much.

Taken together, this suggests that investors value vessels as if they anticipate considerably less mean reversion in earnings then what is indicated in the actual data. This is consistent with the over extrapolation of past movements in earnings, which means there is empirical evidence to support our hypothesis that $\phi_0 < \phi_i$, i.e. that the perceived persistence of demand shocks (ϕ_i) is greater than the actual persistence of those shocks (ϕ_0).

The model-implied value, which we see in *Figure 40*, immediately seems more judicious than the actual market prices. Given our knowledge about the market ex ante, we propose this time series is a more accurate estimation of fundamental values than actual market prices. To further substantiate this claim, we want to see how firms would have fared if they had traded at these prices. *Figure 41* shows one year log excess returns (see *(40)*) calculated using the same earnings, but with actual market prices and estimated fundamental prices respectively.

Figure 41: 1-yr excess return based on market prices and estimated fundamental values respectively



Source: Clarksons Research, authors calculations

We clearly see that the excess return from the estimated fundamental values are much less volatile, with a standard deviation of 5,50% and a mean of 0,06% compared to a standard deviation and mean of 11,46% and -2,19% for actual market prices respectively. Fundamental value refers to the value of an asset, in this case our reference vessel, determined through fundamental analysis without reference to its market value. With this definition in mind, we conclude that the model-implied present value from *Equation (*42) is a more accurate estimate of the fundamental value.

We recognize the reservation, that when ship owners procure new vessels, they are for the most part price takers. We have previously described how the lead time (time from order to delivery) increased during the shipping boom, indicating that the shipyards did not have the necessary capacity to accommodate the sudden increase in demand for ships. Under those conditions, ship owners would have no leverage to bargain about the price and would be forced to pay the inflated market price. A larger fleet was necessary to capitalize on the increase in demand from 2004 to 2009, and when the market grew, firms either grew with it or saw their market share decrease. The long term net cost of loss of market share is outside the scope of this paper, but is assumed to be relevant.

6.4 Forecasting future returns

Although *Figure 40* is suggestive of periods of mispricing, it does little to further our understanding of its origin. The rapid mean reversion is indicative of demand over extrapolation, but what about competitor response? *Figure 42* serves as an investigation into the relationship between future returns, and prices and investments respectively. Because we have computed the excess return for a five year old used handy size containership, we can compare this to market prices and industry investment. Our empirical investigation is organized around basic univariate forecasting regressions of the form: $rx_{t+k} = \alpha + \beta * X_t$. In other words, in section 6.1 we computed the excess return for holding periods of various length ex ante, which allows us to compare net contracting in the past year (as a proxy for investment), with the excess return the following k-years. The k-year forecasting regressions are estimated with monthly data. The biggest limitation of these regressions is the short time series of analysis. The abnormally persistent boom from 2003 to mid-2008 overweighs on the result. In addition, MS Excel, in which these computations are done, does not permit more advanced regression analysis that allow for serial correlation (Newey and West, 1987).

Table 24: Univariate regression statistics with following 1-yr excess return (rx_{k+1}) as the dependent variable

Panel A: Using Market Prices as the explanatory variable (X_t)

Regression Statistics	
Multiple R	0,137863393
R Square	0,019006315
Adjusted R Square	0,014485607
Standard Error	0,113787861
Observations	219

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0,054435637	0,054435637	4,204278191	0,041524019
Residual	217	2,809645984	0,012947677		
Total	218	2,864081621			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0,026048817	0,024639297	1,057206182	0,291592994	-0,022514161	0,074611795
Price	-3,1598E-09	1,54104E-09	-2,050433659	0,041524019	-6,19712E-09	-1,22478E-10

Source Clarksons Research, authors calculations

Table 19 (continued)

Panel B: Using NetContracting (Investment) as the explanatory variable (X_t)

Regression Statistics	
Multiple R	0,006640001
R Square	4,40896E-05
Adjusted R Square	-0,004833744
Standard Error	0,11807815
Observations	207

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0,000126023	0,000126023	0,00903877	0,924350152
Residual	205	2,858202142	0,013942449		
Total	206	2,858328164			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-0,020071022	0,011825213	-1,69730748	0,09115613	-0,043385653	0,003243609
Investment	-0,014226494	0,149638455	-0,095072444	0,924350152	-0,309254194	0,280801207

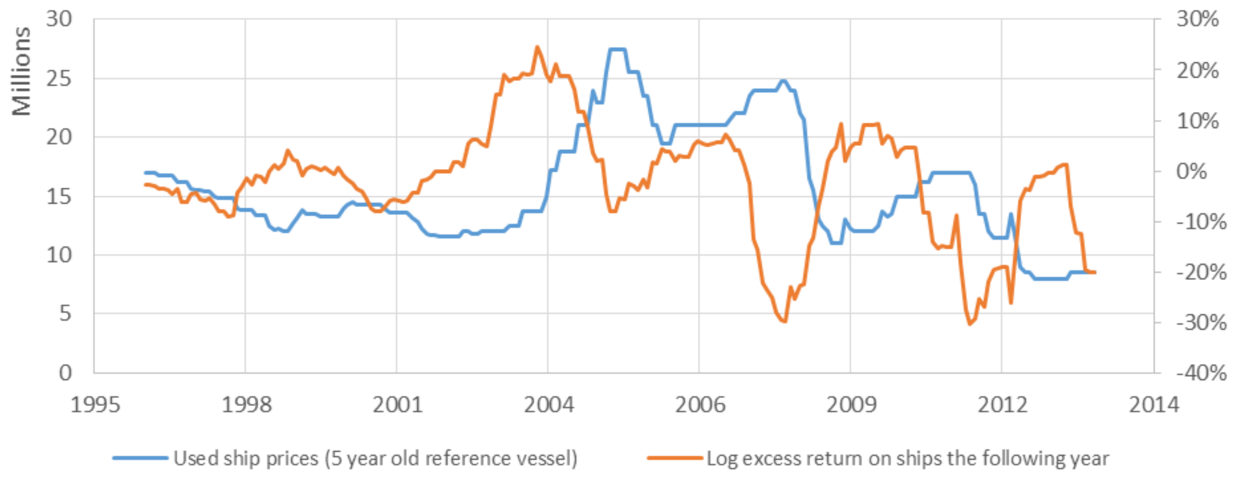
Source: Clarksons Research, authors calculations

It is remarkable, that both variables: investment and prices, negatively forecast the following years return. The regression coefficient for investment is -0,014, implying that for every one pct. of the handy size fleet invested in the market (new build), the following years excess return drops 0,014 percentage points. Albeit a modest slant, it is still noteworthy that industry investment has a negative effect on future return. However, the P-value of 0,92 (see Panel B in *Table 24*) suggests that changes in the dependent variable is not associated with changes in the response. The p-value tests the null hypothesis that the coefficient is equal to zero (no effect). A high p-value (> 0.05) indicates that we cannot reject the null hypothesis. In other words, because Investment has such a high p-value, it is likely not statistically meaningful.

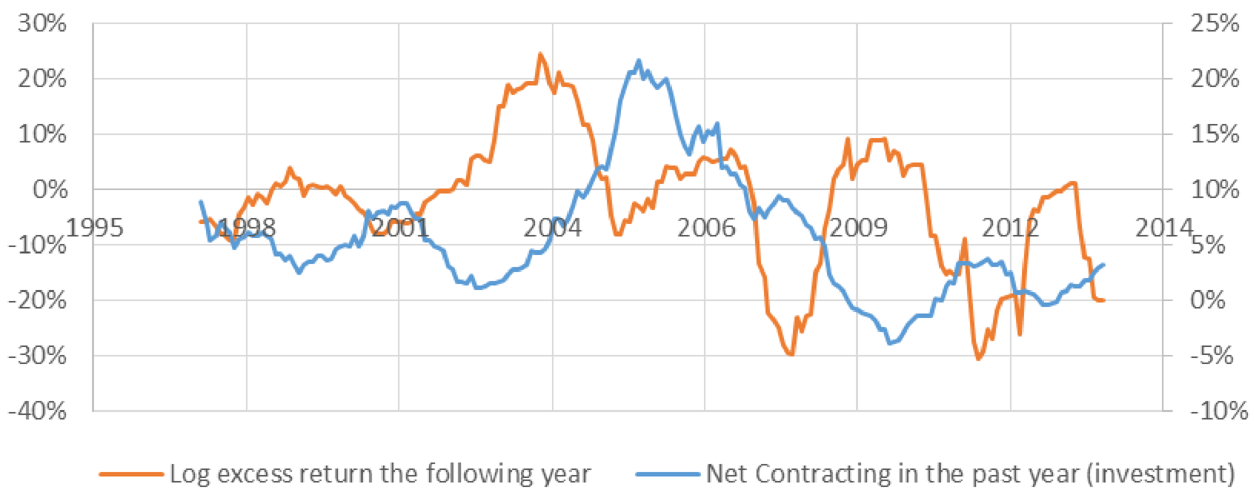
Conversely, the P-value of 0,04 for Prices (Panel A in *Table 24*) indicates that changes in the predictor's value are significantly related to changes in the response variable (excess return). Because ship prices react strongly to transient movements in earnings, the ability of prices to predict future earnings is limited, so high prices negatively predicts future returns. This is consistent with Schiller and Campbell (1988). The economic magnitude of this result however, is surprising. A one standard deviation increase in real prices (USD 5,19 million) is associated with a 2,66 percentage point decline in excess return the following year. At the peak of the cycle in June 2005, (USD 27,50 million), the regression implies an expected excess return over the following two years of -6,95%.

Figure 42: Relationship between prices, investments and future returns

Panel A. Second Hand Prices (P_t) and Future Returns (rx_{t+1})



Panel B. Investments (NetContracting_t) and Future Returns (rx_{t+1})



Source: Clarksons Research, authors calculations

A natural interpretation of the above results is that shipping firms make systematic mistakes in the form of biased expectations about future earnings. These biases could explain why vessel prices soared to such highs in boom, despite the rapid mean reversion that is evident in the historical data. We are not the first to propose the idea that shipping investors have biased expectations. It is evident in the narrative accounts shipping cycles by Stopford (2009): “First, a shortage of ships develops, then high rates stimulate over-ordering … which finally leads to market collapse”. Similarly, Metaxas (1971), in his analysis of fluctuations in the shipping market, argues that: “The duration of the prosperity stage of the “boom” is largely determined by the endemic tendency to overinvest and by the rapidity with which new tonnage can be created in relation to the magnitude of the original increase in demand". Even though we cannot prove statistically that industry investments negatively forecast return, as evidence of competition neglect, we can still clearly see from Panel B in *Figure 42* that investments and subsequent return are very modestly correlated. Noteworthy, when investments are high, return the following year is low; a trend that is consistent throughout the period of analysis.

We have shown that high levels of prices and investments each negatively forecast returns in a univariate regression, albeit the latter with an unacceptably poor significance. However, we want to know if these variables contain separate information about future shipping returns, specifically if prices and investments have separate forecasting power. We address this question by bivariate regressions using both variables:

$$rx_{t+k} = \alpha + \beta_1 * Price_t + \beta_2 * NetContracting_t \quad (43)$$

Table 25 shows that second hand prices and our investment proxy (net contracting) contain independent information about future shipping return. Compared to Panel A in *Table 24*, the coefficient on price is slightly smaller in magnitude in these multivariate regressions, but still remain both statistically and economically significant.

Table 25: Bivariate return forecasting regression of 1-3 year excess return

k	1-year	2-year	3-year
β1 (prices)	-1,1E-08	-2,6E-08	-2,8E-08
β2 (investments)	0,632	1,710	1,909
P-value (β1)	9,97E-05	2,50E-10	5,37E-08
P-value (β2)	5,72E-03	1,91E-07	2,83E-06
R^2	0,082	0,201	0,154

Source: Clarksons Research, authors calculations

We find empirical evidence to support our over extrapolation hypothesis (see section 6.3), that is taking account of the rapid mean reversion by correcting for autocorrelation in earnings, we arrive at a more accurate estimate of the fundamental values, which indicates that ship owners over extrapolate demand shocks. Basically, when the market is booming, firms have unrealistic expectations of the persistence of that boom and vice versa. We do not, however find evidence to support our hypothesis of competition neglect. Statistically, we falsify the hypothesis because our univariate regression on the forecasting power of investment on future returns is insignificant, which means we cannot reject the null hypothesis that the coefficient is equal to zero (no effect). Empirically, we still see a pattern in the data (see Panel B in *Figure*

42), that is suggestive of competition neglect. We refer to a similar study by Greenwood and Hansen (2013), which does indeed find significant statistical evidence to support this, however for the entire bulk fleet and for a much longer time series. Their research even attempts to estimate the exact value of the competition awareness ($1 - \lambda = 0{,}454$). Unfortunately, longer period data series are not recorded for container shipping, but we maintain our claim of the importance of this for future studies. For the purpose of this study we conclude, based on our analysis, that competition neglect does not contribute to the unaccounted for variation (residuals) between model implied and actual market prices. This also means that we will not attempt to account for this in our improved valuation model.

7 Developing an improved vessel valuation model

Referring to section 5.2.3.2, the LTAV valuation model suffers from 'look-back' bias (we recognize the comparison to driving a car only looking though the rear-view mirror). When examining the residuals compared to the Mark-to-market (M2M) model in *Figure 29*, it becomes clear that while the LTAV might suit the purpose of its name (Long Term Asset Valuation), it badly misses market prices. For that reason, our starting point is the M2M model, although we have substituted the Clarksea Index with the earnings series for the handy size segment calculated with *Equation (38).* We refer to section 6.1 for a detailed explanation of why we prefer our own time earnings series. To account for the growing overcapacity in the market, we have included supply relative to demand (supply/demand), measured as Clarksons series "World Container Seaborne Trade" and "Total Container Fleet Development" respectively; both measured in teu. As described in section 2.6, the problem with 'nominal' teu as a measure for capacity, is that it is indifferent to the distance of travel. This is significant, because demand in this case is measured as world container exports, i.e. how many, not how far. Ceteris paribus, a vessel transporting from Copenhagen to Hamburg can sail the route several times in the time it takes a similar sized ship to sail from Copenhagen to Singapore, but they account for the same relative proportion of total fleet capacity. The consequence of high bunker prices is that the vessels are more profitable at low speed (slow steaming), even though it is then less 'effective' in teu-miles, because the decreased vessel speed lessens the teu-mile per ship. Because a 20% reduction in speed reduces bunker cost by 50%, as the bunker price rises, it pays to lower the speed and vice versa, influencing the 'real' capacity of the world fleet. Recognizing this trade-off between bunker cost and teu-miles per ship, we have included bunker cost as a parameter in the regression. Because we do not have access to data on the fuel consumption of all vessel classes and the distance for all sail routes, the combination of supply relative to demand and bunker price is a best-guess approximation to capacity measured in teu-miles. Looking at the summary statistics in *Table 26,* we see that the coefficient for bunker price is positive, which is what we would expect based on our research. When the bunker price goes up, the world fleet slows down in order to preserve fuel, which decreases the capacity in teu-miles, increasing demand for ships, which in turn drives the price up. It also follows logic intuition, that an increase in supply relative to demand, i.e. an increase in capacity, negatively affects prices.

Table 26: Summary statistics for our new handysize vessel valuation model

Regression Statistics	
Multiple R	0,909060843
R Square	0,826391616
Adjusted R Square	0,825972879
Standard Error	3478350,589
Observations	2079

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	5	1,19388E+17	2,39E+16	1973,534	0
Residual	2073	2,50811E+16	1,21E+13		
Total	2078	1,44469E+17			

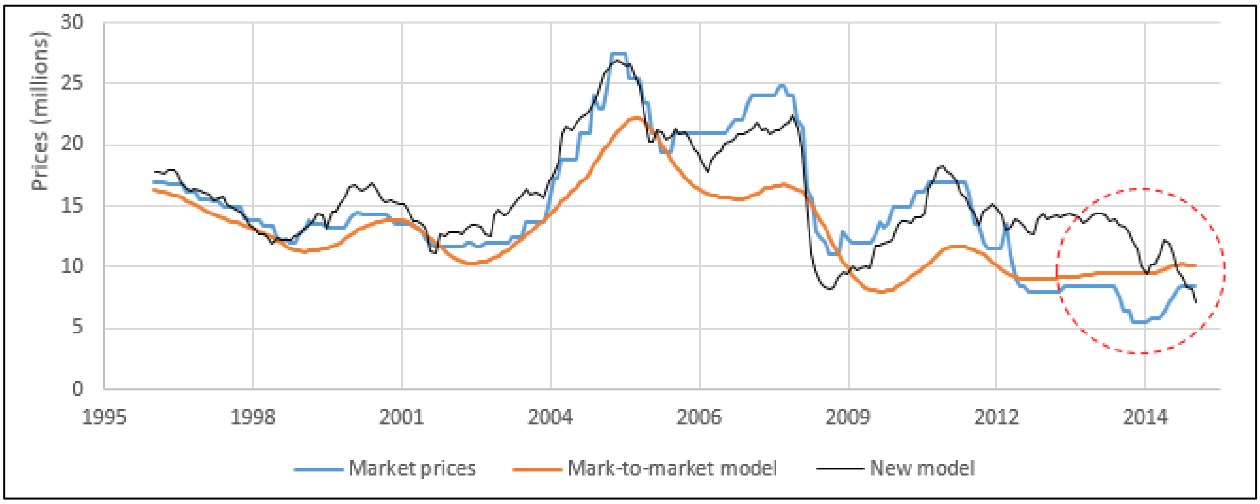
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	20868524,83	834342,4917	25,01194	6,9E-121	19232288,25	22504761,41
Earnings ($)	2,641619879	0,050448486	52,36272	0	2,542684899	2,740554859
Age (yr)	-862916,4282	18779,43084	-45,9501	0	-899744,9392	-826087,917
Bunker ($/MT)	12756,24848	617,661458	20,65249	2,53E-86	11544,94703	13967,54993
Size (teu)	2893,85197	213,8910324	13,52956	4,97E-40	2474,38834	3313,3156
Supply/demand (%)	-10795909,72	869503,8697	-12,4162	3,4E-34	-12501101,59	-9090717,85

Source: Clarksons Research, authors calculations

As opposed to the M2M model, we calibrate our regression using ‘generalized’ data for the handy size segment. Our main innovation is applying data for 5-year, 10-year and 15-year old vessels respectively, for both 1050 teu, 1700 teu and 1975 teu handy size vessels. That way, we obtain 2079 observations for our regression and we get a more robust result. Consequently, our model is suited for evaluating any size and age vessel within the handy size segment (1-2000 teu).

As expected, earnings and size positively affects price, while the opposite is true for age. Looking at the statistics, we see some very impressive P-values, which means that all the coefficients are highly significant (<1%). A note for the reader: when MS Excel computes a sufficiently small number, it simply returns a zero as in this case. We refer to section 5.3.2 for a more thorough explanation of the regression summary. Generally speaking, the F-test is very impressive, and we see from the adjusted R-square that we have a good explanatory power (how well data points fit a line). We look at adjusted R-square because our regression includes a diverse number of predictors. R-squared compensates for the addition of variables and only increases if the new term enhances the model above what would be obtained by probability and decreases when a predictor enhances the model less than what is predicted by chance.

Figure 43: Actual and estimated prices for a 5-yr old handysize vessel (1-2000 teu)

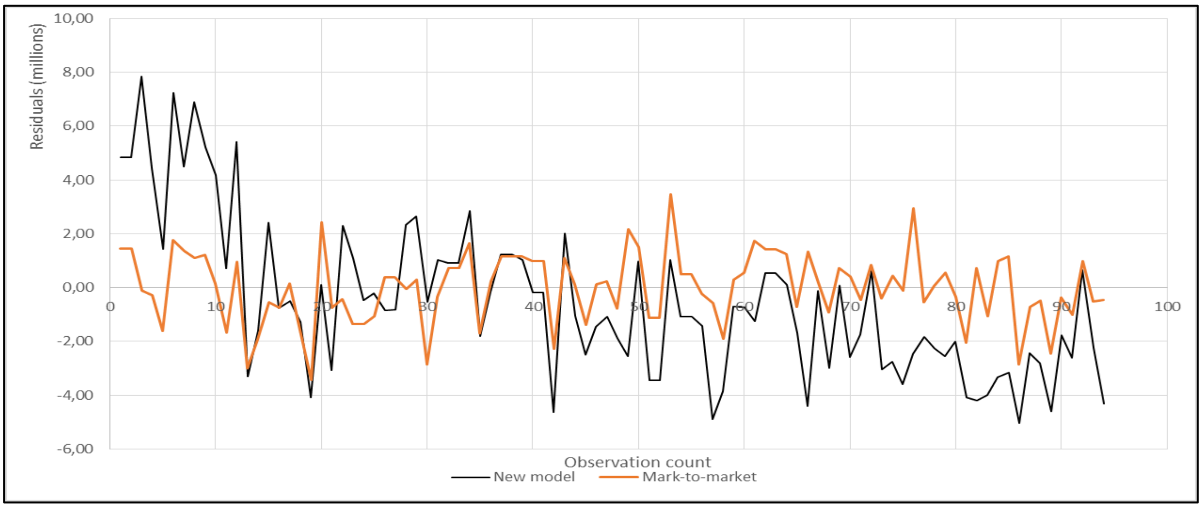


Source: Clarksons Research, authors calculations

When we plot the estimated price from our new model against estimations by the M2M model, we see a clear improvement. In fact, all the way up until 2012, there are few noteworthy discrepancies, except a slight miscalculation in late 2007 and 2008. Until then, our model performs beyond expectations. However, in the latter three years, the model is way off its mark, indicating that there is some variation in the market, that is very much unaccounted for; something that emerges as a significant factor around 2012.

We wish to compare our model to the prices of specific trades estimated by the M2M model. Remember we had close to a hundred actual trades, with the names and information of ships being bought and sold (see section 5.3.3). There are two things to consider. 1: the M2M model was calibrated using these exact trades, so we expect it to be more precise (it is what is was built to do), and 2: the trades all take place between 2013-2015, which is exactly the period of time where our model is worst skewed (the red indication in Figure 43). *Figure 44* depicts the residuals for those specific trades, for both the M2M model and our new model.

Figure 44: Estimation errors for specific trades sample 2013-2015

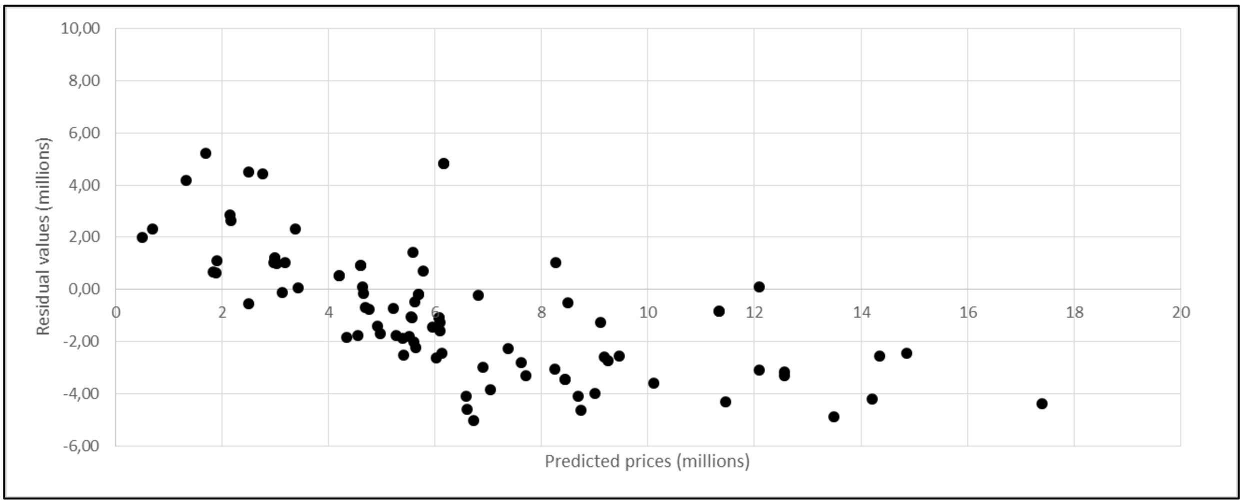


Source: Clarksons Research, authors calculations

Obviously our new model does a poorer job than the M2M model for the period 2013-2015. Although, despite the sum of squared residuals being four times as big for these 94 transactions, compared to the M2M model, our new model was built to match a much longer time period, and our data shows that this is the very worst it can do. Under those circumstances, we are quite pleased with the result.

Of course we are not oblivious to the huge discrepancy between 2010-2015. The residuals in *Figure 45*, plotted against estimations by our new model, indicate that the largest estimation errors correspond with the highest estimated prices. Clearly, in that short time period, there is something our model fails to account for. We have tried including different economic indicators, but with no luck.

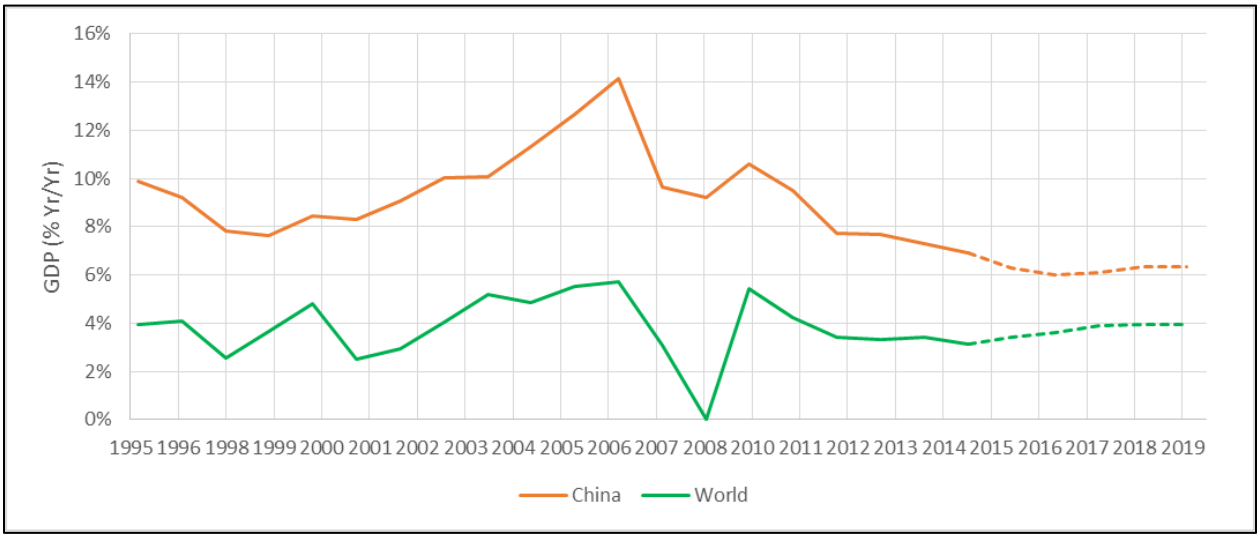
Figure 45: Residual plot against predicted prices for our new valuation model



Source: Clarksons Research, authors calculations

One interesting fact is the development in China, which is vital for the container industry. *Figure 46* shows year over year GDP growth in China compared to the rest of the world. We notice how growth in China has been decreasing more or less since 2006 and is expected to continue to decrease until it bottoms out somewhere between 2016-2017. Naturally, this makes investors and ship owners nervous, because such a big part of their business hinges on Chinese growth. Even though it does nothing to mitigate the discrepancy between 2010-1015 if we include GDP in our model, we suspect that the recent development plays a role in variation we are seeing. By construction, the regression has to take into account all data point, which might be the reason the entire time series have little impact on the variation in 2012-2015.

Figure 46: Year over year growth in World and Chinese GDP



Source: Clarksons Research

As we have already stipulated, our analysis suffers from data limitation. Longer time series and more specific trades over a longer period, would greatly enhance the validity and presumably the accuracy of the model. We hope that our analysis can serve as a fresh glance at a well researched industry, and that our model will serve as the foundation for further study using more extensive and in-depth data. We imagine that shipping firms have access to these kinds of data in-house. The value of accurately calculating the market price need to be addressed, since naturally, these prices contain all the previously accounted for cognitive biases and irrationalities, i.e. they might be artificially inflated or deflated. However, we assume that shipping firms have a fairly good idea of future earnings. By that we mean that they know their OPEX and survey cost exactly, might have long-term lease rates in place, may operate a large part of their own fleet, hedged their bunker cost via future contracts or interest rates via swap agreements etc. etc. Given shipping firms' best-guess estimate of future earnings – and considering the over extrapolation we have accounted for – accurately estimating market prices will allow ship owners to form an informed opinion about the attractiveness of new investments.

7.1 Adjusting for capacity in real TEU

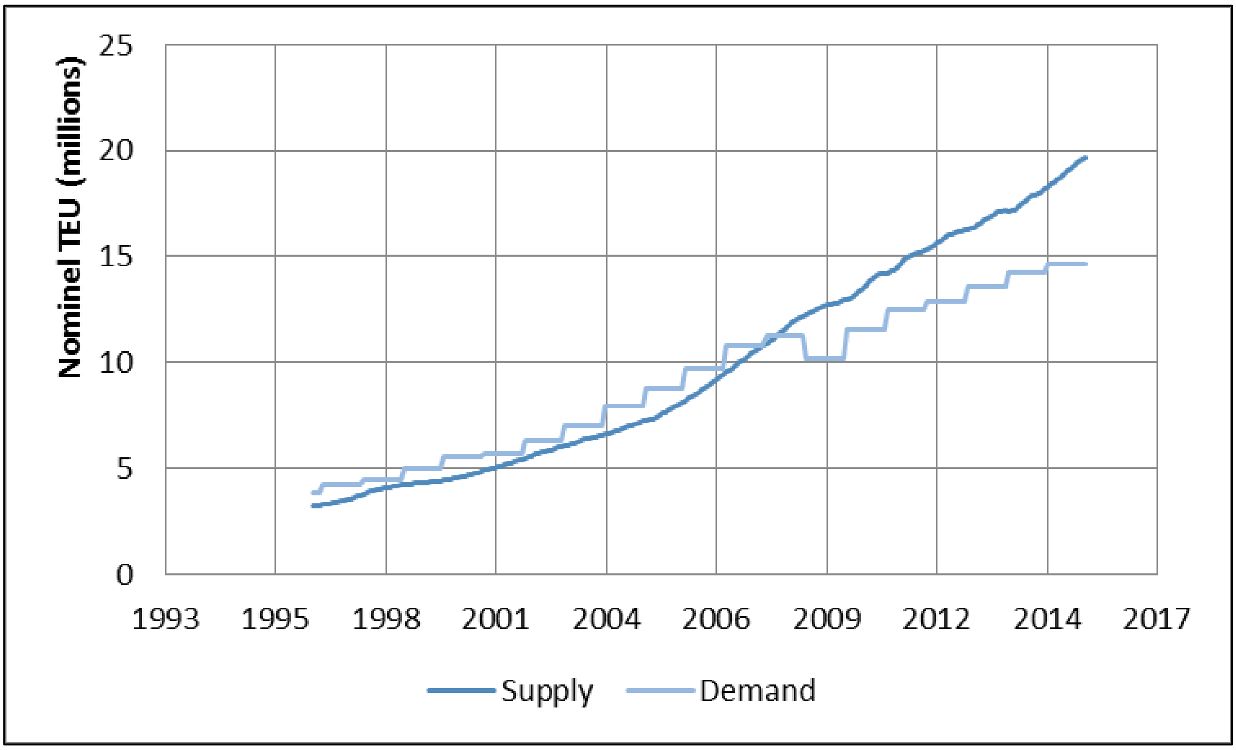
The previous section describes roughly the nominal TEU versus real TEU issue but only accounts for the nominal TEU in the regression. It creates a mediocre link between the demand and supply, within containerized shipping. The nominal TEU is a static measure, but actually it is influenced by external parameters, meaning the bunker price. Nominal TEU alone is therefore containing variation that could be accounted for by looking at it in another perspective.

The advantage of viewing the profit function as in equation *(13)* from the 'speed/bunker consumption' model is, that if the relation between BQ_M and the speed is known, then deriving the optimal speed from this, opens the possibility of estimating the supply in TEU miles as a function of the bunker price. This is as described earlier a more precise benchmark when accounting for the supply side in shipping. When the fleet size and the speed of it is known the real TEU ($\mathrm{TEU_M}$) can be analyzed in relation to the demand for $\mathrm{TEU_M}$. Deviations from market equilibrium should make it more likely to anticipate the direction of e.g. the second hand vessel markets, because an oversupply of TEU miles, would minimize the demand for more vessels, and practically also impact the freight rates. The analysis requires that firms like Maersk know how much bunker fuel they consumes at the different speeds, however this seems reasonable to assume since this expense is significant. Nevertheless, if it is not the case, they could by tracking their speed in a given period, use the method from section 2.6 to calculate their $\mathrm{BQ_M}$.

The benefits of knowing the real $\mathrm{BQ_M/Speed}$ relationship is that the profit can be optimized as a function of the speed. In addition, to being applicable of assessing the market, the general profit maximizing vessel speed further allows the calculation of the supplied $\mathrm{TEU_M}$ instead of TEU capacity.

$\mathrm{TEU_M}$ for the market would practically be a function of the vessel speed, days operating per year and their sizes in TEU. This measure is assumed to be more consistent, and a better expression of the market supply, especially when the fluctuations in the bunker prices is taken into account (*Figure 13*). Considering the significant p-value on $3{,}4 * 10^{-34}$ for the supply/demand (%) as independent variable in the new regression model (*Table 26*), makes it necessary to discuss this. The reason for this is, that the supply/demand (%) is significant in the model, and the above assumption is that it is insufficient, but it should be noticed that the new regression model is predicting the real market prices, which we have proven does not unilaterally equal fundamental values. This could indicate that the market participants do not consider the real TEU, either because of unawareness or maybe from lack of data. As we have described, firms are well aware that slow steaming decreases their fuel spending and the data we suggest for the profit function with respect to cruising speed is easily collected. If market participants do not in fact consider TEU miles, it is a further proof of market irrationality, because rational market players per definition base their choices on rational calculations and their choices are aimed at optimizing their profit. Furthermore, it is consistent with the 'bad models' view, made possible by cognitive dissonance (see section 4, where we build our hypotheses for a detailed explanation of this relationship). If this is the case, a measure of capacity in real instead of nominal TEU would be far more relevant in the prediction of fundamental values.

Figure 47 Nominal TEU capacity and demand



Source: Clarksons Research

TEU_M supply relative to TEU_M demand will, all other things being equal, be an indicator of the direction in the earnings, since an over/under supply would affect the prices incorporated in earnings. If *Figure 47* is considered, is should be clear that in nominal terms the supply substantially exceeds the demand, but with a further analysis of this combined with the low bunker prices in *Figure 10*, the findings could be even more significant. Furthermore, with certain expectations to the market development, it will be possible to calculate the adjustment from expectations. In section 2.4 we account for the relationship between bunker price and the price of crude oil. If the market participants have certain expectations about the development of crude oil, the method of predicting the real TEU supply as a function of the expected bunker price from the estimated development in crude oil prices should be obvious. A study by Oxford Institute for Energy Studies (Bacon, 1968) found that the mean time lag between changes in crude oil prices and subsequent changes in bunker prices were 4,5 month. An increase in crude oil prices, which we have seen since the middle of February 2016, can thus be expected to soon carry over to bunker prices as well. This is of course an oversimplification that does not take into account hedging, currency exchange and emission charges, but it is indicative of the value proposition from better understanding the relationship between speed, fuel cost and real capacity.

As already stated, the initial profit function is a draft, but could easily be enhanced by including port/canal fee as fix cost. Also, the assumption that the freight rate is independent of the time of the freight, could be overcome by substituting the freight rate (FR) with the function of the freight rate with respect to the time of the freight.

8 Conclusion

- *How can we define irrational behaviour in the clamping field between business cycles and speculative bubbles?*

There are several strands of rationality in academic literature. There is the concept of instrumentality, which is basically the idea that individuals and firms are instrumentally rational, that is they use the optimal tools at their disposal, to best achieve their goals. There is the axiomatic concept that rationality is a matter of being logically consistent with preferences and beliefs. Finally, there is a strand that focuses on accuracy of beliefs and the full use of information. In this view, individuals or firms who are irrational, have beliefs that does not make full use of the available information.

We define rationality within the confines of rational choice theory, which basic premises are that 1: individuals base their behaviour on rational calculations, 2: they act with rationality when making choices and 3: their choices are aimed at optimizing their pleasure or profit.

Scholars within economic sociology debates whether or not individuals or firms are fully rational, i.e. rationality defined according to rational choice theory as above, and whether it makes sense to model them as such in formal models. The term homo economicus (the imaginary amoral but logically consistent man assumed in neoclassic models) was coined in honour of this view. The theory of homo economicus has gone on to portrays humans as consistently rational agents who pursue their subjectively-defined ends optimally. The rational agent is assumed to take account of all available information in determining preferences, and to act consistently in choosing the self-determined best choice of action. Rational asset prices thus only reflect utilitarian characteristics like risk, and not value-expressive characteristics like sentiment.

Our working definition of a bubble is as an episode were irrationality causes vessel prices to increases above their fundamental price, higher than they would have in the absence of that irrationality, and were a rational observer with access to all available information would forecast a lower return on those vessels. We rely on Blanchard to mathematically account for a bubble by isolating the term ($\lim_{m\to\infty} \frac{p_{t+m}}{R^m}$), in *Equation (19)*, which if equal to zero leaves the asset price equal to its fundamental value (see section 3.1.1). The bubble element appears whenever there are expectations of returns not based on cash flows (dividend payments), and is thus characterized by an irrational price element added to the assets fundamental value.

As we explain, boom and bust cycles exist in all industries, and the threshold between that and a bubble is only really apparent in hindsight. A bubble is typically a retrospective of an excessive valuation of an asset class. When asked in 2005, if there would be a return to the overcapacity that characterized shipping in the 1970s, Martin Stopford, managing director of Clarksons Research, said that "Shipping is not in a bubble but a 'super-cycle'. By the 1990s, the industry had finally shed the crushing burden of the huge oversupply there had been since the 1970s and it is unlikely to recreate it." In hindsight, we might be inclined to disagree; we know that the industry has is in fact been suffering under a similar burden of oversupply that characterized the 1970s. In every market there are always people claiming that prices are too high. That is what makes a market, and the purpose of this paper is not to cast blame, but rather to constitute a cause-and-effect investigation which can lead to more informed choices in the future.

We conclude that the only difference between a super-cycle and a bubble is magnitude of the expansion relative to the subsequent contraction and the inclination of the decline, both of which are only apparent ex ante. From this perspective, bubbles represent exaggerations of the normal cyclical behaviour of assets. An attempt to distinguish between boom-bust cycles and bubbles could be that boom-bust cycles is a financial phenomenon, in which valuations greatly depart from underlying fundamentals, whereas bubbles have elements of a social-psychological mania with 'blow off tops' Eventually crashes occur because instead of returning to fair value, the overpriced assets become the object of frenzied speculation (see section 3.1.2). Based on our definition of fundamental value however, the distinction is indifferent. If we find evidence of time periods where vessel prices persistently traded at prices higher than their fundamental value, those prices reflect value-expressive characteristics and are per definition irrational.

- *Is there evidence of behavioural biases in second-hand vessel pricing in containerized shipping?*

From our quantitative analysis of historically estimated second hand prices using the mark-to-market approach and the long term asset value approach, we conclude that prices deviate from the fundamental value estimate in a period from 2004-2013. We conclude this based on the fact that the two most commonly used vessel valuation models both estimate values significantly below actually traded prices in this period. This is per construction either a flaw in the models or an indication of unaccounted for variation. Since the models are based on completely different computations, it is unlikely that they both make relatively similar forecasting errors, i.e. varying in magnitude, but similar in direction. This leaves us with an unaccounted for variation. When analysing the market ex ante, the 2004-2009 "super-cycle" is indicative of a period of mispricing, and taken together with the results from the historical valuation, it is reasonable to conclude that fundamental values varied from market prices between 2004 and 2013. Remember that we define fundamental values as the value of a vessel determined through fundamental analysis without reference to its market value (see section 1.4). Since our research shows the mark-to-market -and discounted cash flow approach to be the most common vessel valuation models in our period of analysis, it follows intuitively that vessels persistently traded at higher prices than their fundamental value between 2004 and 2009. Referring to our previous conclusion of rationality, this is per definition irrational. This may seem like an over simplified deduction, but it follows from a lengthy discussion and is underpinned by a thorough valuation analysis. It leads us to boldly conclude that the market for second hand container vessels is indeed prone to irrational behaviour.

Our two primary hypotheses, which we want to test empirically, are that ship owners neglect the competition ($\lambda < 1$) and over-extrapolate demand ($\phi_0 < \phi_i$). We refer to our section on hypotheses building (4) for the details, but basically we propose that prices react over-aggressively to demand shocks because ship owners over extrapolate the persistence of those demand shocks and underestimate the supply response of their competitors. As a result, firms neglect the mean reversion of earnings, i.e. demand shocks revert more quickly than anticipated, which leads to low future returns. We suggest that this is due in some part to ‘bad models’, i.e. bounded rationality, but that it is only possible because of widespread cognitive biases. Specifically, mental substitution and representativeness heuristic (recency bias) as well as cognitive dissonance (belief manipulation hypothesis), amplified by ambiguity aversion (competency hypothesis).

By investigating the relationship between prices and earnings, we identify a pattern of mean reversion in earnings. Quantitatively this comes across in the autocorrelation, which shows that changes in demand are expected to be almost completely reverted away three years later. Prices are clearly responsive to earnings, which we would expect, but significantly amplified. Further investigation shows that earnings yield (earnings relative to prices) oscillates considerably. When earning are high, so are prices, but price do not rise proportionately, which is what we would expect to see if firms recognized the mean reversion in earnings. Instead, when earnings increase, market prices increase relatively more and vice versa, consistent with our hypothesis that firms over extrapolate demand shocks. In section 6.4 we forecast 1-3 year excess return with industry investment approximated by net contracting the previous year, to investigate if we can find evidence to support our hypothesis of competition neglect. While we see a pattern in the data (see Panel B in *Figure 42*), that is suggestive of competition neglect, we are unable to statistically prove our hypothesis. It is interesting however, that because the lead time for a new vessel is 12-36 month, demand shocks is expected to be almost completely reverted away three years after they occur, new investments is almost consistently made when earnings are high and enter the market when earnings are low (see *Figure 38*).

As previously described, the idea of over extrapolation is far from novel. In a 1996 speech called “The Challenge of Central Banking in a Democratic Society”, Allan Greenspan (then chairman of the FED) referred to boom-bust cycles with the term “irrational exuberance”, i.e. unsustainable investor enthusiasm that drives asset prices up to levels that aren't supported by fundamentals. “Irrational Exuberance” is also the title of a 2000 book by Robert Schiller, analysing the broader stock market boom that lasted from 1982 through the dotcom years. Our findings contribute to existing literature by proving that irrational exuberance is not confined to retail investors, but also thrives among shipping analyst. Our research suggest that not even procurement managers at large shipping firms are immune to a social-psychological biases, and thus further chips away at homo economicus, the model of human behaviour assigning humans the infinite ability to make rational decisions. We view this as a contribution to the current break-up with axioms of conventional finance as described in section 3.2.1.

- *Can we apply our analysis to more accurately estimate the value of a second-hand container vessel?*

We have shown that the two common vessel valuation models either suffer from bad input, look-back bias or fail to encompass significant market factors. At least when compared to actual market prices. Naturally, the LTAV is supposed to capture the fundamental value of the vessel, but as we argue, because of the extensive use of sample averages, it is almost non-responsive to changes in current earnings, i.e. they are simply weighed in equally over a 10-year period. This also means that present day calculations is based on earnings from the most extraordinary boom-bust cycles in shipping history (2005-2015). In this light, is reasonable to assume that the next 10 years will look different from the past 10 years, which significantly inhibits the model. As a better estimation of the fundamental values, we offer our suggestive present value calculation from *Equation (42)*. The suggestive present value calculation mitigates the over extrapolation, by estimating earnings over the next four years as a weighted average of the statistical autocorrelation and the sample average. From year five to the end of the vessels economic life, we use the sample average earnings, but we subtract 15% in the years after the vessels become 15 years old. This yields a model that can attenuate the impact of over extrapolation, and prevent it from adversely affecting the valuation in the way that it have recently done. By calculating one-year excess return based on these earnings, but with estimated fundamental prices instead of market prices, the result is a standard deviation of 5,50% and a mean of 0,06% compared to a standard deviation and mean of 11,46% and -2,19% for actual market prices respectively. Clearly the excess return from the estimated fundamental values is much less volatile. Although a useful result, it is an oversimplified model, that does not take into account other factors which our analysis suggest impact vessel prices. A major shortcoming of the model is that we have no way of testing the result; the entire validity lies in the arguments for the input. Because we have nothing to compare our result with, we have no way of knowing if a variable is useful for our purpose. For that reason, instead of trying to improve the suggestive present value calculation further, we focus on the mark-to-market model, which we can test statistically.

With this approach (multivariate regression), we succeed in developing a model that estimates market prices significantly more accurate than the mark-to-market approach. An important recognition however, is that the mark-to-market model as described in this paper is not complete. The literature surrounding this model actually suggests adding significant explanatory variables, which is what we have done here. Our contribution lies in identifying which variables, based on the finding in our analysis. Also, we adjusted revenue (time charter) and cost (operational expense and survey-cost) to more accurately describe our chosen segment (1-2000 teu handy size). In addition to being more accurate, this also allows for a more agile model, because we can scale up and down according to individual firms operational expense and dry-docking cost as well as long-term charter leases. Our main innovation is applying data for 5-year, 10-year and 15-year old vessels respectively, for 1050 teu, 1700 teu and 1975 teu handy size vessels. By applying a little trickery in excel, we were able to also correct for the 15% reduction in earnings for vessels older than 15 years as we did in the suggestive present value calculation in section 6.3, and adjust OPEX according to the different aged vessels (see *Table 12* for operational cost adjusted for age). This way, we obtain 2079 observations for our regression and we get a more robust result. Consequently, our model is suited for evaluating any size and age vessel within the handy size segment (1-2000 teu).

For the most part, the new regression estimates the market prices with satisfying accuracy. Importantly, the market prices contain all the previously accounted for cognitive biases and irrationalities, i.e. they might be artificially inflated or deflated. The usefulness for shipping firms, besides being in a better position to bargain the price, is that they know the model parameters and they know their own variables. Big firm has access to cheaper capital than the average, long term lease agreements in place, hedged bunker costs or interest rate swaps, lower operational expense or even a lower administration fee due to the implementation of new computer software. Whatever the competitive edge, accurately estimating market prices will allow ship owners to form an informed opinion about their own financial situation relative to the market, and thus the attractiveness of new investments on those conditions.

Finally, we mathematically derive the profit function of a vessel with respect to the speed (mph), freight rates ($/TEU/m), size (TEU), charter rate ($/day), bunker price ($/TON) and bunker consumption (TON/day). The profit function takes into account the described relationship between cruising speed and real supply in TEU miles (see section 2.5) and between cruising speed and fuel consumption (see section 2.6). For a better overview, we have settled for an uncomplicated version of this model. Accuracy could well be increased if other parameters were included, such as capital cost, and port and canal fees. However, oscillations, which are what we care about in terms of a regression analysis, would be the same despite minor differences in scale. Firms can use this function to identify the cruising speed within certain situations that maximizes profit, which is extremely useful. This in turn is an indication of the need for new investments. For instance, on a fictive route used in this example, a bunker price of USD/TON 104 means that it is optimal to sail the route with only five vessels of 2000 TEU, where a bunker price of USD/TON 500 makes it optimal to operate nine vessels of the same size on that route (at lower speeds to preserve fuel).

In our new model (*Table 26*) we account for the growing overcapacity in the market by including supply relative to demand a parameter in the regression. Both variables are measured in ‘nominal’ teu. As described in section 2.6, the problem with nominal teu is that it is indifferent to the distance of travel. This is significant, because it gives a skewed image of the real capacity, as, for instance, demand is measured as world container exports, i.e. how many, not how far. If we knew how much bunker fuel different size vessels consume *on average* at different speeds, we could estimate the supply in TEU miles, i.e. real instead of nominal TEU. Demand in TEU miles would practically we know all the major shipping lanes, we can calculate a rough estimate of for demand in TEU miles as well, which together would give us a more accurate benchmark for fleet capacity. We assume that this measure would be statistically significant to our model and increase adjusted R-square, i.e. the percentage of variation explained by only those independent variables that in reality affect the dependent variable, compared to the nominal capacity that we currently use as a proxy. Shipping firms presumably have access to all the necessary data required for this calculation, and even if that was not the case, they could easily compile the data simply by tracking vessels speed in a given period and using the method described in section 2.6 to calculate the bunker consumption per mile.

In conclusion, we have successfully applied our analysis to more accurately estimate the value of a second-hand container vessel by 1: arriving at a best-guess estimate of the fundamental values during the analysis period, 2: identifying parameters for a multivariate regression that in combination more accurately estimates market prices in the same period and 3: devising a theoretical model to optimize profit based on cruising speed.

Is there evidence of an irrational bubble in second-hand vessel prices in container shipping?

If vessels persistently trade higher prices than their fundamental value, as we have proven the case between 2004-2009, we can say that the price exhibits a bubble and that the vessels are overvalued by an amount equal to the bubble, which is the difference between the fundamental value and the market price. Per definition, investors are then irrational in their failure to profit from the mispricing. We call this an “irrational bubble”. However, recall that the fundamental value include the expected price when the asset is sold. If investors rationally expect the future price to increase, then including this in their calculation of the fundamental value is a rational decision. It is possible that the price could then grow and persist even if the expected future cash flow from operations does not support it. This situation can be called a “rational bubble”.

However, because of the significant risk associated with owning a container vessel, i.e. the high cost of keeping the vessel 'in class' and operational despite earnings oscillations (see section 3.2.3), and the fact that the market for container vessels in times of crisis is very illiquid, makes this a poor instrument of choice simply for price speculations. We have no basis to reject the notion of a rational bubble as defined above, but it seems very implausible. Based on our findings, which are outlined in the above conclusions to the research questions, we conclude that there are indeed irrational elements within containerized shipping. It follows from our conclusion on what constitutes rationality, that the market is either rational or it is not. As such, containerized shipping is not a rational market.

9 References

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