Periods of Ownership in Shipping:

Patterns and Influences

Ralitsa Mihaylova

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__**School of Marine Science and Technology**__

Newcastle University, Newcastle-upon-Tyne,

NE1 7RU

United Kingdom

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Abstract

In modern shipping the use of sophisticated investment valuation tools is not the rule but the exception and investment decisions are often based on the useful economic life of the asset, which can be misleading. The purpose of this research is to investigate periods of ownership in shipping based on evidence from the commercial history of vessels built between 1987 and 2007 in order to determine the likely investment horizon for a vessel owner. The research aims to provide an insight into the strategies and practices adopted by shipping professionals in terms of sale and purchase policies of assets. This will facilitate marine service and equipment providers, such as sale and purchase brokers and retrofitted equipment and systems manufacturers, in targeting customers.

The analysis incorporates ship and company level characteristics as well as economic indicators and is focused on the three main ship types – bulk carriers, tankers and container ships. In order to fully address the nature of the data on periods of ownership, also known as time-to-event data, a variety of statistical techniques used in demographical studies and in biomedicine have been employed to: (i) describe patterns of ownership in shipping; and (ii) establish whether certain characteristics at the ship and company levels as well as economic indicators influence periods of ownership. Furthermore, in depth interviews with shipping professionals were also conducted to provide further insights.

In this research the commercial records of 3,908 vessels of 30,000 dwt and above have been examined resulting in 8,042 changes of ownership recorded. Data on 1,125 companies has been gathered based on the ownership history of 2,000 vessels from the sample. The results reveal that different sets of characteristics affect the decision for a ship to be sold by each owner in the succession of owners comprising the commercial history of a vessel. The most likely scenarios for the economic lives of vessels are identified and analysed based on ship and company characteristics.

To My Grandfather.

За теб, Морски.

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Chapter 1. Introduction

1.1. Background

It is of no surprise that in a market as competitive as the shipping market the different strategic behaviour adopted by agents, mainly shipowners, is the explanation for the success or failure of shipping companies (Engelen *et al.*, 2007). Some of the fundamental strategic decisions that shipowners face are related to vessel sale and purchase, ordering new tonnage and the choice of finance (Psaraftis *et al.*, 1992). Such decisions entail major capital investments with considerable ramifications for shipowners' balance sheets. Bendall and Stent (2003) define investment in shipping as '*a large scale capital evaluation problem within the context of a great number of volatile parameters*'. Technically, in an industry as volatile as shipping, every strategic decision of such magnitude must be carefully examined prior to execution with the choice of an investment valuation tool being critical for the success of the venture (Bendall and Stent, 2007). Scholars have been analysing and developing tools, designed to aid shipowners in decision-making, however, the shipping world has proved to be reluctant to embrace modern investment valuation techniques. The lack of an analytical approach to ship investment was documented in the 1970s by Booz-Allen (1973), who claims that most shipowners do not carry out any kind of market analysis prior to ordering additional tonnage.

At the present time, 40 years later, one might expect that decision-making tools focused on ship investment will be an intrinsic part of the strategic behaviour adopted by shipowners, however there is a substantial body of research on such tools which suggests that the use of sophisticated investment valuation tools is not the rule but the exception. According to Psaraftis *et al.* (1992) formal analysis is not common in the shipping world and even highly successful companies avoid using any complicated forms of analysis but instead build their strategic and business decisions on the most '*rudimentary form of analysis*'. Later studies claim that the most used decision rules for investment valuation are based on Discounted Cash Flow Analysis (DCF), Internal Rate of Return (IRR), Net Present Value (NPV) and Payback Period (PBP) (Cullinane and Panayides, 2000; Bendall and Stent, 2003; Alesii, 2006). Most of these approaches, however, are based on the product's life cycle, also known as '*useful life'.* In the context of shipping, the useful life of a vessel can be represented as a sequence of periods of ownership or as a sequence of transitions between owners until the vessel is scrapped. Periods of ownership are inextricably linked to the investment horizon of different owners and the strategies applied by market agents.

One of the main characteristics of the shipping industry is its volatility, which allows fortunes to be made and lost in short periods of time. It is also a well-known fact that high profits can be generated through trading in ships, an approach often associated with the bulk trades, rather than relying on freight revenue earnings (core activities). Such speculative behaviour associated with market timing and trading ships as commodities is known as '*asset play'*. Many scholars claim that asset play based strategies, despite involving a higher level of risk, are more profitable provided that the investment decision has been timed right (Adland and Koekebakker, 2004; Alizadeh and Nomikos, 2007; Thanopoulou, 2010). However, there are many arguments against such a perception. Sødal *et al.* (2009) state that such trading rules are based on '*short term asset values'* and when the '*the strategies are adjusted for transaction costs and illiquidity in the second-hand market, the excess profits evaporate'*. According to Fama (1965) the only way to outperform a long term investment strategy is to be able to predict with precision market trends and their impact on the second hand vessel prices, a task that has been puzzling analysts for years.

Naturally, the two approaches – core activities based ship operation and asset play, coincide with the two main types of investment behaviour generally regarded as long-term and short term investment strategies. The long term investment strategy is also known as '*buy and hold*' and it corresponds to the perception that financial markets give a favourable rate of return in the long run despite unavoidable market fluctuations. The antithesis of buy and hold is associated with trying to achieve high payoff through buying on the lows and selling when the market peaks. Modelling shipowners' behaviour and predicting market trends are topics of interest in the maritime economics' literature, however such studies, as discussed in later chapters, usually refer to '*short term*' or '*long term*' investment horizons. Sødal et *al.* (2009) state that an '*asset play investor has typically a fairly short investment horizon compared to the typical lifetime of a ship of 25 years or more'*. Furthermore, Engelen *et al.* (2007) based their model on the two distinctive views of agents – short term and long term. They also claim that the number of short term players will increase whenever ship prices are increasing i.e. when '*short term decision making can be more profitable*' (Engelen *et al.*, 2007). Although researchers distinguish between short and long term investment horizons, there is very limited empirical evidence regarding periods of ownership in shipping and characteristics that influence them.

1.2. Research aim, objectives and development of research questions

Despite the body of research on various investment strategies preferred and adopted by agents and how they can be optimized in order to achieve greater profitability (reviewed later in the thesis), there are only two comprehensive studies which provide empirical evidence regarding periods of ownership, namely: (i) Einarsen's (1938) investigation of periods of ownership of Norwegian vessels built between 1883 and 1932 and (ii) Stott' s (2013) investigation of typical periods of ownership of bulkers, tankers and container ships built between 1987 and 1992 that have reached the end of their economic lives. This research builds on and aims to expand Stott's (2013) findings on periods of ownership by examining vessels built between 1987 and 2007 including ships that were still in operation at the end of the data collection phase.

The **aim of this research** is to investigate periods of ownership in shipping based on evidence from the commercial history of vessels built between 1987 and 2007 in order to determine likely investment horizon for a vessel owner and whether certain characteristics that relate to the asset, the ownership structure and the state of the market influence periods of ownership.

Based on the research aim, the **objectives of this research** are as follows:

1. To investigate length and likely patterns of ownership in shipping based on evidence from the commercial history of vessels built between 1987 and 2007;
2. To determine the influence of a number of characteristics on ship level, company level and economic indicators on periods of ownership in shipping.

In order to address the aim and the objectives of this research the following **research questions** were developed:

1. What can be regarded as likely length of ownership in shipping?
2. What can be regarded as likely patterns of ownership in shipping?
3. What characteristics at ship level and company level influence periods of ownership in shipping?
4. Do economic indicators, such as earnings, influence periods of ownership in shipping?

1.3. Overview of research design

The following section provides a brief overview of the research design. A more detailed discussion on research paradigms and the methodology used as part of this research is provided in Chapter 3. In order to achieve the aforementioned research objectives by addressing the research questions in an adequate manner, the following tasks were performed:

- Examination of the literature with a focus on length of ownership in shipping, identification of characteristics that may affect it and suitable research methods to address the research questions;
- Conducting pilot interviews in order to: (i) critically review and extend, if needed, the list of characteristics identified as likely to have an effect on periods of ownership in shipping as part of the examination of the literature; (ii) refine the questions and the interview process to be used later on;
- Conducting a desk-based study on changes of ownership based on the commercial history of ships built between 1987 and 2007 and collating the data on periods of ownership to include all of the characteristics identified as likely to have an effect on periods of ownership in shipping;
- Carrying out the numerical analysis on length and patterns of ownership and characteristics that influence periods of ownership in shipping;
- Conducting in-depth interviews in order to complement the findings from the numerical analyses of periods of ownership and to investigate shipping professionals' perception of patterns of ownership and characteristics that influence them;
- Summarising findings on periods of ownership in shipping.

The first phase of the research was dedicated to an examination of the literature in terms of length of ownership and the characteristics that are perceived to have an impact on periods of ownership. The literature search revealed that the attempts to estimate periods of ownership in shipping are very limited and that there is no empirical evidence regarding length of ownership that is relevant to the current state of the shipping industry. The literature review on length of ownership and characteristics that influence it included academic journal papers on maritime economics related topics, such as ship investment modelling, and a variety of industry publications such as IHS Fairplay and Lloyd's List, which are believed to reflect the views of shipping professionals.

The product of the literature search in terms of influences on periods of ownership in shipping is a list of hypothesised characteristics that affect periods of ownership. Three pilot in-depth interviews were then conducted with two industry professionals at executive positions and one academic with considerable experience. The main purpose of the pilot interviews was to test and critically review the list of hypothesised characteristics that affect periods of ownership.

The second phase of the research involves the data collection stage. A desk-based study on the commercial history of nearly 4,000 ships built between 1987 and 2007 was conducted in order to identify the changes of ownership needed to establish periods of ownership. The next step was to collate a dataset combining the data on periods of ownership and the list of characteristics identified as likely to influence periods of ownership based on the results from the literature search and the pilot interviews.

The third phase of the research was dedicated to the numerical analyses involving periods of ownership. These include an overview of ships' life histories and length of ownership as well as investigation of the potential influence of the characteristics considered as part of this research.

The fourth phase of the research comprises in-depth interviews with shipping professionals focused on their perception of the influence that the characteristics considered as part of this research have on periods of ownership as well as further elicitation on length of ownership in shipping. The findings generated as part of this phase are used as complementary to the numerical analyses and as a means to provide further elicitation on particular influences and their perceived importance.

The last phase of this research is dedicated to collating and analysing the findings from the numerical analyses and the in-depth interviews resulting in conclusions about periods of ownership in shipping and their likely patterns and the influences that affect them. As well as a summary and a critical discussion of the findings, this phase also includes recommendations regarding further research.

Figure 1.1. presents the different research phases carried out as part of this research.

Start

	Tasks	Chapter
Phase 1	**Literature search:** - investigate length of periods of ownership in shipping; - identify characteristics that may influence periods of ownership; - identify suitable methods to investigate periods of ownership in shipping. **In-depth interviews (pilot):** - validate/extend the list of characteristics that may influence periods of ownership.	2, 3, 7
Phase 2	**Desk-based study:** - determine and record changes of ownership based on the commercial history of vessels built between 1987 and 2007 using IHS Sea-Web data; - cross-reference the recorded data with Clarksons Research Limited data and investigate ambiguities; - calculate periods of ownership based on the identified changes of ownership; - collate the final dataset combining periods of ownership data with the characteristics identified as likely to influence periods of ownership according to Phase 1.	4
Phase 3	**Numerical analyses on periods of ownership:** - provide an overview of ships' life histories and owner sequence; - provide an overview of length of periods of ownership based on evidence from the commercial records of vessels built between 1987 and 2007; - investigate the effect of characteristics that are likely to influence periods of ownership in shipping.	5, 6
Phase 4	**In-depth interviews:** - investigate shipping professionals' perception regarding length of periods of ownership in shipping; - investigate shipping professionals' perception regarding likely patterns of ownership; - investigate industry professionals' perception regarding the effect of characteristics identified as likely to influence periods of ownership and their perceived effect size.	7
Phase 5	**Finalise research findings:** - prepare a summary and a critical discussion of research findings; - suggest recommendations for further research.	8

End

Figure 1.1. Research Phases

1.4. Contribution to knowledge

In times when the shipping industry is subjected to a constant stream of new safety and environmental regulations, many owners are forced to consider retrofit or fleet substitution options. This research will provide an insight into length of ownership associated with shipping, which will be of interest to a variety of industry representatives such as sale and purchase brokers, retrofitted equipment and systems manufacturers, paint manufacturers and other types of marine service providers whose activities are directly or indirectly dependent on buyers' behaviour and preferences. The data on periods of ownership will contribute to a better understanding of shipowners' attitudes and the strategic decision-making process in the context of ship sale and purchase policies in shipping. This research will also provide an insight into whether such decisions are affected by characteristics such as sector preferences, nationality and company type. Such knowledge will benefit academia in terms of ship investment modelling endeavours as it provides empirical evidence on payback periods and benefits industry as it will confirm or deny common perceptions based on anecdotal evidence regarding periods of ownership, investment horizons and sale and purchase policies adopted by agents in the shipping industry.

This research uses a comprehensive framework for determining changes of ownership based on cross-referencing data from the two most reliable[1] shipping data providers – Clarksons Research Services Limited and IHS Maritime's Sea-Web, and therefore the data generated provides a reliable and accurate estimation of periods of ownership. Another contribution of this research is the novel use of techniques from the survival analysis family that handle time-to-event data and which appear to be underutilised in maritime economics and shipping business studies. Furthermore, this research utilises machine learning techniques based on the tree-based methods introduced by Breiman (1984), which, to the best of the author's knowledge, have not been applied to maritime economics related problems to date.

This research has potential for further applications such as serving as a basis for the development of an 'asset liquidity index' for example, which could provide banks with a more sophisticated way for classifying assets and assigning credit ratings to investment opportunities in shipping.

[1] Data reliability and limitations are discussed in more detail in section 4.2.1.

The contribution of this research can be summarised as follows:

- Provision of more accurate and reliable estimation of length of ownership in shipping;
- Provision of a comprehensive review of length and patterns of ownership in shipping at a disaggregated ship and company level, which accounts for inherent differences within shipping segments and ownership structures; thus more thorough understanding in terms of sale and purchase decisions is obtained;
- Contribution to understanding the characteristics that influence periods of ownership in shipping based on estimating their average effect on periods of ownership over the period 1987 to 2015;
- Contribution to the application of techniques common in biomedical science and demographical research to maritime economics.

1.5. Structure of the thesis

This thesis is divided into eight chapters. A number of appendices with supporting information are presented at the end of the thesis. Additional descriptive statistics, all model diagnostics and relevant output from the statistical models investigating the characteristics that influence periods of ownership are presented in a separate data annex.

The first chapter contains a brief introduction aiming to summarise the main investment strategies in shipping and the implication regarding periods of ownership. The chapter aims to familiarise the reader with the main objectives and research questions addressed as part of this research and to provide a brief overview of the chosen research design accompanied by a summary of the contribution of the research. Finally, a brief summary of the structure of the thesis is presented.

The second chapter introduces key concepts related to periods of ownership in shipping, such as typical ownership structures, strategic decisions and practices adopted by shipping professionals, in order to shed light on the complexity of the phenomena under investigation. Apart from familiarising the reader with current trends in ship investment related topics, the chapter aims at identifying a list of characteristics that are likely to influence periods of ownership.

The third chapter addresses the overall research design adopted as part of this research. The first part of the chapter deals with the choice of a research paradigm. The second part of the chapter is dedicated to the research methods and their application, with particular attention to the driving factors behind the choice of methodology, such as the nature of the data on periods of ownership.

The fourth chapter provides a brief overview of the data collection process, the sampling framework and limitations related to the reliability of the data used. The main part of the chapter is dedicated to introducing and describing the characteristics considered as likely to have an effect on periods of ownership as part of this research.

The fifth and sixth chapter summarise the results on length and patterns of ownership as well as the results from the numerical investigation regarding influences on periods of ownership on ship level and company level respectively. Chapter six also includes an investigation of the effect of economic indicators on periods of ownership.

The seventh chapter summarises the results from the interview stage of this research, which aimed to complement the numerical findings on periods of ownership by providing further information regarding the perceived importance of the characteristics affecting periods of ownership considered as part of this research.

The eighth and final chapter of the thesis provides a critical discussion on the conclusions reached alongside suggestions regarding potential further research.

Chapter 2. Literature review

2.1. Introduction

Reilly *et al.* (2016) define investment horizon as the expectation about the length of time that certain investment will generate profit and treat the term as synonymous with payback and payoff horizon. There is a myriad of different approaches which aim to measure investment horizon (Reilly *et al*., 2016). One of these approaches, inspired by accounting requirements, is based on estimating the expected asset life (Reilly *et al*., 2016). This approach has been used to determine investment horizon by gathering empirical data based on the resource allocation process for purchasing depreciable assets, such as vehicles and other equipment (Souder and Shaver, 2010; Souder and Bromiley, 2012; Shao and Zhang, 2013). In the context of this research periods of ownership are a measure of the expected asset life with each owner and provide information regarding the investment horizon on individual ship level. Due to the close relationship between investment horizons on ship level and periods of ownership, the first section of the literature review examines typical investment strategies and perceptions regarding investment horizon in shipping.

2.2. Investment Horizon and Types of Investment Strategies in Shipping

2.2.1. Types of investment strategies in the context of shipping

Shipping is one of the most competitive, capital-intensive, fragmented and cyclical industries. Its '*notorious volatility'* (Haralambides *et al.*, 2004) is the reason why fortunes are made and lost as market conditions change. The success of shipping companies rest on the ability to adapt to the ever-changing conditions of the market. According to Psaraftis *et al.* (1992) there are three main types of decisions that shipowners have to consider – strategic, tactical and operational. Strategic decisions '*involve capital acquisition issues*' (Psaraftis *et al.*, 1992) and are usually related to vessel sale and purchase, tactical decisions represent vessels' '*allocation/utilization*' whereas operational decisions cover the '*day-to-day operation'* of the ship. As the focus of this research is periods of ownership, the examination of the literature is limited to strategic decisions which are deemed to have an impact on the phenomenon under investigation, such as vessel acquisition policies. There are different reasons for buying or selling a vessel, which are usually related to the company's overall market strategy. Merikas *et al.* (2008) summarise those into three classic motives for investing in shipping:

- In booming markets due to the lucrative cash flows;
- In depressed markets in order to benefit from '*asset play'*[2];
- In order to replace an old vessel.

Revenko and Lapkina (1997) provide a detailed list of the most common reasons driving the sale and purchase of ships (Table 2.1).

	Reasons to buy a ship	**Reasons to sell a ship**
1	Need to renovate and partially replace the fleet;	Renovation of the fleet due to aging;
2	Need to improve competitiveness;	Depreciation of fixed assets;
3	Availability of liquid resources;	Previous obligations to former owners;
4	Expectation of higher dividends in the future;	Reduction of fleet operating costs;
5	Growing or new volumes of traffic;	Forced sale to meet collections, taxes, etc.
6	Short-term acquisition in expectation of resale opportunities at favourable prices in the future (asset play);	
7	Expectation of a substantial increase in profits as a result of an analysis of the current market situation;	
8	Expansion of the company.	

Adapted from: Revenko and Lapkina (1997)

Table 2.1. Reasons Driving the Sale and Purchase of Vessels

Due to the volatility of shipping markets, the fluctuations in the prices for second-hand ships create the opportunity for generating large profits from speculative asset trading (Alizadeh and Nomikos, 2006; Thanopoulou, 2010). This approach is also known as anticyclical investment or asset play. Merikas *et al.* (2008) define asset play as consistent with the short term investment strategy of '*buy low and sell high'*. Thanopoulou (2010), based on Theotokas' work, expands this definition by stating that the term '*asset play'* is also used to portray the buying and selling of newbuilding contracts and newbuilding options. Scarsi (2007) suggests a model of the hypothetical behaviour of shipowners, which assumes that there are two distinctive strategies in shipping – asset play and operation.

[2] The term is explained below.

1. *Buying low* – because the price of ships depends on freight rates level, acquiring ships at the bottom of the market means paying less and having a lower break-even point.
2. *Selling high* – when freight rates are supposed to be at the maximum level, the value of ships increases and shipowners can obtain an appreciation of their assets on the second hand market.

→ Asset play

3. *Spot charter on a rising market* – when the demand is high, shipowners can take advantage from freight rates increasing hiring their ships on short term basis.
4. *Taking a T/C when the peak is reached* – when shipowners imagine that the market peak is reached, they can assure the freight rates level for the future hiring their ships on long term basis.

→ Operation

Source: Scarsi (2007, pp 577-590)

Figure 2.1. Shipowners' Hypothetical Behaviour

According to Thanopoulou (2010) exceptional profits can be made through asset play if agents apply the '*anticyclical investment strategy*'. Such behaviour often involves acquiring tonnage during market slump periods and it is inherent to '*astute*' investors who have secured considerable cash reserves ready to be used whenever the next opportunity presents itself (Thanopoulou, 2010). There are other advantages associated with the anticyclical strategy apart from low asset prices. For example, second-hand tonnage is readily available and it can be obtained at relatively cheap prices when freight rates are low. Furthermore, the orderbook for new vessels decreases substantially when there is a surplus of shipping capacity. When this occurs, shipyards are left hungry for new orders, which reduces the lag between placing an order and the delivery of a ship. Most importantly, however, a ship acquired during a slump period has a lower break-even point, which means that its profit generating capability increases (Scarsi, 2007). According to Scarsi (2007), companies that own such ships accumulate greater profits, which allows them to persevere through longer periods of uncertainty. Guaranteeing the liquidity of a company is a prerequisite for affording such moves as the raising of equity capital or approaching banks is quite difficult in times of weak markets and high uncertainty. Therefore Thanopoulou (2010) claims that asset play is a '*self-financed and indeed historically self-sustained activity*'. The main risk with successful implementation of anticyclical investment strategy in shipping stems from the cyclical nature of shipping markets. The success of such a strategy rests entirely on the assumption that markets will recover, however, the time horizon of the future revival of the market is difficult to forecast as it depends on a variety of factors (Alizadeh and Nomikos, 2006).

Many believe that the anticyclical investment strategy is preferred in shipping despite the higher level of risk associated with it. Tsolakis *et al.* (2003) claim that '*the bulk of the bulk markets is asset play*'. According to Sjögren (1999) buying ships during a slump is the '*managerial rule of thumb' because it provides additional tonnage for when the market recovers'*. Thanopouhlou (2010) states that '*investment strategies are often associated with asset play, if not with asset play alone…*'. Rousos and Lee (2012) point out that asset play has gained such popularity amongst investors that wishing for high second hand volatility is '*a common business approach*'. Whether the underlying motive is just an astute acquisition policy which suggests that the owner keeps the vessel and operates it or asset play, it is not clear. Apergis and Sorros (2010) claim that it is common for publicly listed shipping companies to '*reduce the number of vessels they handle through sales at prices higher than they were purchased'* implying that said companies use both strategies – anticyclical asset trading and operation at once.

Asset play is deemed to be risky, however, Thanopoulou (2010) claims that investing in booming markets could be just as risky or even riskier since in order to gain any profit from an investment timed in such a way, freight rates must remain high for a considerable period of time. According to Volk (1984) and Goulielmos and Psifia (2006), however and seemingly contrary to the idea that asset play is the preferred strategy by agents, one of the paradoxes related to ship investment is the fact that '*most-if not all-orders are made during high freight rates*'. This theory is supported by the fact that despite of the great recession following the market collapse in 2008, the 2010 and 2011 ship completions were historically high (OECD, 2017). A potential factor that contributes to overordering is the time it takes to deliver a ship after placing an order. According to Porter (1983) firms, whose expansion strategies are dependent on long lead times are more likely to invest in additional capacity early if they have an optimistic view regarding future market growth. Kalouptsidi (2014) demonstrates that time lags and the fact that they lengthen during periods of investment activity, influence the shipping markets and often result in price volatility.

The problem becomes more complex as fluctuations in demand add uncertainty (Fusillo, 2003). Fusillo (2003) warns that shipping companies are more likely to order excess capacity than risk being affected by tonnage shortages during times of high demand. Partially this is attributed to: (i) the fact that financial penalties for cancelling orders are usually not significant enough to discourage such strategies (OECD, 2017) and (ii) that it may be more profitable for a company to bear the costs of excess capacity than that of supply shortage.

Goulielmos and Psifia (2006) identified three types of cases that led to exceptions to the aforementioned rule of thumb regarding the high volume of orders during market peaks from a historical perspective: technology (1965, 1983), special shipbuilding terms (1975 in Japan) and special ordering policy (the Sanko case, 1983). The case of Sanko shipping company is a good example of poor timing, which is in line with Porter's (1983) theory regarding expansion strategies. Sanko tried to gain a competitive advantage in the early 80s through employing the anticyclical investment strategy. The management believed that the period needed for the market to recover would not exceed 4 years. In the middle of the estimated slump period, Sanko expanded their fleet. Such a bold speculative move encouraged other investors to do the same, which deepened the recession and delayed market recovery.

Attempts to explain the volume of over-ordering in times of booming markets have been made from a behavioural rather than strategic point of view. Zannetos (1966) introduced the concept of '*zero memory'* of shipowners, which suggests that they do commit the same mistakes over and over again. Scarsi (2007) claims that shipowners often act irrationally by carrying out the decision-making process based on emotional elements and thus blinded by '*cognitive biases'*. Greenwood and Hanson (2013) explain the overordering during market booms due to a form of overconfidence referred to as '*competition neglect'* (Kahneman, 2012).

Low and medium entry barriers can attract investors in times of high rates of return. As the shipping industry is volatile, the profits generated during high freight rates can be significant. This attracts market players which may not have previous experience in shipping. The presence of profit driven market players, attracted by high freight rates and relatively new to the industry, contributes to the imbalance of supply and demand and partially explains the overreaction that ultimately leads to overcapacity and low freight rates. Furthermore, Porter (1983) suggests that the capacity oversupply phenomenon is encouraged when firms' entries into markets with high exit barriers are supported by lenders. Arguably, one of the reasons for the continuously depressed shipping markets in recent years has been the availability of finance provided by equity firms and other financial institutions.

An investor with a short term investment horizon is expected to acquire and sell assets more frequently than an investor, who is interested in providing a reliable service. Sødal *et al.* (2009) state that an '*asset play investor has typically a fairly short investment horizon compared to the typical lifetime of a ship of 25 years or more'*. Therefore, the following section aims to summarise the characteristics that are perceived to affect investment horizon in shipping.

2.2.2. Characteristics that affect investment horizon

According to the resource-based view (RBV) theory, which was introduced in the mid-1980s by Wernerfelt (1984), Rumelt (1984) and Barney (1986), performance is related to company-specific resources. These resources were classified by Penrose (1959) as: (i) tangible (assets) and (ii) human (skills). The utilisation of these resources forms the company's competitive advantage (Peteraf and Bergen, 2003). In the context of shipping, RBV theories have been used to investigate competitive advantage in relation to: (i) the supply chain and the liner sector (Wong and Karia, 2010; Kuo *et al.*, 2017; Liu *et al.*, 2017) and sustainability practices (Lai *et al.*, 2011; Pantouvakis *et al.*, 2017).

In the context of this research shipping companies can be defined on the basis of the vessel as unit of production (Stopford, 2009) and the analysis is based on estimating the investment horizon on an individual ship (project) level. Therefore, the focus is on the asset rather than the company. Investigating company performance and competition in general is outside the scope of this project. The literature review aims at identifying characteristics affecting strategic decisions related to acquisition and sale and purchase (S&P) policies.

In order to facilitate the literature search on characteristics that may affect investment horizon on an individual ship level, the types of characteristics were grouped into three main categories: (i) characteristics that relate to the asset (ship level characteristics), (ii) characteristics that relate to firm differences (company level characteristics) and (iii) market dynamism (economic indicators). According to asset allocation literature investment horizon can be viewed as the difference in product or asset life cycles (Friedman and Segev, 1976; Reilly *et al.*, 2016). It should be noted that investment horizon is usually investigated in relation to a firm or an investor's strategic management. Periods of ownership on the other hand refer to the investment horizon related to the asset itself. Although these levels of investment horizon – on firm or individual asset level, are different it is assumed in this research that they are interconnected. For example, it is assumed that if a ship is acquired by an investor, whose market strategy is based on a short term investment horizon, then such investors are not expected to keep ships for their whole economic lives. Based on the above, the review of characteristics perceived to influence periods of ownership included characteristics perceived to influence investment horizon in general. The following section provides a short summary of characteristics that are claimed to affect investment horizon in the maritime economics literature.

a) Ship Level Characteristics

Segments (Ship Type)

There is a broad consensus in the maritime economics literature that shipping is a highly segmented industry (Kavussanos, 1996; Farthing and Brownrigg, 1997; Kavussanos, 1997; Glen and Martin, 1998; Kavussanos and Alizadeh, 2002b; Kavussanos and Tsouknidis, 2016). There are two broad categories, namely tramp and liner shipping (Stopford, 2009; Rousos and Lee, 2012). The dry-bulk segment of the fleet is often described as an example of '*perfectly competitive market'* (Norman, 1979; Adland and Koekebakker, 2004). However, both dry-bulk (bulk carriers) and wet-bulk (tankers) segments are part of a relatively open transportation system with low barriers to entry. Due to the level of competition combined with low barriers to entry, these segments are often associated with speculative behaviour (Abouarghoub *et al.*, 2012). On the other hand, in the liner trade, the focus is on the quality of the service and commitment to customers, which implies a long-term relationship and therefore long term time horizon. Ding and Liang (2005) suggest that customer satisfaction and loyalty are the driving factors behind the strategic decisions of liner shipping companies. Fan and Luo (2013) warn that shipping investment decisions are crucial for liner companies as insufficient investment may result in a decrease of the market share and it may '*endanger the long-term competitive position of a shipping company*'. Due to the high level of segmentation and the different investment horizons associated with specific segments, the main ship level characteristic – ship type, aims to distinguish between shipping segments.

Ship Size

Although earlier work has concentrated on differences between shipping segments (Beenstock, 1985; Beenstock and Vergottis, 1993), many have argued against the homogeneity within each segment. For example, Glen (1990) suggests that such a view of the segments is outdated due to increased route and size differentiation. Furthermore, there is evidence that the volatility of prices varies by ship size (Kavussanos, 1996, 1997) with higher volatility associated with larger vessels. Alizadeh and Nomikos (2007) suggest that higher volatility associated with larger vessels makes them more suitable for asset play. According to Wood (2000) there is a direct relationship between the size of tankers and the trade in which they are employed. Mokia and Dinwoodie (2002) suggest that small tankers are involved in serving the coastal trades, whereas large vessels make long hauls. This is applicable to bulk carriers and container vessels as well (Stopford, 2009). Rousos and Lee (2012) claim that investigating investment opportunities is based on several main choices where shipping segment and ship size are the two most basic ones. The authors claim that although ship sizes vary, ships that belong to the same segment and size class typically serve the same trade, which makes such vessels homogenous. Furthermore, such vessels are often assumed to display similar mathematical properties and economic structure in the literature (Kavussanos, 2002; Rousos and Lee, 2012).In the light of these arguments regarding the benefit of ship size disaggregation in the examination of investment behaviour, the analysis on periods of ownership includes ship size.

b) Company Level Characteristics

According to Lorange (2005) one of the critical choices that shipowners need to make is whether the focus will be primarily on operations (core activities) or asset play. He states that one of the conditions for generating profit by relying on freight revenue earnings is to run an efficient operations department whereas with asset play timing is indispensable. The presence of these two distinctive groups suggests that agents in shipping exhibit rather heterogeneous behaviour in the form of different objectives and time horizons.

Among some of the main differences between these two types of investment behaviour are expected time horizons and risk attitudes. As asset play is associated with high levels of risk and short term investment horizons, investors exhibiting such behaviour are expected to have the same attitude. Based on simple heuristics, one would expect that the amount of risk market participants are prepared to take is inextricably linked to the strategic decisions they face. Cullinane (1995) states that agents' willingness to take risks depends on individual circumstances, values and attitudes. According to an earlier study by Cullinane (1991) a considerable portion of dry bulk shipowners are risk neutral or risk loving and contrary to common perception, characteristics such as sector preferences, nationality or liquidity situation do not influence one's attitude towards risk. These findings contradict the results of Lorange and Norman (1970)'s empirical analysis in favour of the relationship between risk attitudes and liquidity. Cullinane (1991) suggests that the differences in the results obtained can be attributed to the increased awareness of shipowners regarding the role of capital markets and a potential improvement in the supply of capital. However, other authors and practitioners believe that factors such as risks, traditions, experience and potential for profit do have an impact on strategic decisions such as choosing a sector (Berg-Andreassen, 1998; Scarsi, 2007). Furthermore, Pires *et al.* (2012) argue that the rationale behind investment decisions varies by segment and investor type giving as an example the opposing objectives of representatives from different sectors such as a container operator and a bulk carrier owner. The following section summarises some of the main characteristics perceived to influence investment horizon on individual ship level and periods of ownership that are linked to ship-owning companies.

Company type

According to Yeo (2012) ownership structure '*influences a firm's acquisition strategies'*. Lorange (2010) states that the concept of a classic shipping firm is consistent with a privately held company built on vertical integration. Such firms combined a variety of activities such as shipowning, chartering, ship management and manning. However, according to Lorange (2010) in time the generalist and integrated approach to shipping was replaced by the four specialized archetypes – owning, operating, using and innovating and each one of them requires a specific organizational approach. Stopford's (2009) classification of common shipping company types implies that private bulk companies are prone to applying the anticyclical investment strategy. Furthermore, there could be differences between companies that are involved in the same trade. For example, the behaviour of a vertically integrated oil major employing all its fleet to carry its own oil will be quite different compared to the behaviour of an independent tanker owner trading on the spot market (Psaraftis *et al.*, 1992). Psaraftis *et al.* (1992) highlight the fact that longer planning horizons are associated with the activities of an oil major and every strategic decision has more weight.

Another interesting observation is that a certain level of delineation can be observed among the three levels of decisions when comparing an oil major and an independent owner as some decisions that are operational for an independent owner can be tactical for an oil company for example (Psaraftis et al. 1992). This phenomenon can be attributed to the longer planning horizon and the fact that a shipping division's behaviour is modelled according to the transportation requirements of the oil company.

Based on the above, there appears to be an agreement that investment motives can largely vary depending on the nature of the shipping company. Furthermore, it has been recognized that the expectations of stakeholders might have a strong impact on choosing an investment strategy since they might be focused on long term growth or short term revenues (Engelen *et al.,* 2007). A distinctive trait of the shipping industry is the existence of a large number of companies with concentrated ownership (Gulbrandsen and Lange, 2009; Stopford, 2009; Tsionas *et al.*, 2012; Drobetz *et al.*, 2013). Kavussanos and Alizadeh (2002a) suggest that it is typical for private investors or small shipping companies with a relatively short time horizon to actively participate in the sale and purchase market and count on capital gains rather than freight revenues.

According to Yeo (2012) a common type of investors in shipping are the '*institutional investors'*[3], such as hedge funds and investment banks, who are interested in risky acquisitions with high yield of return achieved in a short period of time. Kang and Kim (2012) distinguish between state-owned and private enterprises in their investigation of ownership structure and firm performance based on the Chinese corporate reform. According to the authors, private entities are focused on accounting performance, which implies shorter investment horizon in comparison to state-owned enterprises.

According to Drobetz *et al*. (2013) there is very weak evidence that publicly listed companies use market timing strategies. However, it is recognised that shipping companies started considering capital markets in the late 1990s (Grammenos *et al.*, 2007; Merikas *et al.*, 2009; Drobetz *et al.*, 2013), which implies that the longitudinal

[3] Bushee (1998) suggests that institutional investors can be treated as a homogenous group.

data on investment behaviour of public companies is relatively limited. Furthermore, there are certain advantages to companies that decide to go public apart from access to the capital markets such as options for future refinancing for example (Syriopoulos, 2010), which suggests that public companies should be regarded in a category of their own.

Based on the above it can be concluded that there is a broad agreement in the literature that different types of business entities exhibit different attitudes towards strategic decisions and potentially employ different investment horizons.

Company size

Company size is an indicator used often in the literature regarding investment decisions to control for firms' level of investment (Souder and Shaver, 2010; Souder and Bromiley, 2012; Shao and Zhang, 2013) and to explain variation between ownership and governance (Rediker and Seth, 1995; Zahra, 1996; Kroll *et al.*, 1997; Zahra *et al.*, 2000)[4]. Furthermore, many researchers report a positive relationship between company size and returns in the long term (Levis, 1993; Jaskiewicz *et al.*, 2005; Ahmad-Zaluki *et al.*, 2007; Merikas *et al.*, 2010).

In the case of shipping, company size can be measured as fleet size. Rousos and Lee (2012) in their investigation of investment decisions suggest that investment modelling should include indicators such as: (i) decision-makers' business strategies, achieved in this research via distinguishing between business entities and (ii) fleet size. Fan and Luo (2013) claim that companies of different size have different ship acquisition policies as large companies acquire tonnage to maintain or expand their market share, whereas small companies '*expand aggressively to survive in the market*'. Tsionas *et al.* (2012) claim that company size is a principal component of ownership structure. The authors report that according to their investigation of concentrated ownership and firm performance, concentrated ownership is characterised by better financial performance and smaller size. Syriopoulos (2007) also links company size to performance. Furthermore, larger companies tend to be more diversified (Cullinane, 1995) and less likely to default, whereas small companies are believed to have a limited access to capital markets and are usually associated with concentrated ownership (Drobetz *et al.*, 2013). Merikas *et al*. (2010) state that smaller US-listed

[4] It should be noted that the size of the firm is represented by different metrics in different studies, for example asset value (Zahra *et al*., 2000); market share (Souder and Shaver, 2010), etc.

shipping initial public offerings (IPOs) are found to be more speculative than larger companies.

In the light of the above, company size is included in the analysis on periods of ownership in shipping.

Nationality

According to Schneider (1989) strategy formulation is not '*culture-free'* as it requires the gathering and interpretation of information. Although the author acknowledges that '*within-nation'* differences exist as a result of multiculturalism, *'between-nation*' differences are perceived to be much more significant, which is the reason why nationality is often used as a proxy for cultural differences. Williamson (2000) postulates that culture indirectly influences asset allocation decisions as it imposes constraints on governing structures. Shao and Zhang (2013) investigate this problem further by suggesting that culture has a direct impact on investment horizon and find that companies from individualistic countries invest in long-term assets.

Traditionally some shipping nations are presumed to be more prone to asset play than others are. Veenstra and Bergantino (2000) state that nationality is an important element of the ownership structure of shipping companies. Despite the findings of Cullinane (1991), which suggest that risk attitudes do not vary according to nationality or illiquidity, accumulating high profits by employing short term anticyclical investment strategy is often associated with certain nationalities. For example, Tvedt (2003) states that '*the main asset players in the bulk markets are independent owners in Europe, especially Greek shipowners'*. Thanopoulou (1996) claims that there was a clear, albeit not uniform, pattern suggesting that many representatives of the Greek shipping community relied on an anticyclical investment strategy in the past. Later analysis by Bragoudakis *et al.* (2013) suggests that this trend disappeared after 2006. Greek shipowners, however, are not the only ones perceived to employ speculative asset trading strategies.

Thanopoulou (2010) points out that asset play is not geographically exclusive behaviour as Norwegian shipowners, for example, have been known to take advantage of the market volatility when timing the decision to buy or sell. According to Lorange (2005), Norwegian shipowners' affinity towards asset play post World War II is a product of gradually increasing wages, which led to higher operational costs and lower profit respectively (illiquidity). In an attempt to '*compensat*e' for the additional financial burdens, many shipowners shifted their attention to more profitable short-term speculation on ships. However, such strategic change entailed higher risks and consequently led to the demise of many Norwegian shipping companies.

In the interest of brevity, structural and regulatory changes on national level have not been examined in great detail. However, the following works on the history of some of the most prominent shipping nations deserve to be mentioned: (i) Greek shipping (Thanopoulou, 1996; Goulielmos, 1997; Corres, 2007; Lagoudis and Theotokas, 2007; Pallis, 2007; Theotokas, 2007; Moutafidou, 2008; Theotokas and Harlaftis, 2009; Thanopoulou, 2010; Bragoudakis *et al.*, 2013; Chouliarakis and Lazaretou, 2014); (ii) Norwegian shipping (Einarsen, 1938; Einarsen, 1965; Waage, 1998; Jenssen, 2003; Tenold, 2005; Tenold, 2006a; Tenold, 2006b; Brautaset and Tenold, 2008; Tenold and Aarbu, 2011); (iii) British shipping (Sturmey, 1962; Hope, 1990; Gardner *et al.*, 1996; McConville and Glen, 1997; McConville, 2003; Harlaftis and Theotokas, 2004; Goss, 2011); (iv) Japanese shipping (Wray, 2005); (v) Swedish, Danish and Scandinavian shipping (Lorange and Norman, 1970; Sjögren, 1999; Sornn-Friese and Iversen, 2011; Sjögren *et al.*, 2012; Iversen and Tenold, 2014).

In the light of the above, even though nationality itself may not directly influence the choice of strategy and investment horizon, there are other exogenous (national policies and regulations) and endogenous (culture), or perhaps a combination of both, factors that affect certain shipping communities in ways that make them more prone to adopting a short term investment strategy. As the focus of this research is to detect patterns and investigate the influence of company level characteristics, nationality is included in the analyses.

c) Economic indicators

The most important decision in shipping investment concerns the timing of investment/divestment. The survival of a shipping company rests on the timing of buying and selling of ships. Fayle (1933) states that world economy and random events trigger the shipping cycles. Goulielmos and Psifia (2006) refer to such events as ‘*exogenous factors’*, which vary in size and impact. They give as an example the following: wars, oil price shocks and the closure of the Suez Canal. Although this research does not distinguish between individual exogenous factors, it is believed that the effect of such events on the shipping industry is reflected in the economic indicators, which represent the state of the shipping markets. The cyclicality of the shipping industry, including the effect of exogenous factors, is what makes it a lucrative business as some of the most successful shipowners owe their success to adequate market timing in terms of investment decisions. The most critical ability of a successful shipowner therefore is the ability to read the market (Scarsi, 2007).

The benefits of ordering a vessel during a slump have been discussed earlier. These benefits are connected to obtaining a ship at an advantageous price, which allows companies to accumulate more profits due to lower capital costs. Correct timing is also the key to making an astute investment choice when purchasing a second hand vessel. However, if a shipowner's aim is to expand their fleet through the purchase of second-hand ships, then the driving criteria will be the cost of such ships relative to the newbuilding price, the market outlook and future expected cash flow (Drewry, 1992). Such an attitude combined with the shipowner's conviction that the respective second hand values are relative to the newbuilding costs and/or the option of securing a favorable long term charter could justify buying a ship as the market peaks (Drewry, 1992). Alizadeh and Nomikos (2007) report that higher capital gains lead to a higher number of transactions (sale and purchase) in the shipping market. Bendall and Stent (2003) claim that freight rates (earnings) and asset prices should be included in the investment decision. Merikas *et al*. (2008) discovered that when the freight rates are increasing, the demand for second-hand vessels is larger than that for new ships, whereas low freight rates encourage shipowners to dispose of '*excessive capacity'*.

Based on the evidence of the importance of the state of the market to sale and purchase policies in shipping, economic indicators are included in the list characteristics that are perceived to influence periods of ownership. The range of economic indicators is divided into two main groups: (i) shipping market indicators and (ii) global economic indicators. The shipping market indicators are based on the four shipping markets as defined by Stopford (2009): newbuilding, sale and purchase (second-hand), demolition and freight rates market. The global economic indicators are based on the basket of indicators provided by Clarksons Research Services Limited (CRSL), a leading ship-brokerage firm regarded as one of the most reliable data providers in the shipping industry. The global economic indicators included in CRSL's database SIN (Sea-Intelligence Network) are the following: economic growth (industrial production), exchange rate, inflation, interest rates, oil price and bunker price.

d) Other considerations

Another aspect of ship acquisition is the choice between buying a second-hand vessel or ordering a new one. The advantages, disadvantages and considerations regarding the choice between a second-hand and a new vessel are presented in Table 2.2.

	Newbuilding	Second hand ship
Advantages	Customisation; Lower operation costs; Maximum vessel life expectancy.	Prompt delivery; Lower capital costs.
Disadvantages	High capital costs; Not immediately available; Risk of delayed delivery; Market may deteriorate during lead time.	Price likely to be market related; Decreased economic life; Higher operation costs; Vessel could be a distress sale and may have been idle for some time; Potential need for retrofit due to new regulations; Design criteria determined by previous owner and may be unattractive.
Considerations	Which builder/yard? Lead time? Standard ship or custom design?	Vessel condition? Life expectancy? Market expectations?

Adapted from: Drewry (1992) and Fan and Luo (2013)

Table 2.2. Buying Ships: Advantages, Disadvantages and Considerations

In the literature there is often a distinction between owners who purchase new vessels and owners who prefer second-hand tonnage. For example, Fan and Luo (2013) agree that the motivation behind purchasing a new or a second hand vessel differs significantly. The authors claim that acquiring new ships serves the long term strategy of a company, whereas buying second hand vessels is associated with satisfying short term needs. Furthermore, Einarsen (1938) classifies owners as '*first owners'* and '*subsequent owners'* where the distinction implies that owners who purchase new tonnage are driven by the motivation to provide quality of service, whereas subsequent owners are perceived to be more speculative and driven by ship price. Regardless of the exact combination of reasons for such a distinction, both Einarsen (1938) and Stott (2013) find length of ownership corresponding to first owner to be greater than length of ownership corresponding to subsequent owners. Therefore, the number of the owner in the succession of owners each vessel has had is taken into account when estimating and comparing length of ownership.

2.3. Overview of Ship Investment Research and Assumptions Regarding Periods of Ownership

2.3.1. Traditional ship investment valuation tools and real options analysis

The decision to invest in shipping carries a number of embedded risks that should be carefully examined prior to execution. As a result, researchers have been promoting the use of investment valuation tools for decades (Booz-Allen, 1973; Taylor, 1979; Psaraftis *et al.*, 1992; Bendall and Stent, 2003). Psaraftis *et al*. (1992) state that shipping companies are reluctant to use sophisticated forms of analysis but instead build their strategic and business decisions on the most '*rudimentary form of analysis*'. The most common techniques used for justifying an investment in shipping are based on Discounted Cash Flow Analysis (DCF), Internal Rate of Return (IRR), Net Present Value (NPV) and Payback Period (PBP) (Cullinane and Panayides 2000; Bendall and Stent 2003; Alesii 2006; Rousos and Lee 2012). The inflexibility of approaches such as DCF, NPV and other traditional techniques is recognized in the management and finance literature (Souder and Shaver, 2010). One of the main disadvantages of the DCF approach is the underlying assumption that the project will be operated until the end of its useful life. Furthermore, it is based on a pre-determined scenario which according to Bendall and Stent (2007) is often not '*a reflection of real-world competitive interactions and the operating environment of most firms*' and thus it is likely to overlook '*strategic concerns about future uncertainty*'.

Due to the volatility and the capital intensity associated with shipping, however, shipping companies need to be extremely adaptive to the changes in the operating environment. Therefore, many believe that real options analysis (ROA) because of its flexibility is a more appropriate tool for evaluating investment decisions under uncertainty than DCF and NPV (Bendall and Stent, 2007; Pires *et al.*, 2012). The flexibility of ROA stems from enabling decision-makers to manage projects actively by exercising more control and giving them the opportunity to alter the course of their actions upon changes of circumstances (Bendall, 2002; Bendall and Stent, 2003; Bendall and Stent, 2007). The term '*real options*' is usually ascribed to Myers (1977) who pioneered the idea that corporate real assets can be treated and analysed as call options. Gonçalves (1993) was the first to apply ROA in a shipping economics context. Since then, the concept gained popularity in shipping investment analysis. Dixit and Pindyck (1994) applied the theory to entry and exit decisions in the tanker sector.

However, they recognize the possibility of the failure of the real option mark-up hypothesis under competition. Bendall (2002)'s overview on the applicability of ROA is one of the most renowned works in the field. According to Bendall (2002, p 646) using an options approach turns capital investment into '*an on-going process requiring active managerial involvement'*. Dikos (2008) applied the real option analysis to entry and exit decisions but modifying it by setting the decisions in a partial equilibrium framework. Dikos and Thomakos (2012) estimated the real option value in the tanker sector and claim that it can be used as a measure of investment flows.

Pires *et al.* (2012) apply real options analysis to ship appraisal through suggesting a methodology that considers the abandonment option. The study concentrates on a tanker ship investment problem where an oil company has to decide whether it would be more profitable to expand its fleet in order to substitute an equivalent chartered ship. The paper uses Monte Carlo simulation as a tool for investment analysis under uncertainty combined with abandonment option consideration. The ship is assumed to have a useful life of 15 years. The model is based on the assumption that the investor evaluates the project every 5 years or in other words, it focuses on the option to abandon in years 5 and 10 which suggests that the investor is likely to own the vessel for 5, 10 or 15 years. Apart from convenience reasons and having equal re-evaluation periods, there is no justification for choosing those specific values as typical periods for evaluation, which consequently could turn into typical periods of ownership.

2.3.2. System dynamics in maritime economics

System dynamics was originally developed and introduced with the sole purpose of understanding complex industrial systems through modelling and simulating their behaviour. An interesting feature of system dynamics is the fact that a model can have an entirely qualitative (conceptual) or quantitative nature. The concept was introduced to the shipping transport literature by Taylor (1976) who demonstrated that system dynamics can be used to model decisions in the context of shipping. Although Taylor's (1976) model is detailed and it considers certain reasons that may generate sale and purchase activity, this theoretical work does not include assumptions about periods or patterns of ownership. Later Engelen *et al.* (2006) developed a two-fold model representing a holistic viewpoint towards traditional market conditions by modelling the different markets as a system and then within this framework an endogenous model for shipowners' strategic decisions, such as the sale of a ship, was introduced. The assumptions made by the authors regarding shipowners' behaviour are of great interest. First, it is hypothesized that ships can be scrapped or sold when operating them has become too expensive due to old age. Secondly, the hypothetical shipowner used as a base for the endogenous model has 14 dry bulk ships with an average age of 12.5 years. These two assumptions combined imply that the primary motive for owning a ship is making profit from operating a vessel which suggests the employment of a long term investment strategy, although it should be noted that there is no mention of when the shipowner in question acquired the vessels. However, the authors do point out that a factor that has a great impact on the chosen investment horizon is the relationship with the shareholders and whether they are interested in long-term or short-term revenues (Engelen *et al.*, 2006).

2.3.3. Multi-criteria decision making (MCDM)

When addressing a complex set of alternatives the different motivations and preferences of decision makers need to be evaluated (Ishizaka and Siraj, 2018). Multi-Criteria Decision Making (MCDM)[5] is a family of techniques designed for the systematic evaluation of multiple and potentially conflicting objectives (Keeney, 1976; Belton and Stewart, 2002; Marttunen *et al.*, 2017). MCDM is based on mathematical derivation which is capable of classifying a range of alternatives or selecting the optimal solution based on the values of decision makers (Doumpos and Zopounidis, 2002; Zanghelini *et al.*, 2018).

According to Marttunen *et al.* (2017) MCDM's applications have grown substantially due to the popularity of the methods in the corporate decisions literature but also due to the versatility of the methods which allow for combinations between various MCDM techniques or other methods. Some of the popular MCDM methods[6] include:

- AHP (Analytic Hierarchy Process);
- ANP (Analytic Network Process);
- ELECTRE (Elimination AND Choice Expressing Reality);
- TOPSIS (Technique for Order Preference by Similarity to Ideal Solution).

The AHP is regarded as one of the most frequently used multi-criteria decision making techniques (Vaidya and Kumar, 2006) due to its simplicity (Forman and Gass, 2001). The Analytic Hierarchy Process (AHP) is a method based on pairwise comparisons,

[5] Also referred to MCDA (Multi-Criteria Decision Analysis) by some authors. The hierarchy of the terms is conflicting in the literature and it varies between disciplines. In the context of this research, MCDM is assumed to be the term which unites all multi-criteria decision-making techniques.

[6] For more information on the different approaches, see Mattunen *et al*. (2017)'s review of MCDM methods and Russo and Camanho (2015) for a systematic review of the literature on AHP.

which are ranked according to a priority scale derived by experts (Saaty, 1990). Often the AHP is carried out in conjunction with other methods.

In shipping MCDM approaches (including combination of approaches) have been applied to a variety of problems such as choosing registry (Kandakoglu *et al.*, 2009); assessing safety factors in coastal shipping (Hsu *et al.*, 2015); technology selection (Ren and Lützen, 2015); selecting partners for strategic alliances in liner shipping (Ding and Liang, 2005); shipping asset management (Bulut *et al.*, 2012).

The MCDM approaches are also used in portfolio management and optimization. In the context of shipping, portfolio management and diversification are often referred to as the '*traditional approach to risk reduction'* (Psaraftis *et al.*, 1997). According to Lorange and Norman (1973) the general portfolio planning considerations refer to the shipping company's choice of '*involvement between different types of shipping* activities'. This process involves choosing between a diversified fleet and niche shipping on the very basic shipping company level; however, for a big corporation that is involved in various sectors or investors, it could be a matter of diversification of activities, assets (i.e. bonds/stocks), etc. Portfolio management and optimization's primary role in maritime research is to tackle risk management problems. Lorange and Norman (1971) pioneer the analysis on hedging techniques in shipping markets, Cullinane (1995) explores hedging strategy formulation in shipping as a portfolio optimization problem. For instance, Lorange (2005, p. 113) provides a sample analysis of Index-based shipping portfolio and carries out an assessment of returns on portfolio strategies using the three main ship types – bulk, tanker and container with a specialized software - Marsoft. The assessment is scenario-based with various holding periods – 2, 3 and 5 years. Lorange (2005, p. 113) claims that according to the results investments in the bulk and container sector seem more profitable in the short term whereas in the '*longer term'* tankers seem to be a more attractive option. However, there is no further elaboration on whether these holding periods were specifically or randomly chosen.

Rousos and Lee (2012) introduced MCDM to ship evaluation problems by applying an analytical hierarchy process (AHP) with the aim to formulate the psychological factors that affect investment decisions in shipping.

The aim of their work is to formulate a model capable of producing investment proposals that take into account monetary and non-monetary considerations, the latter being the psychological constraints of the investor. According to Rousos and Lee (2012) the most important sub-criteria in the preference decision vector are sector preference and asset play possibilities with combined weight of 57%.

Reviewing the literature on current trends in ship investment research revealed that often when modelling shipowners' behaviour, researchers make assumptions about likely periods of ownership. Another example is Veenstra's (1999) assumption that transactions involving 5-year-old vessels are '*replacement*' driven whereas transactions with 10-year-old vessels are deemed to be '*speculative*'. Although such assumptions provide interesting views on typical investment horizons, no justification regarding the chosen periods is provided. According to the literature search, it was concluded that the assumptions regarding typical periods of ownership in the maritime economics and investment modelling literature are based on arbitrary numbers and not on empirical data.

2.4. Types of Ownership in Shipping

In order to estimate periods of ownership in shipping, the owner of a vessel needs to be identified. Veenstra and Bergantino (2000) acknowledge that the ownership, the management and the operation of vessels are usually carried out by '*different companies under different management*' and that different '*classes of ownership'* can be distinguished[7]. In terms of ship ownership, there are two main classes of ownership referred to as 'registered' and 'beneficial' owner respectively. The registered owner of a vessel is the '*legal title of ownership of the vessel that appears on the ship's registration documents*'[5] (Sea-Web, 2017b), whereas the beneficial owner, also referred to as ultimate owner (OECD, 2003; Kang and Kim, 2012), is the entity that gains '*the ultimate financial benefit from a vessel's operation*' (Fox, 2005). It should be noted that the beneficial and registered owner can be the same entity or different entities. Mandaraka-Sheppard (2013, p.123) states that under English law beneficial ownership:

> *'…refers to such ownership as is vested in a person who, whether or not he is the legal owner of the vessel, is in any case the equitable owner.*
>
> *Thus 'beneficially owned' refers to equitable ownership, whether or not accompanied by legal ownership. Equitable ownership is meant to cover an*

[7] The roles of the types of companies involved in the ownership, management and operation of ships as defined by Sea-Web (2017) and as used in the context of this research are described in Appendix A-1.

owner for whose benefit the legal owner holds the shares in the ship under the English law concept of trust. The adjective 'beneficial' before owner ensures that, if the ship is operated under the cloak of trust, she can still be arrested for maritime claims. The commercial reality is that registered owners of ships are not just legal owners of bearer shares. They are both legal and beneficial owners of all shares in the ship. Any division between legal and equitable interest in the ship occurs in registration. For example, the legal property in the shares may be held by A and the equitable by B.'

Apart from being conceptually complex, beneficial ownership in shipping can be rather difficult to determine. Historically shipowners benefited from limited liability, however certain regulatory changes[8] and more rigorous attempts by courts to '*pierce the corporate veil'* (Fox, 2005) led to further fragmentation of ownership as identity disclosure became less attractive. Creating a corporate entity which grants anonymity to shipowners can be achieved using bearer shares or nominee shareholders, directors or intermediaries (OECD, 2003; Fox, 2005). These developments increased the popularity of open registers, referred to also as flags of convenience, as such ship registers allowed registration based on the above instruments for achieving anonymity. Other reasons for choosing an open register are for example crew costs, level of government control, fiscal reasons, limited availability of skilled labour in respective nations (some national registers require the crews to constitute nationals only) (Bergantino and Marlow, 1998; Goulielmos, 1998; Chung *et al.*, 2007; Mitroussi and Arghyrou, 2016). Hoffmann *et al.* (2004) even suggest that the choice of register is also driven by the state of the vessel and other ship level characteristics, such as ship type, size and age. Likely reasons for switching between ship registers include the amount of savings in tax and labour costs Kavussanos and Tsekrekos (2011) and likelihood of PSC[9] inspections (Cariou and Wolff, 2011). This suggests that re-flagging or changing the ship register is not uncommon in shipping.

According to Article 91 of the 1982 United Nations Convention on the Law of the Sea (UNCLOS, 1982), which came into force in 1994, each state can determine the conditions for the registration of ships in its territory. Article 91 also provides that there must be a '*genuine link*' between the state and the ship (UNCLOS, 1982). However,

[8] Such as the Oil Pollution Act of 1990 (OPA'90), which introduces the potential for unlimited liability and it caused the phasing out of single-hull tankers.
[9] Port State Control (PSC).

no specific definition of '*genuine link*' is provided, which allows for certain liberty in interpretation. As a result, certain open registers, for example Liberia, introduced the requirement that vessels could only be registered under Liberian flag if they are owned by a Liberian company[10]. In some cases, due to these requirements, two vessels under the same beneficial (ultimate) ownership can be registered in two different countries – one in Liberia and one in Cyprus for example (Harwood, 2006). Respectively, a change of the ship's flag might also lead to a change of the registered owner depending on the requirements of the Flag. Based on the above, it is concluded that estimating periods of ownership in shipping based on registered owner information will not provide accurate or reliable results. Instead, in the context of this research, periods of ownership are estimated based on beneficial ownership on group company level as defined by Sea-Web (2017):

> '*This is the parent company of the Registered Owner, or the Disponent Owner if the ship is owned by a bank. It is the controlling interest behind its fleet and the ultimate beneficiary from the ownership. A Group Beneficial Owner may or may not directly own ships itself as a Registered Owner. It may be the Manager of its fleet, which is in turn owned by subsidiary companies. Its ships may also be managed by a 3rd party under contract.'*

It should be noted that only companies that own or have been known to own ships in the past, excluding subsidiaries of larger companies that only operate or manage vessels, are defined as group beneficial owners[11].

Although the limitations of using registered owner related data have been presented in this section, beneficial ownership data is scarcely used in the maritime economics literature. Apart from certain issues related to anonymity preferences discussed earlier, a likely reason is that such data is not readily available. The need for more accurate ownership data has been highlighted mainly in studies dealing with investigating the distribution of the world fleet by nationality. For example, Tenold (2000) recognizes that there is a disparity between ownership and registration of the majority of the world fleet and provides a few different scenarios to illustrate how the

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[10] According to the Liberian Flag requirements every vessel registered should be owned by 'a Liberian corporation, registered business company, limited partnership or LLC, or by a Foreign Maritime Entity (FME) (an entity existing in another jurisdiction and registered in Liberia for the purpose of owning or operating a vessel)' (LISCR, 2016, p.3).

[11] Further information on data gathering, processing and limitations can be found in Chapter 4.

nationalities involved in ship ownership and registration can be multiple. Veenstra and Bergantino (2000) claim that the most important economic activities in shipping are related to the beneficial ownership, the flag and the operation of vessels and that all three categories can be associated with one or multiple nationalities. Nguyen (2011) proposes country of domicile as a more accurate measure than registered tonnage for examining the portion of national tonnage across maritime nations' fleets. Kang and Kim (2012) use an alternative classification for the ownership of state-owned enterprises in China which is based on ultimate rather than registered ownership. Conceptually the problem is similar as using legal (registered) ownership does not provide the level of accuracy needed, however it should be noted that the goal of the study by Kang and Kim (2012) is to identify shareholders, rather than the entities serving as beneficial owners.

Pruyn *et al.* (2011) provide a critical examination of the research regarding second hand ships' value estimation including approaches used and known data limitations. One of their comments raises concerns regarding the accuracy and reliability of the data used in maritime economics papers. Pruyn *et al*. (2011) point out that there is a disparity between monthly sales quoted by data providers and the actual number of sales reported. The authors claim that this is likely a result of the fact that sales volumes '*are mostly filled by 'guestimates', estimates of a number of knowledgeable brokers*', which use internal (for the data provider) models as the foundation of their prediction, thus introducing bias to the data.

In the light of the above, it is recognised that the data often used in maritime economics related research has its limitations. Although some of these cannot be overcome as they depend on external factors such as reliability of data providers, an attempt can be made for the introduction of metrics, which are more appropriate for the investigation of specific problems. This research aims to determine periods of ownership based on group beneficial ownership in an attempt to provide a more accurate and reliable account of patterns of ownership in shipping.

2.5. Concluding Remarks

This chapter provided a review of the literature on characteristics perceived to influence investment horizons and associated periods of ownership in shipping and it identified three distinct groups of characteristics which are likely to have an effect on periods of ownership, namely: (i) ship level characteristics; (ii) company level characteristics and (iii) economic indicators. To complement the findings of the literature review, three pilot in-depth interviews were conducted with two industry professionals at executive positions and one academic with considerable experience[12]. The following three additional ship level characteristics were suggested by the interviewees as likely to have a potential effect on periods of ownership: speed, fuel consumption and shipbuilder (shipbuilder area). Table 2.3 summarises the list of main characteristics included in this research.

Ship Level	**Company Level**	**Economic Indicators**	
		Shipping Market	**Global**
Ship Type	Company Type	Freight Rates (Earnings)	Economic Growth
Ship Size	Company Size	Newbuilding Prices	Oil Price
Speed*	Nationality	Second hand Prices	Bunker Price
Fuel Consumption*		Demolition Prices	Inflation
Builder (area)*			Exchange Rate
			Interest Rate

*Added as a result of the pilot in-depth interviews.

Table 2.3. List of characteristics to be included in the analysis

Chapter 3 will introduce the methods selected to address the research questions.

[12] The results from the pilot interviews as well as the reminder of the in-depth interviews carried out as part of this project are discussed in Chapter 7.

Chapter 3. Methodology

3.1. Introduction

The literature search on length of ownership in shipping confirmed that the assumptions regarding periods of ownership used in ship investment research are arbitrary and that they are not based on actual empirical evidence. Furthermore, the parts of the literature review focusing on the choices of an investment strategy and on the investment horizon respectively, which both have a direct impact on periods of ownership identified three broad groups of characteristics that are perceived to have an effect on periods of ownership in shipping, namely: (i) ship level characteristics, (ii) company level characteristics and (iii) economic indicators. However, despite the number of factors discussed in the literature as having an influence on sale and purchase related decisions, no formal integrative investigation of the influence of such factors has been attempted in terms of periods of ownership.

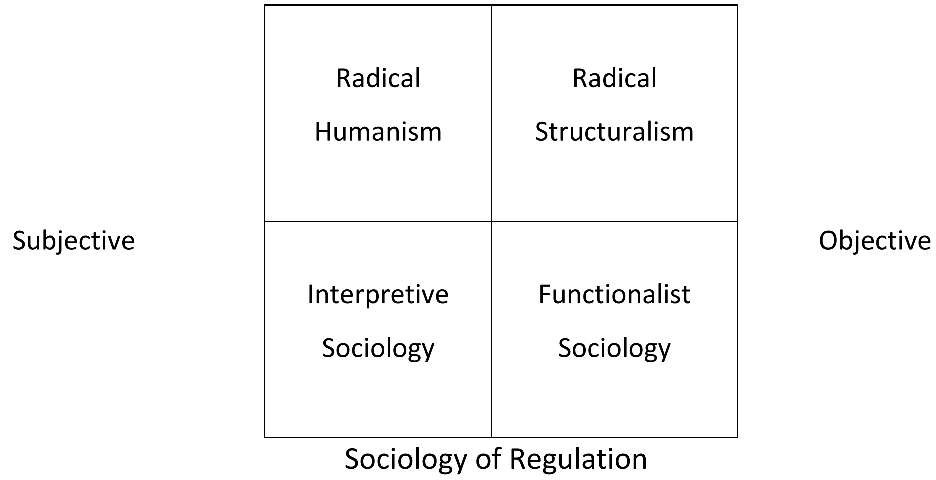
The approach that is chosen in this research to tackle periods of ownership in terms of patterns and influences is based on addressing this knowledge gap. The purpose of this Chapter is to discuss the chosen methods and the possible limitations associated with them.

3.2. Overall Research Design

3.2.1. Brief overview of research paradigms

When determining the overall design of a study, the selection of a topic and a research paradigm are the two essential choices that need to be made. Collis and Hussey (2003) point out that the term '*paradigm*' is used *'quite loosely'* in academic research and different interpretations are associated with it. This phenomenon could be explained by the very definition of the term itself. The concept of the paradigm was introduced by Thomas Kuhn in the 1960s. However, Kuhn (1962) states that paradigm as a concept has a dual nature which is most likely the reason behind common misconceptions. The first, also referred to as sociological, sense of paradigm he defines as '*the entire constellation of beliefs, values, techniques, and so on shared by members of a given community'* (Kuhn, 1962, p.175). On the other hand, the deeper meaning Kuhn attributes to the term has to do with the idea that *'paradigms can guide research even in the absence of rules*' (Kuhn, 1962, p.42).

Burrell and Morgan (1979) developed a framework that consists of four distinctive paradigms – functionalism, interpretivism, radical humanism, radical structuralism, (Figure 3.1).



Source: Burrell and Morgan (1979, p. 22)

Figure 3.1. Sociology of Radical Change

Saunders *et al.* (2009) state that Burrell and Morgan's framework can be used by researchers as a map when trying to clarify their own view about the world and to navigate their own research but also as a reminder of the different approaches other researchers might adopt. In contemporary research, there is '*considerable blurring'* (Collis and Hussey 2003) and '*oversimplification*' (Mangan *et al.*, 2004) of the concept of research paradigms. Generally, two main research paradigms, sometimes also referred to as philosophies - positivist and phenomenological (Collis and Hussey 2003), are used. These philosophies generally reflect Burrell and Morgan's functionalist and interpretive paradigm respectively.

According to Easterby-Smith *et al*. (2012, p. 22) the fundamentals of positivism lie in the belief that the '*social world exists externally, and that its properties should be measured through objective methods, rather than being inferred subjectively through sensation, reflection or intuition*'. The positivistic philosophy is based on the belief that the world is predictable and subjected to set norms and patterns. Therefore, quantitative strategies typically associated with positivism have been seen as appropriate by many when applying deductive explanatory analysis under standard conditions (Clarke, 2003). Creswell (1994) defines a quantitative/positivistic study as an inquiry into a social problem whose aim is to *'determine whether the predictive generalizations of the theory hold true'* with the help of numerical tests and statistical analyses. On the other hand, research that falls within the phenomenological paradigm is based on the belief that the world is in a '*dynamic state of flux, with multiple subjective realities'* (Clarke, 2003). Creswell (1994) describes a qualitative study as the process of building '*a complex holistic picture, formed with words, reporting detailed views of informants and conducted in a natural setting*'. A list of the key features of both paradigms is provided in Table 3.1.

	Positivist Paradigm	Phenomenological Paradigm
Basic beliefs	The world is external and objective Observer is independent Science is value-free	The world is socially constructed and subjective Observer is part of what is observed Science is driven by human interests
Researcher should	Focus on facts Look for causality and fundamental laws Reduce phenomena to simplest events Formulate hypotheses and then test them	Focus on meanings Try to understand what is happening Look at the totality of each situation Develop ideas through induction from data
Preferred methods	Operationalising concepts so that they can be measured Taking large samples	Using multiple methods to establish different view of phenomena Small samples investigated in-depth or over time

Source: Easterby-Smith, Thorpe et al (1991); Found in: Mangan et al (2004)

Table 3.1. Positivist and Phenomenological Paradigms - Key Characteristics

The remaining two paradigms, namely radical humanism and radical structuralism, are rarely used in the context of maritime economics (Woo *et al.* (2013), however, a brief outline is provided.

The radical humanist paradigm is closely related to the interpretive sociology paradigm in terms of its approach to social science as both paradigms view the world as anti-positivist (Burrell and Morgan, 1979). However, at the core of the radical humanist paradigm is the notion that existing social arrangements affect human development as the human mind and consciousness are dominated by ideologies controlled by large social institutions (Burrell and Morgan, 1979). Social theorist whose work is guided by this paradigm '*seek to change the social world through a change in modes of cognition and consciousness*' (Burrell and Morgan, 1979, p. 34). According to Burrell and Morgan (1979) some of the famous theorist who subscribe to these values are: Marx (early work), Sartre, Habermas, Illich, Castaneda and Laing.

On the other hand, structuralists' attitude towards science conforms to the attitude promoted by functionalist theory (positivist). Most radical structuralists agree that society is '*characterised by fundamental conflicts which generate radical change through political and economic crises*' (Burrell and Morgan, 1979, p 34) and that change can be achieved through a societal transformation. According to Burrell and Morgan (1976) famous theorists that exhibit the radical structuralists' view are: Marx (late work), Engels, Lenin, Colletti.

3.2.2. Methodological triangulation

According to Ghauri and Gronhaug (2002) methodological triangulation[13] can be defined as the process of combining methodologies in a single study of a given phenomenon. Some of the main arguments against the use of methodological triangulation stem from the idea that due to the different underlying assumptions associated with both paradigms, the study will be disjointed (Burrell and Morgan 1979). Among some of the more practical arguments against mixed method research[14] as summarised by Easterby-Smith *et al.* (2009) are in the complex nature of replicating such studies, in the fact that they usually involve the use of more resources than single method studies and in matters regarding the competence of the researcher in using both techniques. The advocates of methodological triangulation suggest that both views of reality are compatible and that they are essential in fully comprehending behaviour (Haase and Myers, 1988) and that the view that they cannot be successfully combined can obstruct the advancement of science (Onwuegbuzie and Leech, 2005). Mixed method research is regarded by many to be a natural way of combining the strengths of each method since it acknowledges the importance of the physical world as well as the influence of human experience (Johnson and Onwuegbuzie, 2004) and thus employing the best of both worlds (Chen, 1997) to the study of a given phenomenon. Coleman (1986) argues that the use of methodological triangulation provides the means to fully understand social phenomena. Furthermore, Denzin (1988) claims that it enhances validity and reliability. Despite the array of advantages associated with methodological triangulation, it should be noted that most researchers recognize the fact that mixing data types without integrating them in a study is nothing more than a collection of methods (Harrison III, 2012).

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[13] Easterby-Smith *et al*. (2009, p. 146) claim that there are different types of triangulation, namely theoretical, data, investigator and methodological.

[14] According to Harrison III (2012) methodological triangulation is also referred to as '*mixed method research*' in business studies.

According to Johnson and Onwuegbuzie (2004) mixed method research is connected to pragmatism. A pragmatic inquiry consists of three different stages (Johnson and Onwuegbuzie, 2004), namely the process of discovering patterns (induction), testing the formed theories (deduction) and applying contextual judgements (abduction).

Tashakkori and Teddlie (1998) give three main reasons why the pragmatist philosophy deserves consideration by a researcher, namely: (i) it provides a paradigm that acknowledges the use of methodological triangulation; (ii) it does not focus on concepts such as truth and reality and thus frees the researcher from participating in the debate associated with such concepts and (iii) it presents an opportunity for adopting a practical approach which aims at answering the research question fully by choosing the methods that are deemed to be most appropriate. As the phenomenon, which can be investigated quantitatively but it involves a social element as periods of ownership depend on the decisions of agents involved in the shipping industry, it is believed that employing a mixed method approach will enrich the findings on patterns and influences associated with periods of ownership.

Panayides (2006) points out that maritime researchers can assist the industry through providing a '*simplification of complex phenomena'* and substantive decision support, '*leading to implementable systems'*. Panayides (2006) also states that both, '*quantitative and qualitative tools may be useful in this respect*.'

According to Woo *et al.* (2013) maritime transportation is '*both, an economic activity in which economic entities are involved and a social phenomenon in which a number of social actors interact'*. Looking at maritime transportation as an economic activity suggests that the phenomena observed can be investigated and measured with the tools that are provided by mainstream economics and traditional quantitative approaches as the ones identified by Woo *et al*. (2013) and Talley (2013) as the most commonly used in shipping research. The second part of the definition provided by Woo *et al*. (2013), however, recognizes the presence of social actors and their interactions. Such social phenomena, for example the decision to buy or sell a ship, are better examined in qualitative terms.

The proposed methodology aims at capturing the essence of the phenomenon under investigation, namely length and patterns of behaviour in terms of periods of ownership and therefore, the most appropriate methods reflecting the nature of the phenomenon were sought. This research is based on methodological and data triangulation and thus a mix of deductive and inductive (quantitative and qualitative) approaches is used (Table 3.2).

Research Question	Type(data)	Approach	Method
RQ1 What can be regarded as likely length of ownership in shipping[15]?	Quantitative/ Qualitative	Deductive Inductive	Statistical analysis Interviews
RQ2 What can be regarded as likely patterns of ownership in shipping[16]?	Quantitative/ Qualitative	Deductive Inductive	Statistical analysis Interviews
RQ3 What characteristics on ship level and company level influence periods of ownership in shipping?	Quantitative/ Qualitative	Deductive Inductive	Statistical analysis Interviews
RQ4 Do economic indicators, such as earnings, influence periods of ownership in shipping?	Quantitative/ Qualitative	Deductive Inductive	Statistical analysis Interviews

Table 3.2. List of Research Questions in Terms of Data Type, Approach and Method

3.3. Methodology and Methods

The objectives of this research are related to periods of ownership in shipping. As a period of ownership can be defined as the time a vessel is in the possession of a specific owner, determining each change of ownership is thus crucial to the analysis of length and patterns of ownership.

3.3.1. Identifying changes of ownership in the context of shipping

Periods of ownership in the context of this research are calculated based on the changes of group beneficial owner, rather than registered owner as this provides a more realistic information on the actual changes of ownership. According to the examination of the literature carried out as part of this research, changes of ownership in shipping in relation to periods of ownership have been investigated historically for two distinct subsets of the world fleet as discussed earlier. The first study conducted by Einarsen (1938) is based on the commercial history of Norwegian merchant fleet vessels built between 1883 and 1932. The second study on the topic, conducted by Stott (2013) is based on the commercial history of bulkers, tankers and container ships built between the beginning of 1987 and the end of 1992 and scrapped before 2013. As this research builds on the investigation of periods of ownership carried out by Stott

[15,15] Based on evidence from the commercial history of vessels built between 1987 and 2007.

(2013), the definition of change of ownership adopted as part of this research rests on the one provided by Stott (2013), who defines it as:

> *'a change where the specific asset is actually sold and money changes hands in the realisation of the asset. Put another way, a sale is constituted by a change that may require the services of a sale and purchase broker.'*

According to the definition of changes of ownership presented above, the additional ambiguities described in previous studies on periods of ownership and the author's own experience in gathering the data, the following 'rules', partially adapted from the work of Einarsen (1938) and Stott (2013), have been used in this research:

- Delivery date equals 'entry into operation' and the beginning of the follow up period for each vessel included in the sample;
- The first owner is the first operating owner, therefore any changes of ownership that may have occurred prior to the entry into operation of the vessel are not counted as part of this analysis;
- The information on the changes of ownership is monthly, therefore it is assumed that each change occurs at the beginning of the respective month;
- Where the date corresponding to the change of ownership is missing from the data providers' listings, additional information, such as changes of the name, flag, the DOC[17] holder of the ship is taken into consideration;
- If a change of ownership occurs shortly before a vessel proceeds to a ship-breaking yard, it is not counted as an actual change of ownership as such changes of ownership usually involve demolition brokers;
- A transfer of ownership of a vessel between subsidiaries of the same parent company is not treated as an actual change of ownership;
- A transfer of ownership between two companies, where the new holding company is a joint-stock venture of the previous owner and another company, is not treated as a change of ownership unless proof of a monetary transaction is found. Often in such cases, the 'previous' owner ceases to exist as a legal entity;
- When a ship is transferred from a company owned by one family member to a company owned by another family member, the ties between the companies and the nature of the transfer are further investigated. For example, a wedding gift exchange between shipowning families may come in the form of vessels;

[17] DOC stands for Document of Compliance.

- When the parent company is absorbed by another company through some form of consolidation (mergers and acquisitions), the transfer of the fleet of the parent company to the new company is not considered an actual sale so there is no change of ownership for each individual ship involved in the transaction;
- Lease-back transactions, where the vessel is registered with the lessor for a limited amount of time and then it returns to the same owner as before, are not considered as actual changes of ownership in the context of this research.

Based on the framework for identifying changes of ownership as described above, the commercial history records of 3,908 ships have been examined resulting in a total of 8,042 changes of ownership being recorded. A detailed description of the process of calculating periods of ownership with the data collected as part of this research is described in later chapters[18].

3.3.2. Statistical analysis

The methods employed to address the research questions under investigation have been chosen based on the nature of the data on periods of ownership. Periods of ownership corresponding to each owner represent the time each ship is in the possession of the respective owner until the ownership is terminated. This type of data, where the time until an event of interest is observed or alternatively until the end of a follow up period, is known as 'time-to-event'[19] (Frees, 2010). The two common limitations related to such data are referred to as '*censoring*' and '*truncation*'. There are three distinct forms of censoring that are often found in the literature – right, left and interval censoring. Right censoring is the most common type of time-to-event data as it represents observations that have not experienced the event of interest by the end of the observation period (Vittinghoff, 2005). On the other hand, left-censoring takes place when the event of interest has occurred before the start of the observation period. Another typical form of data incompleteness is observed when it is known that the event has occurred, however the exact time remains unknown (Frees, 2010). In such cases, when the data represents an interval of time rather than an exact moment in time, interval censoring is present.

Truncation is the second major form of data limitation common for time-to-event data and it refers to missing data rather than incomplete observations due to censoring (Frees, 2010). Right truncation is observed when all of the study subjects have

[18] See Chapter 4, section 4.3.1., e) Dates.
[19] It is also referred to as 'survival data' or 'censored data' in the literature.

experienced the event of interest, a common scenario when working with historical datasets. According to Harrell (2015) left-truncation occurs when subjects of the data cannot be included in the dataset because they have failed before the time origin of the study, whereas delayed entry occurs when subjects enter the study after the chosen time origin. Clearly, defining the start of the observation period, also referred to as the time origin, is crucial to classifying data limitations. Ideally all subjects would be enrolled in the study before the first event of interest has occurred and followed until each one of them experiences the event allowing for all the information on the event of interest to be gathered and analysed. Such study designs are often referred to as incident cohort designs, however they are not particularly common due to the presence of a variety of data limitations (Cain *et al.*, 2011).

A key concept in any analysis of time-to-event data is the presence of multiple timescales. Hills *et al*. (2014, p. 2) define timescale as '*a variable that varies deterministically*' within each subject during the observation period. The concept of multiple timescales arises from the very nature of time-to-event data, which consists at least of the following: (i) time of entry, (ii) time of exit and (iii) object status at the end of the follow up (Hills *et al.*, 2014). However, a number of events, some of interest, some maybe not, can occur during the follow up period. An important decision in the analysis of time-to-event data is the choice of time zero, which is defined by Kleinbaum and Klein (2006) as '*the starting point for determining individual's 'true' survival time'*.

A simplified diagram of the economic life of each vessel consisting of the main events related of interest in research is presented in Figure 3.2. In terms of the data on periods of ownership, the follow up period starts with the delivery of the vessel to the first owner, which is assumed to be the moment the ship enters into operation. The end of the follow up period is the end of the data collection phase, which is discussed at length in following chapters[20]. The event of interest in this research is defined as '*termination of ownership'*, which represents a sale to: (i) a subsequent owner or (ii) a scrap yard, where ships are being demolished. Periods of ownership by definition reflect the time each ship has spent in the possession of a respective owner, where '*respective owner'* refers to the number of the owner in the succession of owners that the vessel has had by the end of the follow up[21], i.e. first owner, second owner, etc.

[20] See Chapter 4, section 4.2.2. Sampling Frame and Sample Size.
[21] Note that the vessel will not necessarily be observed to the end of the follow up period as it might be scrapped before then. This is discussed in more detail in Chapter 4, section 4.2.2.

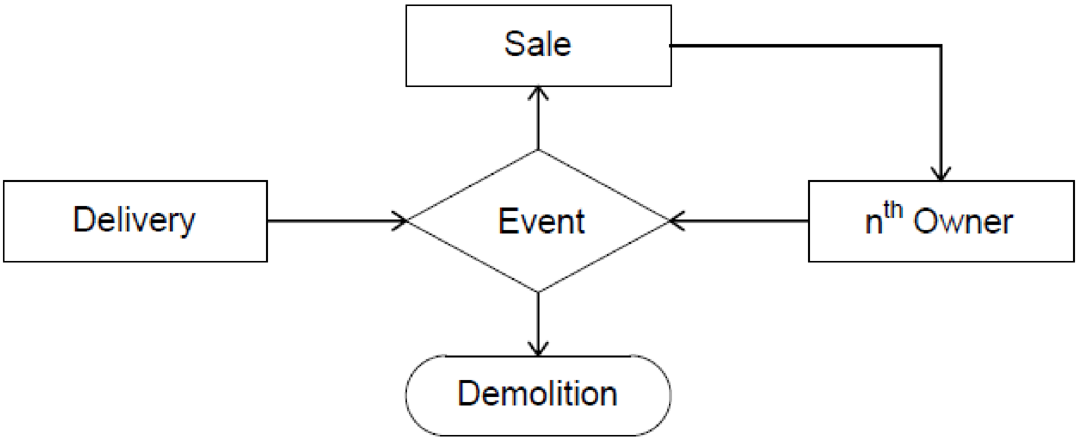
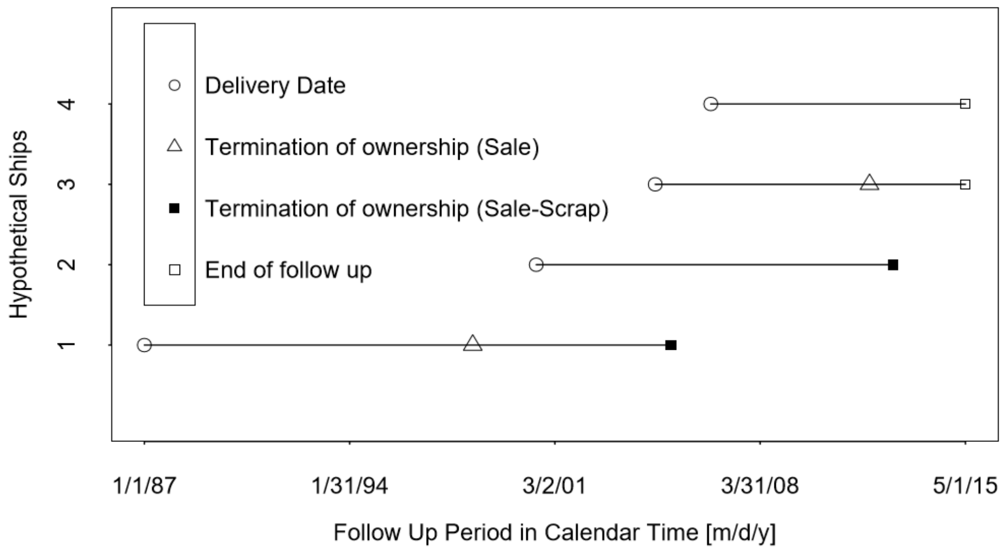


Figure 3.2. The Economic Life of a Vessel

This inherent characteristic of the data and the fact that this research seeks to expand on the results on periods of ownership by owner number reported by Stott (2013) defines the choice of time zero as the moment the vessel enters into the possession of the respective new owner. Under these definitions, a censored event can arise in the following ways: (i) at the end of the follow up the ship is known to be still in operation and in the possession of the last known owner; (ii) the ship stopped existing during the follow up due to a reason other than being scrapped, which in the context of shipping is represented by a total loss of the vessel at sea[22]. Technically, one can argue that when a vessel is laid up it is not in operation, however, as these occurrences are a temporary out of service arrangement and no change of ownership occurs during that period, censoring is not applicable. As per the data collection design, only right censoring is present in the data gathered for the purposes of this research. In theory, an example of left-truncated data would be the number of vessels on order that were cancelled before delivery, although depending on the date of cancellation often in practice such slots/vessels do get completed by the shipyards and re-sold to other owners. Figure 3.3 illustrates the economic lives of four hypothetical vessels as if they were included in the dataset in relation to the follow up.

[22] The number of ships lost at sea represents 0.6% of the sample, which is a negligibly small number.



Note: All the dates on the 'Calendar time' axis are arbitrary although the beginning of the delivery period is January, 1987 and the end of the latest data collection phase is May, 2015.

Figure 3.3. Dates of Interest in the Life Cycle of Ships

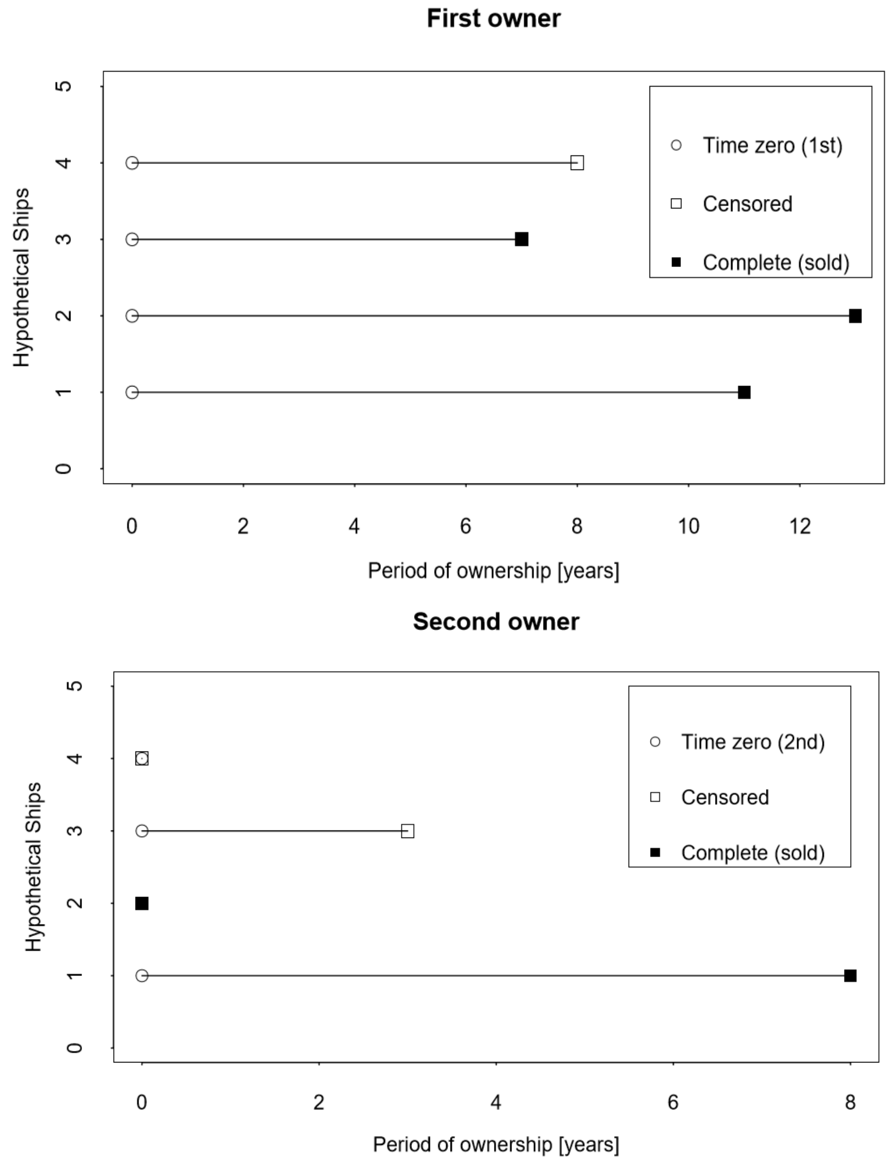
The first hypothetical ship, depicted in Figure 3.3 was delivered in the beginning of 1987, it was sold once in 1998 at age 11 years and it was scrapped in 2006 at the age of 19 years. This means that the period of ownership corresponding to the first owner is 11 years, same as the ship's age at that point, whereas the period of ownership corresponding to the second owner is 8 years. The second ship was delivered in the year 2000 and was never sold by the first owner before it was scrapped in late 2013 at the age of 13 years. The commercial life histories corresponding to the periods of ownership of these two vessels are therefore complete. Ships number three and four are censored as they were still in the possession of their last known owners, the second and the first respectively, at the end of the follow up period in May, 2015. As there is no information on any termination of ownership that may have occurred after May, 2015, the life history data of these vessels is incomplete. However, if the data corresponding to each owner number is treated independently, then for ship number three the data constitutes of a complete record for the first owner and a censored record for the second owner[23]. As mentioned earlier, there are multiple timescales associated with time-to-event data. In the context of periods of ownership, the following timescales can be distinguished:

- Calendar time;
- Age of the ship since delivery, where delivery is the date of entry and time zero;

[23] Ship records are discussed further and examples, based on actual data are presented in Chapter 4, section 4.2 and Chapter 5, section 5.2.1.

- Ownership time by owner number, where the date the ship enters in the possession of the respective owner is the date of entry and time zero;
- Generic time, which can be any of the above.

As time advances at the same pace on each timescale, Hills *et al*. (2014) postulate that ‘*it suffices to use only the entry point on each of the time scales*’. For the purposes of this research, the chosen entry point is ownership time by owner number. Figure 3.4 depicts the ownership time with the first and second owners of the four hypothetical ships from Figure 3.3.



Note: Time zero is the date the ship enters in the possession of the respective owner (1st or 2nd). Complete observations (also referred to as records) are the ones that have experienced the event of interest (termination of ownership). Censored events are the ones that have not experienced the event.

Figure 3.4. Timescale Example – Ownership time

It should be noted that time zero for the first owner is the delivery date of the vessels, whereas time zero for subsequent owners is the date at which the transfer of ownership is carried out. For the sake of simplicity, this date is referred to as '*change of ownership*' or simply '*sale*'. The second and the fourth of the hypothetical ships represented in Figure 3.3 both had a total of one owner by the end of the follow up, which is the reason why only their censor status appears on the timescale example plot representing the second owner on Figure 3.4. In order to investigate periods of ownership and to accommodate the fact that they each represent the time the vessel was in the possession of a different owner, the data corresponding to each owner number has been pooled together across all ships, or in other words, the analysis is stratified by owner number. There are additional reasons for pooling the data in such a manner, namely: (i) there is evidence that periods of ownership tent to vary by owner number[24] and (ii) stratifying the analysis by owner number acts as a natural stratification by age, which is advised as being a bias reducing method when the subjects', or in this case the vessels', age range is wide (Seppa and Hakulinen, 2009). The nature of time-to-event data restricts the choice of data analysis techniques as using methods that are not designed to handle incomplete data can have a negative impact on the interpretation and the validity of the research findings.

a) Investigating length and patterns of ownership in shipping

The data on periods of ownership used in this research is derived from data on: (i) the delivery date of the ships; (ii) potential changes of ownership data, as defined earlier as part of this research[25], gathered and collated through an examination of the commercial history records of 3,908 ships, and (iii) the dates on which the ships were broken up where applicable. The purpose of the analysis concerning the length of periods of ownership is to provide a summary of the likely patterns of ownership according to the definition of change of ownership adopted as part of this research, where '*likely patterns'* refers to the most common values assigned to periods of ownership in terms of appropriate measures of central tendency and an overview of the length of ownership in relation to the succession of owners. The measures of central tendency of most interest applied to periods of ownership in shipping are the mean (average) and median (middle) values. In the presence of censored data, the median is a preferred measure as time-to-event data is often skewed, which translates

[24] As discussed in Chapter 2, section 2.2.2.d)
[25] See definition of change of ownership – Chapter 3, section 3.3.1.

into either an under or an over estimate of the true mean depending on the length of time corresponding to censored observations relative to this of complete observations[26]. It should be noted that because the analysis is divided by owner number and periods of ownership are estimated in years[27], the difference between mean and median is in the range of 6 months in most cases as demonstrated in later chapters.

In light of the above, the first step in the analysis of periods of ownership in shipping is reporting the mean and median of time-to-event data based on the characteristics of interest concerning this part of the analysis, namely owner number and ship type. Although this approach is straightforward, the stratification by owner number requires more attention. To examine periods of ownership by owner number, all records corresponding to a specific owner number are pooled together and grouped in independent categories, i.e. first owner period, second owner period, etc. Although this technique facilitates the investigation of the research questions, namely to examine patterns of ownership in shipping and whether they are affected by a set of characteristics on ship and company level – it also ignores the fact that the economic life of vessels is finite, which implies that length of ownership is expected to vary depending on total number of owners. For example, a ship with 2 owners in total is expected to have spent longer with each owner as opposed to a ship with 6 owners in total. In order to better address the question of any likely patterns of ownership in shipping, methods common in multistate analyses can be used as complementary to the findings from the pooled owner data. Andersen and Keiding (2002) note that the simplest multi-state model for survival data constitutes of only two states: 1) alive, a transient state and 2) dead, an absorbing state. An absorbing state is one that does not allow further transitions (Andersen and Keiding, 2002; Willekens, 2014). In the case of periods of ownership, the transient states refer to the number of owners as the ships transition from being in the possession of one owner to another, whereas the absorbing state refers to the demolition of the vessels. Multi-state analysis is popular in demographical tradition therefore certain descriptive methods used for summarising transitions between states have been borrowed in order to illustrate better the most common life histories of vessels.

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[26] An example of this phenomenon in practice is shown and discussed in Chapter 5, section 5.2.2.
[27] In decimal years, where a year is 365.25 days long, which suggests that a tenth of the year is 36.525 days. For example 6.6667 years is 6 years and 8 months.

The first technique used is the Lexis diagram[28], which represents transitions and states in relation to two time scales, usually calendar time and age (Willekens, 2014). Additional graphical methods used to visualise life histories, also popular in demographical studies, include state distribution plots and frequency of state sequences. State distribution plots are particularly useful in displaying collective life history based on specific samples, whereas frequency of state sequences is used for determining the most frequent combination of states (Willekens, 2014). In the context of this research '*state*' refers to the owner number and '*state sequence'* respectively to owner number sequence. These graphical techniques are used as complementary to the findings on mean and median periods of ownership by owner number as they provide a more accurate depiction of the life history of vessels. For example, the use of these techniques provides information on the length of ownership based on the total number of owners per ship type.

b) Investigating the effects of ship and company level factors on the length of periods of ownership

One of the main objectives of this research is to establish whether a certain set of characteristics, on ship and company levels respectively, independently or collectively affect the length of ownership in shipping. In order to do so a range of methods, commonly known as survival analysis, are employed. Traditional regression modelling strategies, such as multiple linear regression and logistic regression, were initially explored as potential methods for addressing the research questions. It was concluded that due to the inherent characteristics of the type of data and, more specifically, the presence of data limitations, such as censoring, time-to-event data cannot be analysed as a continuous outcome (Vittinghoff, 2005). If the subject of interest is the occurrence of a particular event, then logistic regression can be applied, however when the time until the event is also important applying logistic regression leads to a waste of information and statistical power (Vittinghoff, 2005; Harrell, 2015).

Introduction to survival analysis and its applications

Miller (1981, p.1) explains survival analysis (SA) as a '*loosely defined statistical term that encompasses a variety of statistical techniques for analysing positive-valued random variables*'. The distinct capabilities of SA techniques are related to the fact that in survival studies the dependent variable is the time until a specific event (the

[28] For more information on the history, development and the name of the diagram see Vandeschrick (2001).

event of interest) occurs (Frees, 2010). Kleinbaum and Klein (2012, p. 16) state that there are three main goals that can be achieved through survival analysis, namely: (i) the estimation and interpretation of survival functions; (ii) the comparison of survival functions and (iii) the assessment of the relationship between explanatory variables to survival time. According to Cox (1984, p. 1) there is a wide range of potential problems that SA techniques could be applied to such as:

> '…*the duration of strikes or periods of unemployment in economics, the times taken by subjects to complete specified tasks in psychological experimentation, the lengths of tracks on a photographic plate in particle physics*…'

Survival models have a number of applications in a variety of disciplines although, as Lawless (2003) points out, the use of lifetime distributions is frequently applied in biomedical sciences. Often the event of interest in such studies is '*death*'. Classic examples of times of interest in biomedical studies are the time from diagnosis to death and the time from the start of a remission period to the end of the remission period (Bewick *et al*., 2004). The models are often used to estimate the likelihood of survival of patients when testing new treatments (Guo and Zeng, 2014).

The models are also used in ecology (Princée, 2016), population biology (Krebs, 1989; Pollock *et al.*, 1989; Debyser, 1995; Nuss and Warneke, 2010) and organizational ecology (Parsa *et al.*, 2011). Versions of survival techniques are often used in engineering to investigate the reliability of machinery (Lawless, 2003). Although the mathematical definitions of the main concepts in survival and in reliability analysis are identical, the terminology (i.e. survival function or reliability) is different, which is the reason why in many sources they are often seen as equivalent approaches. Although there are many fundamental similarities, preferences towards certain assumptions are prevalent in each area. In the past, one of the main differences between the two was the presence of censored data in survival studies (Tietjen, 1986; Christensen, 2016), although more and more censored data is included in reliability studies nowadays (Christensen, 2016). Another commonly discussed difference stems from the underlying assumption about the distribution of the data. In reliability analysis, parametric models are preferred as specifying the underlying distribution leads to increased accuracy of the predictions (Tsokos, 2011)[29]. However, when dealing with

[29] The examples are not exhaustive and it should be borne in mind that non-parametric methods have been developed for reliability analysis. For further information on the debate about the similarities and differences of survival and reliability analyses, see Tietjen (1986); Ma and Krings (2008); Christensen

large proportions of incomplete data, estimating the underlying distribution of the data is challenging. Furthermore, the choice of the most appropriate technique depends solely on the type of problem being addressed. In many studies in biomedicine and other areas, the independent effects of covariates are of interest where the differences in the survival of groups of subjects based on a set of characteristics are the focus. In such cases, the underlying distribution is not of particular interest. Instead of taking the risk of misspecifying the distribution, and thus jeopardising the validity of the findings, often a semi-parametric approach based on partial likelihood is employed in biomedical research and other areas[30]. In this research, the same approach is adopted as the main research questions are focused on the effect of certain characteristics on the phenomenon of interest.

Survival analysis tools are also used in social sciences where the presence of longitudinal data facilitates the estimation of long-term effects of certain phenomena and their distinctive characteristics. According to Ma and Krings (2007), there are disciplines where traditional elements of survival analysis, life tables for example, are particularly important, such as actuarial studies and population demography. Jacobs et al (2011, p. 388) provide a detailed, albeit not exhaustive, list of potential applications of survival methods in a range of social science areas of interests such as:

> '…*duration of marriages, time to adoption of new technologies, time between trades in financial markets, lifetime of firms, payback periods for overseas loans, spacing of purchasing of durable goods, time from initiation and resolution of legal cases, time in rank, and length of stay in graduate school'*.

There are many examples of investigations of ownership duration in the literature with the help of survival analysis techniques, such as the housing market (Cunningham and Kolet, 2011); corporate ownership and equity duration (Bøhren *et al.*, 2005); foreign owners and plant survival (Bernard and Sjöholm, 2003; Gorg and Strobl, 2003; Girma and Görg, 2004; Kronborg and Thomsen, 2009). In the context of maritime related studies, Tenold and Aarbu (2011) used the Kaplan-Meier estimator[31] to examine the conditional probability of company survival based on the performance of the 1960 population of Norwegian shipping companies over a twenty-year period. As

(2016). For non-parametric methods in reliability analysis see Tsokos (2014) and Kalaiselvan and Rao (2015).

[30] The approach in question is Cox Regression, discussed later in this chapter.

[31] The method is discussed in more detail later in the present section.

part of the study, a survival regression model was constructed which included a set of explanatory variables including company age, main port associated with the company and company size – small (1-2 ships), medium (3-5 ships) and a reference group (more than 5 ships). Bijwaard and Knapp (2009) focused on analysing the effects of the economic shipping cycle and inspections on maritime incidents by using duration analysis. The authors considered the use of logit or probit model but rejected the possibility because: (i) the methods only reflect the probability of an incident occurring at a set point in time and (ii) are unable to accommodate time-varying covariates (Bijwaard and Knapp, 2009). The potential of various techniques from the survival analysis family that handle time-to-event data appears to be underutilised in maritime economics and shipping business studies. One of the contributions of this research is thus to demonstrate the use of different tools and methods from the survival analysis family and in the context of ownership duration in shipping. The following parts of this section introduce the notations, functions and common techniques used in survival analysis.

Survival analysis – notations, functions and methods

- *Cumulative Distribution Function*

The cumulative distribution function (CDF) provides an effective way of describing the continuous probability distribution of a random variable in survival analysis (Smith *et al.*, 2003). The cumulative distribution function of a random variable survival time *T* is denoted as:

$$F_T\ (\mathrm{t}) = P_t\ (T \leq t)$$

Equation 3.1. Cumulative Distribution Function (CDF)

The CDF presented in Equation 3.1 can be interpreted as the probability of an event occurring before or at time *T* which is less than or equal to the time *t*. In other words, this is the probability that the survival time *T* of a randomly selected subject will be less than or equal to a stated time*, t* (Hosmer *et al.*, 2008).

- *Probability Density Function*

The probability density function (PDF), similarly to the CDF, is often used when describing continuous probability distribution. The PDF of a random variable *T*, denoted as $f_T\ (t)$, can be expressed as:

$$f_T(t) = \frac{dF_T}{dt}$$

Equation 3.2. Probability Density Function (PDF) where the PDF of a random variable is the derivative of the cumulative distribution function and it represents the probability of an event at time *t* (Smith *et al.*, 2003).

- *Survival Function*

Often in practice, however, it is more convenient to work with the complement of the cumulative distribution function – the survival function. The survival function, *S(t),* represents the probability of the event not occurring before a specified time *t* or equivalently to the probability of the survival time being greater than a stated value (Hosmer *et al.*, 2008). The sum of the survival function and the cumulative distribution function, denoted as *F(t)* in Equation 3.1, is always 1, therefore:

$$S(t) = Pr(T > t) = 1 - F\ (t)$$

Equation 3.3. Survival Function

S(t) is also referred to as survival rate (Le, 1997). The survival rate is a convenient way for reporting proportions of the sample that '*survived*' at fixed points in time (Miller et al, 1981). As a simple example, similar to one discussed by Miller et al (1981), assuming that 50 out of 75 subjects survived the first year of follow up in a hypothetical study, the corresponding survival rate is 66.7%. As the number of subjects that have experienced the event increases with time, the corresponding survival rate decreases which is the reason why survival curves appear to slope downwards. Figure 3.5 represents a survival curve. In theory the survival curve appears smooth as it describes a continuous probability distribution, however, often in practice events are measured using a discrete time scale (i.e. months, years), which results in the curve appearing to be stepwise.

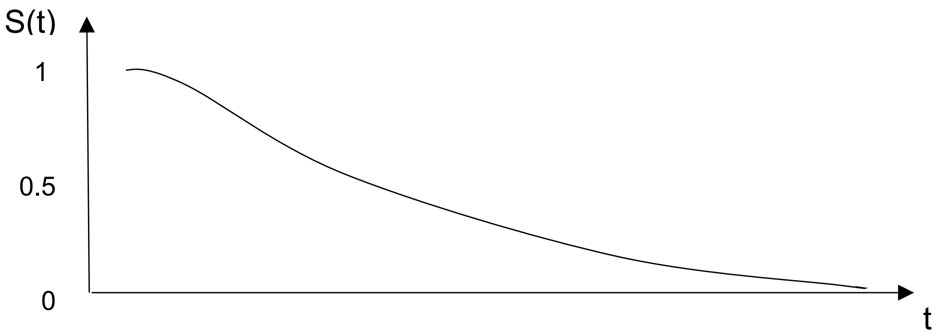

Figure 3.5. Survival Curve

In the context of this research, the survival rate in the models stratified by owner number and ship type, where the beginning of the period with each individual owner (n_i) is the time origin for that owner number (i), represents the proportion of ships that were not sold (to another owner or a scrap yard) before a specified time *t* while in the possession of the respective owner (i).

- *Hazard Function*

Another useful summary of the distribution of survival time is given through the hazard function, *h(t).* The hazard function is the probability of an event occurring at time *t* given that the event has not already occurred also described as the '*short-term event rate for subjects who have not yet experienced the outcome event*' (Vittinghoff, 2005a, p.212). The mathematical definition of the hazard function is provided in Equation 3.4 where *f(t)* is the probability density function (PDF) and *S(t)* is the survival function.

$$h(t) = \frac{f(t)}{S(t)} = -\frac{d}{dt}\ln S(t)$$

Equation 3.4. Hazard Function

Jacobs et al (2011, p. 388) define the hazard function as the '*probability per time unit that a case that has survived to the beginning of the respective interval will fail in that interval*'. In the current case, the hazard function provides the probability of a ship being sold, given that the ship has not yet experienced the event of interest for the duration of the period spent with the respective owner.

- *Kaplan-Meier (KM) Estimator and Survival Function Comparisons*

The standard nonparametric tool used for estimating the survival function is the Kaplan-Meier (KM) estimator, also referred to as the product-limit estimator[32]. It was developed by Kaplan and Meier (1958) as a means to overcome the incompleteness of survival data. Hosmer *et al*. (2008, p. 17) point out that the estimator takes into account all data entries regardless of the presence of censoring 'by considering survival to any point in time as a series of steps defined at the observed survival and censored times'. Actuarial life tables are based on the same concept, however, in the case of the Kaplan-Meier estimator the intervals used for calculating the associated hazards are not arbitrary (i.e. one year) but depend on the data (Miller, 1981; Chiang, 1984; Kiefer, 1988). Klein and Moeschberger (2003) point out that the '*steps*' of the survival function corresponding to the aforementioned intervals depend on two main factors – the pattern associated with the censored observations prior to each event time (t_i) and the number of events occurring at t_i.

[32] For more information on the reasons why it is also referred to as the product-limit estimator, see discussion in Harrell (2015, p. 411).

$$\hat{S}\,(t) = \prod_{t_i \leq t} \left(1 - \frac{d_i}{n_i}\right)$$

Equation 3.5. Kaplan-Meier (Product Limit) Estimator

where d_i represents the number of events at time t_i and n_j is the number of study participants that have not experienced the event prior to t_i.

The Kaplan-Meier estimator can be used to produce graphical representations of the survival functions. Although one of the main purposes of such graphs is to give a visual indication as to whether survival functions corresponding to different strata are similar, formal statistical tests need to be carried out in order to investigate whether any of the differences are statistically significant. There are two types of tests used for comparison of survival functions: (i) the log-rank test, introduced by Mantel (1966) and (ii) the generalised Wilcoxon procedure, first proposed by Gehan (1965). A variety of modifications of these tests exists, which is partly the reason why authors use different names when referring to the same technique[33]. Both tests are used as part of this research as they complement each other. The log-rank test is sensitive to changes later in time, whereas the generalised Wilcoxon is sensitive to changes over time that may occur early on (Martinez and Naranjo, 2010). For the sake of clarity, hereinafter, the names used in this research to refer to these tests are consistent with the nomenclature as it appears in the statistical software used to analyse the data – *R*[34]. The package used to calculate both tests is '*survival*' by Therneau and Grambsch (2000). According to the documentation of the survival package the log-rank test is referred to as log-rank or Mantel-Haenszel test, whereas the generalised Wilcoxon is referred to as the Peto & Peto modification of the Gehan-Wilcoxon test. Apart from comparing estimated survival curves, the KM estimator serves as an indication of whether or not certain assumptions, namely the proportional hazards assumption discussed later, have been met. Crossing survival curves serve as an indication that the proportional hazards assumption might be violated.

Cox Proportional Hazards Regression Model (Cox PH model)

According to Harrell Jr *et al*. (1996) prediction can be used for forecasting and hypothesis testing. In survival studies, the most common hypothesis being tested

[33] Leton and Zuluaga (2005) offer a comprehensive list of the different versions and names used in the literature.
[34] R version 3.2.5.

refers to whether certain covariates influence survival (Harrell Jr *et al.*, 1996). One of the main objectives of this research is to establish whether certain characteristics on ship and company level have an effect on periods of ownership. According to Fox and Weisberg (2011) the most interesting part of survival modelling is exploring the relationship between survival time and one or multiple predictor variables, which are usually referred to as covariates. The most widely used method for examining such relationships is the Cox Proportional Hazards Regression (Cox PH), which was first proposed by Cox (1972). The approach has gained huge popularity since its introduction in 1972 and is referred to as 'the cornerstone of modern survival analysis' (Guo and Zeng, 2014). Partially, this is due to the fact that the baseline hazard is an unspecified function and as such can take any form but the covariates enter the model linearly (Fox and Weisberg, 2011), which makes the model semi-parametric. Cox (1972) introduced the method of partial likelihood[35] used for model estimation, which is independent from the baseline hazard. The function can be written as:

$$L(\beta) = \prod_{j=1}^{k} \frac{\exp(\sum_{i=1}^{p} \beta_i X_{(j)i})}{\sum_{l \in R(t_{(j)})} \exp(\sum_{i=1}^{p} \beta_i X_{li})}$$

Equation 3.6. Cox Partial Likelihood Function

where β is the collection of unknown parameters, *k* are different failure times assuming there are no tied events, *i* is the subject which experiences the event at time $t_{(i)}$ and *R(t)* is the risk at time t.

According to Fox and Weisberg (2011), the estimates made based on the partial likelihood might not be as accurate as those that are based on maximum-likelihood estimates for a parametric model, whose distribution has been correctly determined, however the fact that the baseline hazard function need not be specified is the '*compensating virtue of Cox's specification*'. The Cox proportional hazards model is built on the proportional hazards assumption which postulates that the hazard ratio does not vary with time. In other words, the hazard in '*the comparison group is a constant proportion of the hazard in the reference group*' (Fox and Weisberg, 2011, p.215). For example, if men are twice more likely to experience a heart failure at the age of 50 than women, then they are twice more likely to experience a heart failure

[35] For a discussion on the name, the derivation and the scientific discussion surrounding the partial likelihood, see O'Quigley (2008).

age for age (at any other age). The Cox model specifies the hazard at time *t* for a subject with covariate *X* as:

$$h(t, \boldsymbol{X}) = h_0(t)exp\left(\sum_{i=1}^{p} \beta_i X_i\right)$$

Equation 3.7. Cox Proportional Hazards Model

where $X = (X_1, X_2, \ldots, X_l)$ are the covariates. The hazard is a product of $h_o(t)$ - the baseline hazard, and the exponential of the sum of $\beta_i X_i$, where β_i is the linear predictor. The exponential of the sum of $\beta_i X_i$ represents the relative risk based on the characteristics of the different covariates. The exponential of the coefficient β alone provides '*the constant hazard ratio for an increase of one unit in the covariate in question*' (Guo and Zeng, 2014). The hazard rate measures the probability of a subject experiencing a certain event given that the subject is at risk (Klein and Zhang, 2011). The hazard rate (HR) can be written in the form of:

$$HR = \frac{h_1(t)}{h_2(t)} = \frac{h_0(t)e^{\beta x_1}}{h_0(t)e^{\beta x_2}} = e^{\beta(x_1 - x_2)}$$

Equation 3.8. Hazard Rate

where x_1 and x_2 are the covariates corresponding to different subjects[36].

A potential issue that may arise in using Cox PH models is in handling tied events. Often in practice time is measured on a discrete scale as opposed to on a continuous scale, which results in observations with identical survival times (Borucka, 2013). There are several established methods for handling tied survival times, namely the Breslow, the Efron and the '*exact*' methods. Although the Breslow approximation is claimed to be easier to program, the Efron method[37] performs better when there are many tied survival times (Therneau and Grambsch, 2000; Borucka, 2013) and is claimed to be the preferred method for handling tied events as the '*exact*' method is too computationally expensive (Fox and Weisberg, 2011).

[36] A practical example of how to interpret the output of a fitted Cox model with actual data is discussed in Chapter 5, section 5.2.1.c).
[37] The Efron method is also the default method in the coxph function from the package 'survival' used for generating the models presented in later chapters.

According to Wei (1992) the Cox PH model is *'almost exclusively'* used by researchers '*to draw inferences about the covariate effect'* in the presence of censored observations. This statement is supported by the observation that the majority of the papers reviewed as part of the literature review on the topic employ a Cox PH model. The Cox model belongs to a family of hazard models and it has numerous extensions. For example, one of the main assumptions under a Cox model is that the study population is homogenous, which is often not the case in practice.

In economics, for example, the Cox PH model has a limited use as most practitioners prefer mixed proportional hazards models, also known as frailty models[38] in biostatistics, which account for unobserved heterogeneity of the data. A mixed proportional hazards (MPH) model can be used for univariate (independent) failure times, such as periods of ownership in the context of this research. However, Liu (2014) states that Cox PH models are flexible enough to mitigate the impact of unobserved heterogeneity under a well-defined theoretical model, especially when large samples are available. Furthermore, Bijwaard *et al.* (2011) state that one of the primary reasons for using the MPH model is to distinguish between unobserved heterogeneity and duration dependence, which represents the change of an effect over time, however this proves to be difficult in practice. The authors then refer to Wooldridge (2005), who claims that such a distinction is irrelevant when the main purpose of the study is to examine the effects of covariates on the average duration. As the aim of this research is to establish whether certain covariates on ship and company level have an impact on periods of ownership on average, the use of a MPH model is discarded in favour of the more robust Cox PH model.

- *Model building process*

Model building and covariate selection are topics that receive wide attention from the statistics community. Popular methods, developed for linear regression, have been extended to accommodate time-to-event data. Despite the number of relatively recently introduced approaches to model variable selection[39], Liang and Zou (2008) argue that their employment in practice might not gain popularity due to complex computational issues. Therefore, more traditional approaches were considered as part of this research. A classical method for covariate selection in survival analysis is

[38] Frailty is a special case of random effects model.
[39] For more information on traditional and recently introduced variable selection approaches, see Khan and Shaw (2013).

stepwise regression However, building a model via semi-automated covariate selection procedures based solely on statistical significance without prior consideration of the phenomenon under investigation can be misleading. Hosmer *et al*. (2008) suggest the employment of purposeful selection of covariates instead, an approach that allows the researcher to re-evaluate the variable selection decision at each step of the model-building process. A short summary of the purposeful selection of covariates method as described by Hosmer *et al.* (2008) includes the following steps:

- A multivariable model containing all covariates significant at univariate level (at 20-25% significance level) is fitted;
- Any covariates which are not found to be significant based on the Wald statistic and the likelihood ratio test are removed from the multivariable model;
- A check whether the removal of any of the variables has produced a significant change in the coefficients (a cut off value of 20% is used) is performed;
- All the variables that were first removed are then being added to the model again and their impact is re-examined;
- A check for non-linearity is performed;
- A check for interactions is performed;
- Model diagnostics are carried out.

Although this approach is robust and it provides the opportunity for decisions to be re-evaluated, the significance of covariates is judged on the likelihood ratio test alone. Harrell (2001) suggests that potential overfitting can be reduced by introducing a penalty for model complexity, such as the Akaike information criterion (AIC) (Akaike, 1973). The AIC approach penalizes degrees of freedom in an attempt to balance the model fit with number of parameters where the optimal model is one that fits the data well but does not include superfluous variables (Klein and Moeschberger, 2003).

The AIC[40] is presented in Equation 3.9 where p is the number of parameters, k is a predetermined constant (usually 2) and L is the likelihood function.

$$AIC = -2Log\ L + kp$$

Equation 3.9. Akaike Information Criterion

[40] According to Klein and Moeschberger 2005, p. 277) the AIC is '*reminiscent of the adjusted R^2 in least-squares regression, in that both are attempting to adjust the fit of the model by the number of parameters included*'.

In the light of the above, the technique adopted for the initial model selection in this research is based on the purposeful covariate selection method suggested by Hosmer *et al.* (2008). The AIC was used to optimise the model fit during the final iterations of the method in relation to re-examination of the effects of variables.

In the case of a large number of covariates, most available covariate selection approaches, including stepwise regression and the more recent penalised approaches, can prove to be quite unstable (Walschaerts *et al.*, 2012). An alternative is the use of machine learning approaches such as survival trees and random survival forests (Wright *et al.*, 2016). According to Walschaerts *et al*. (2012) the tree-based methods introduced by Breiman (1984) are amongst the most important developments in optimal model selection. In order to achieve a more stable and accurate prediction, Breiman (1984) developed the bagging method, also known as bootstrap aggregation, which is based on '*a family of random trees'* (Walschaerts *et al*., 2012). Ishwaran *et al.* (2008) were the first to extend the ensemble tree method to accommodate censored data. In the context of time-to-event data, Ishwaran and Kogalur (2010) define the base learner as a '*binary survival tree*' and the ensemble as the '*cumulative hazard function formed by averaging each tree's cumulative hazard function*'. The authors' contribution also includes a novel high dimensional variable selection method referred to as '*minimal depth'*. Minimal depth is based on the concept that variables that have a strong effect on survival are those '*that split nodes nearest to the root node*' (Ehrlinger, 2016). The analytical threshold for variable impact proposed by Ishwaran and Kogalur (2010) is the mean of the minimal depth distribution. Technically, minimal depth ranks the covariates by importance but this capability of the statistic is ignored as the purpose of this research is to establish which covariates do have an effect on periods of ownership and not to rank their importance.

Recent research on comparing the predictive ability of Cox model based covariate selection procedures with machine learning techniques suggests that for the best results to be obtained these methods should be used in a complementary fashion (Walschaerts *et al.*, 2012). Therefore, for the purpose of this research several approaches have been used in a complementary way to ensure that the covariates selected in the final models have a significant effect on periods of ownership. Purposeful covariate selection has been used in order to examine the effect of covariates. During the iteration stages when covariates, excluded as a result of the preliminary screening, are being re-evaluated again, the AIC is used to evaluate the model fit. The model, identified as the optimal one based on these techniques is then examined with the help of RSF. In order to validate the choice of covariates in the model identified as optimal, minimal depth is used to measure the predictive capability of the chosen covariates. If any of the covariates are identified as being non-significant at this final stage before carrying out model diagnostics, their inclusion in the optimal model is re-evaluated again until the results from all methods converge.

- *Model Diagnostics*

In terms of assessing the model fit, there are several types of residuals associated with the Cox PH model[41] whose purpose is to examine: (i) the functional form of the covariates; (ii) the presence of outliers (investigating influential observations) and (iii) the proportional hazards (PH) assumption. The following section provides a brief overview of the nature and purpose of the residuals used as part of this research.

A method, introduced by Barlow and Prentice (1988) and often used to detect any nonlinearity arising from misspecification of the functional form of the covariates is assessing the martingale residuals. According to Harrell (2015, p.494), martingale residuals can be used to: (i) estimate the transformation of a single variable; (ii) check the linearity assumption for a single variable; (iii) estimate marginal transformations for more than one variable and (iv) estimate transformation for variable *i* adjusted for other variables. However, martingale residuals can be very skewed, which makes the identification of potential outliers challenging (Therneau *et al.*, 1990; Fitrianto and Jiin, 2013). Therefore, deviance residuals for Cox PH models, proposed by Therneau *et al.* (1990), were used as part of this research.

The reason for the robustness of the Cox PH model is the PH assumption itself according to which the hazard ratio does not vary with time. As mentioned earlier in this chapter, an indication that the PH assumption might be violated are crossing KM curves. Kleinbaum and Klein (2014) discuss several types of approaches[42] for checking whether the PH assumption holds, namely: (i) goodness of fit; (ii) interaction with time and (iii) graphical representation. For the purposes of this research, the validity of the PH assumption is checked graphically with the help of Schoenfeld residuals. O'Quigley (2008) describes Schoenfeld residuals as the difference between

[41] See Fitrianto and Jiin (2013) and Harrell (2015) for a detailed overview of types of residuals.
[42] For a detailed discussion on available approaches and comparisons between graphical approaches see Harrell (2015, p 486-500).

the observed value of a covariate, which is assumed to have been sampled at time X_i, and the expected value of the same covariate.

The issue of potential violation of the PH assumption receives a lot of attention in statistics and there are several approaches, approved by the statistical community, as to how to deal with a violation of the PH assumption such as stratification of the model or including a time interaction (Harrell, 2015; Hosmer *et al*., 2008). However, Schemper *et al.* (2009) argues that ideal proportional hazards are a rare occurrence in practice. For example, Suciu *et al.* (2004) report that in 43% out of the 127 papers using survival analysis and published in major medical journals between 1999 and 2001 they reviewed, the survival curves did cross. According to Bewick *et al.* (2004) the log-rank and similar tests used for comparing survival curves are robust enough and 'small departures' from the proportional hazards assumption, which in the particular case described by the authors manifested themselves in the form of survival curves crossing, do not invalidate the tests. Allison (2014) finds the concern about a potential violation of the proportional hazards for a specific variable to be often unfounded as in such cases the variable coefficient represents the average effect of that variable over the follow up time. According to Allison (2014) and Schemper (1992) estimating the average effect on survival is usually '*sufficient*' as in most cases researchers are interested in establishing whether certain covariates affect survival. As this is the purpose of applying the Cox model to periods of ownership data, the same philosophy is used when reviewing model diagnostics in the context of this research.

c) Investigating the effect of economic indicators on periods of ownership

The analysis by owner number encompassing characteristics on ship and company level deals with fixed covariates, which remain constant over time, such as ship and company type. However, economic indicators, such as earnings, are not fixed and change over time. In order to determine their influence on periods of ownership, these changes should be taken into account. The popularity of the Cox model, apart from its robustness, is also due to its capability to encompass covariates which change over time. Such covariates are referred to as time-varying or time dependent covariates.

According to Therneau *et al.* (2017) in practice this works because of the very nature of the Cox model, namely the fact that at each event time the model compares the covariate values of the subject that had the event to the values of the subjects that were at risk at that time. Time-varying covariates can be internal or external (Kalbfleisch and Prentice, 1980; Hosmer *et al.*, 2008). Internal time-varying covariates are subject specific and represent scores or values generated by the subjects under investigation such as, for example, blood pressure in biomedical studies (Fisher and Lin, 1999). External covariates are not subject specific and reflect environmental factors that affect all subjects (Hosmer *et al*., 2008). Economic indicators are therefore external covariates as they apply to all ships included although there might be different indices reflecting different shipping segments (type) or vessel sizes.

In practice, one of the challenges associated with time-varying covariates is related to data handling, storage and computational power required. These issues arise from the fact that the model requires the covariate values to be known at each event time for all subjects. For example, in the context of this research, monthly economic indicator data has been obtained from Clarksons Research Services Limited. This means that in order to include the monthly data on economic indicators, the information on periods of ownership for an individual ship has to be split into monthly time intervals. If a ship has been followed for exactly 25 years, this will result in 300 (i.e., 25 years x 12 months) individual records tied to the commercial history of a single ship. Often such a data set raises concerns regarding correlation issues based on the existence of multiple observations corresponding to the same subject. Therneau *et al.* (2017) state that there is no reason for any correlation issues to arise as the algorithm uses a single observation corresponding to each subject at all times. However, Therneau *et al.* (2017) give two exceptions to this rule, namely in cases where: (i) there are multiple events associated with each subject, which causes the data observations corresponding to the events to be correlated and (ii) the same subject appears in overlapping intervals, which results from data coding mistakes. The design of the analysis aiming to determine the influence of certain characteristics on periods of ownership is stratified by owner number as discussed in earlier sections. This implies that subjects can experience the event of termination of ownership only once, which means that there is no theoretical reason for correlation issues to arise when using time-varying covariates as part of the analysis other than data coding mistake.

3.3.3. Qualitative analysis

The aim of the qualitative part of this research is three-fold: (i) to help identify potential characteristics that industry professionals believe have an effect on periods of ownership in shipping; (ii) to provide potential elicitation on patterns of ownership in shipping and (iii) to gauge industry professionals' opinions about the perceived importance (effect size) of the types of characteristics considered as part of this research. In order to fulfil these aims, fifteen in-depth face-to-face interviews with industry representatives were conducted between February and September 2016. It should be noted that the aim of the in-depth interviews is not to validate the statistical results but to seek, if possible, additional insights regarding patterns and influences associated with periods of ownership in shipping.

One of the advantages of interviews as used in phenomenological research is that they allow for further elaboration in the context of conceptually difficult questions, which minimises the presence of bias induced through misinterpretation of the questions (Schutt, 2015). In addition, semi-structured interviews are based on an informal framework consisting of a list of topics and potential questions which might change from interview to interview (Saunders *et al*., 2009). There is no specific order the questions should follow and some might be omitted or added in the process depending on the context. According to Longhurst (2009) in-depth, semi-structured interviews are suitable when the focus of the research is rooted in '*complex behaviours, opinions, and emotions*' and when the information needed to be gathered reflects '*a diverse range of experiences'*. As the phenomena under investigation, namely determining length and patterns of ownership, depend on the behaviour of agents that invest in shipping, which is a function of complex factors, such as experience, motivations and market sentiment, in-depth semi-structured interviews have been chosen as a preferred method.

In-depth interviews and qualitative methods are often scrutinised in terms of generalisability of findings as they are sometimes perceived to lack '*quantitative research's power to generalise'* (Brannen, 2005). However, Brannen (2005) argues that qualitative findings can be generalised to other settings or used for theoretical generalisation. Some researchers suggest that in-depth interviews' purpose is not to make generalisations but to form categories based on the data and to investigate any relationships between such categories (Charmaz, 2006; Dworkin, 2012). This is in line with the second research objective of this research, which focuses on investigating the influence of characteristics on periods of ownership in shipping.

A brief questionnaire is added at the end of each interview in order to gauge shipping professionals' perceptions regarding the characteristics identified as potentially affecting periods of ownership as a result of the literature review. Johnson and Turner (2003) review the main methods for data collection used in social and behavioural science from a pragmatist point of view and provide examples of studies, which employed combinations of questionnaires and in-depth interviews. Adams and Cox (2008) state that triangulation between qualitative and quantitative approaches can aid researchers when constructing a questionnaire. Therefore, the questionnaire includes closed questions (usually associated with the quantitative approach) designed as rating scales and open-ended questions (usually associated with the qualitative approach). The closed questions sought to evaluate the perceived effect of the characteristics identified as likely to influence periods of ownership as well as the perceived importance of the three groups of characteristics (ship, company level and economic indicators) identified as potentially having an effect on periods of ownership. Filling-in the questionnaire was followed by a brief discussion on the rationale behind each interviewee's choice. Through open questions the interviewees were encouraged to identify, to add and discuss any additional characteristics that influence periods of ownership, which may have been missing from the list they were provided with.

The questionnaire is included in the section on qualitative analysis because: (i) it includes both open (associated with the qualitative) and closed questions (associated with the quantitative approach); and (ii) was administered after each in depth interview as part of the interview process.

a) Sampling Process

Sampling quality, regardless of the nature of the research paradigm, has an impact on the transferability of the findings. Robinson (2014) suggests a four-point approach when contemplating qualitative interview-based research (Table 3.3).

Point	Name	Definition
Point 1	Define a sample universe	Establish a sample universe, specifically by way of a set of inclusion and/or exclusion criteria.
Point 2	Decide on a sample size	Choose a sample size or sample size range, by taking into account what is ideal and what is practical.
Point 3	Devise a sample strategy	Select a purposive sampling strategy to specify categories of person to be included in the sample.
Point 4	Source the sample	Recruit participants from the target population.

Adapted from: Robinson (2014).

Table 3.3. The Four-Point Approach to Qualitative Sampling

The first point involves defining a sample universe and a target population by setting both inclusion and exclusion criteria. For the purposes of this research, the target population consists of shipping industry participants and representatives, who are involved in or are familiar with commercial shipping. This includes shipowners, onboard and shore personnel and other professionals involved in different areas of commercial shipping activities such as, but not limited to, service providers and equipment manufacturers, surveyors, insurers, bankers, and shipbrokers. As the quantitative part of this research is based on a sample including the three main commercial shipping segments – bulker, tanker and container – the target population is limited to professionals with experience in commercial shipping. This means that shipping professionals whose experience is primarily based on defence work and navy ships, for example, have been excluded from the target population as the purpose of naval vessels is not related to any form of commercial trade and different motivations clearly apply.

The second point refers to sample size. The decision on a sample size range was based on practical considerations such as the fact that the world-wide shipping industry is perceived as being very private and a high rate of participation was not expected. According to Guest *et al.* (2006) a satisfactory level of saturation[43] is usually achieved within the first 12 interviews, although the number 30 is sometimes cited as being a benchmark for achieving a high saturation of the findings. As the interview stage findings are taken to be complementary to the statistical findings obtained from the data analysis on periods of ownership and the anticipated difficulties with recruiting a large enough number of interviewees, it was deemed that the number of in-depth

[43] Guest *et al.* (2006) define saturation as: '*the point at which no new information or themes are observed in the data*'.

interviews that were going to be used as a minimum threshold for the purposes of this part of the research was 12.

The selection of a sampling strategy was dictated by the circumstances surrounding the interview opportunity process and it is a combination of both convenience and so-called snowball sampling. The convenience sampling strategy was a product of the University environment. For example, two suitable potential participants from an industry background and one representative of academia were identified amongst the list of external visitors (guest lecturers) who visited Newcastle University in 2016. These prospective interviewees were then approached in person about whether they would be interested in participating. In addition Mr Phil Parry, the Chairman of Spinnaker Global Ltd, which is one of the most established shipping recruitment agencies[44] facilitated the research by publishing a short article containing the intended research overview and a call for volunteers for the interview stage on the 24th of September 2015 in Spinnaker Global's weekly newsletter – Changing Course, which is sent out to 25,000 shipping professionals[45]. This resulted in one participant and the interview was carried out in early February 2016.

The bulk of the interviews conducted as part of this research were carried out between the 4th and the 8th of June 2016 during the biennial international shipping exhibition taking place in Athens – Posidonia 2016. Posidonia 2016 was visited by more than 22,000 shipping professionals from 101 countries and hosted 1,825 exhibitors ranging from shipyards to various service providers (Posidonia, 2016). Although carrying out interviews during an international shipping exhibition bears a resemblance to convenience sampling in the sense that all potential participants were convenient in their collective proximity, however snowball sampling, also known as referral sampling (Robinson 2014), was used in order to contact potential participants.

The same strategy was also used during a visit to the SMM 2016 in September, a maritime trade fair, that is the German counterpart of Posidonia. The SMM 2016 was visited by 50,000 industry representatives from 124 countries. More than 2,200 exhibitors from 66 nations advertised their products and services.

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[44] More information on Spinnaker Global Ltd is available here: https://spinnaker-global.com/

[45] The article is available here: https://spinnaker-global.com/blog/1417_24-09-2015_typical-periods-of-vessel-ownership

The number of interviewees recruited as a result of all the recruitment strategies described above are presented in Table 3.4.

Recruitment Strategy	Number of interviewees**
External visitors to Newcastle University*	3
Spinnaker Global's Newsletter	1
Posidonia 2016	9
SMM 2016	2
Total	**15**

** The interviews with the guest lecturers who visited Newcastle University were conducted first and were treated as 'pilot interviews' as discussed later.*
***The interviews were conducted between February and September 2016.*

Table 3.4. Recruitment Strategies and Number of Interviewees

b) Interview Process

The interview questions were designed to explore the concept of periods of ownership in the context of shipping, the perception that industry professionals have with regards to length and patterns of ownership, and the characteristics and factors that may affect periods of ownership.

The sample interview questions were purposefully kept broad as it has been established that asking direct closed questions, especially early on, may affect the interviewees' responses (Silverman, 2013). Although this is a problem common in surveys, it may also occur in in-depth interviews when details, necessary to understand interviewees' accounts, are obtained through closed questions (Ritchie *et al.*, 2014). This effect is often attributed to a type of behaviour, referred to as '*acquiescence'*, which Krosnick and Presser (2010, p 275) define as '*an endorsement of an assertion made in a question, regardless of the assertion's content*'. Krosnick and Presser (2010) provide a detailed list of interview design characteristics and respondents' characteristics that may lead to acquiescence. In terms of the structure of the interview some of the factors that are deemed to increase the probability of acquiescence are difficult questions (Gage *et al.*, 1957; Hanley, 1962; Trott and Jackson, 1967) and fatigue caused by a large number of questions . The potential effects of these factors were addressed by conducting pilot interviews, which allowed for the suitability and the number of the sample questions to be tested and revised.

In terms of interviewees' characteristics, Leech (1983) suggests that sometimes the desire to be polite may result in acquiescing. Furthermore, people are likely to try and influence the way others perceive them. Krosnick and Presser (2010, p 286) warn that a form of social desirability response bias is when '*observable characteristics of the interviewer may indicate to a respondent the answer the interviewer considers desirable'.* A strategy to mitigate this is to pay attention to conflicting statements made by respondents and follow up with open questions in order to explore attitudes further. Furthermore, Ritchie *et al.* (2014) advice that it should be established early on that there are no right or wrong answers, which was incorporated into the introductory phase of the interview process.

Another form of bias that may impact qualitative data gathered through interviews is researcher bias. Some of the reasons behind such bias identified by Poggenpoel and Myburgh (2003) include mental discomfort and lack of experience in conducting interviews. Kvale's (1996) criteria of a successful interviewer, later extended by Bryman (2012), and the approach to interviewing described by Ritchie *et al*. (2014, p 198) served as the theoretical basis for the interview process. A way for the interview process to be tested and for researchers to gain practical experience in applying interview techniques is through conducting pilot interviews (Holloway, 1997; Van Teijlingen *et al.*, 2001). Van Teijlingen *et al.* (2001) provide a detailed list of the functions of pilot studies and state that '*pilot studies are a crucial step in the research process'*.

In order to select the most appropriate questions for the interview process, a framework proposed by Collis and Hussey (2009) was followed. The framework contains four requirements that need to be satisfied in order for the question to be deemed adequate, namely whether they: (i) relate to aspects of the research questions; (ii) are clear and easy to understand by the target audience; (iii) provide relevant and sufficient information to answer the questions and (iv) would be answered willingly by the participants.

The first three interviews conducted with the guest lecturers visiting Newcastle University, were treated as '*pilot interviews',* which aimed to test whether the above requirements have been satisfied. The feedback from the pilot interviews was then used to: (i) refine the questions and the interview process; (ii) to corroborate and extend, if needed, the list of characteristics identified as likely to influence periods of ownership as a result of the literature review. The most fundamental piece of feedback relates to the list of characteristics identified as likely to influence periods of ownership as the following three additional ship level characteristics were suggested by the first interviewee as likely to have a potential effect, namely: speed, fuel consumption, and shipbuilder (including builder nationality). As the other two participants in the pilot interviews agreed that the aforementioned characteristics might influence periods of ownership, these suggestions were added to the list of characteristics that were considered as part of this research[46].

Any additional feedback from the pilot interviews was related to the format of the questionnaire in terms of structure, font size, and layout[47]. For example, a suggestion that was incorporated in the questionnaire design was to have separate sections corresponding to the effects of the characteristics in terms of periods of ownership in relation to first and subsequent owners. The owner number level was added after one of the participants in the pilot interviews remarked that their answers would have been different depending on the owner number.

Because of the design process and the feedback from the pilot interviews, each interview was separated into three phases, namely: (i) an introduction, (ii) a discussion on a pre-determined list of topics/questions regarding length and patterns of ownership and (iii) a discussion on the characteristics that are likely to affect periods of ownership.

Upon expressing an interest in participating, each potential interviewee was provided with more detailed information about: (i) the research aim and objectives and (ii) the structure and expected length of the interview. If the potential interviewee was comfortable with undertaking the interview process, a formal consent was obtained. The interviews lasted between half an hour and one and a half hours depending on the availability of the participants.

The introduction served as an "*ice-breaker*" and means to establish a more informal connection. During this stage general questions regarding background and experience were exchanged. An interview guide was constructed as a list of '*memory prompts of areas to be covered'* (Bryman, 2012, p 473). Interview guides have several functions including improving the structure, the pace and the overall quality of the

[46] However, speed and fuel consumption were subsequently excluded from any subsequent analyses as a result of the data exploration stage on characteristics that influence periods of ownership. Descriptive statistics regarding these two characteristics can be found in Data Annex Chapter 4, section 3.1. The exploratory work on the potential effects of these characteristics and a list of the reasons which led to their omission from the subsequent analyses can be found in Data Annex Chapter 5, section 3.
[47] A copy of the final design of the questionnaire is available in Appendix C-2.

interview process. Interview guides were developed for each phase of the interview process and outlined as bullet points below.

The **introduction phase** includes the following topics:

- Name;
- Current organisation;
- Current position;
- Number of years in current position;
- Past organisations and positions held;
- Industry experience in years;
- Date of interview.

The **second phase** included discussion on the following pre-determined topics and loosely defined questions:

- Lengths of periods of ownership in shipping – what is '*short*' and what is '*long*'?
- Patterns of ownership – owner sequence and stereotypes, behaviour of owners in terms of periods of ownership – then and now?

The results from the second-phase of the interview process were used to establish whether the interviewees were aware of any likely patterns or trends of ownership and the perception regarding length of periods of ownership in shipping.

Bryman (2012, p 622) notes that in recent years the barriers between quantitative and qualitative research are becoming more blurred due to the fact that each '*is used as an approach to analyse the other*'. One of the common quantitative approaches to the analysis of qualitative data is content analysis (Collis and Hussey, 2003; Driscoll *et al.*, 2007; Bryman, 2012). The method converts qualitative data into quantitative data by counting the frequency of the use of specific words or themes (Collis and Hussey, 2003). The technique, under the form of a '*word cloud'*, is used to summarise the characteristics that were mentioned by the interviewees during the open discussion on patterns of ownership[48].

The **third phase** of each interview consisted of a discussion on:

- The potential effect of the characteristics identified as likely to influence periods of ownership;
- The perceived importance of such characteristics.

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[48] Presented in Chapter 7, Figure 7.2, p 239.

The final list of characteristics on ship and company level, identified as likely to have an effect on periods of ownership in shipping, and used as a basis of the discussion in the third phase of the interviews was a product of the literature search and the feedback from the three pilot interviews conducted as part of this research. The additional 12 interviews were then used as means to further corroborate and refine the list of characteristics identified.

In order to achieve this, a short questionnaire was incorporated as part of the third phase of the interview process. As abstract ideas and opinions are difficult to capture and measure, Collis and Hussey (2014) suggest the use of rating scales. Therefore, in order to investigate the perceived importance of certain characteristics, a rating scale was added to the third phase of the interview process. The rating scale, which represented the closed questions in the questionnaire, is based on a variation of the Likert scale. The participants were asked to examine a list of characteristics arranged in three main groups: ship level, company level, and economic indicators. The participants were then asked to determine whether these characteristics have an effect on periods of ownership, in their opinion, and were offered the following choices for each characteristic in the three groups: (i) it does not have an effect; (ii) not sure and (iii) it does have an effect. If the participants believed that a certain factor did have an effect, they were asked to establish the '*effect size'* by ranking that perceived effect with one of the following: (i) weak; (ii) medium and (iii) strong. The importance intensity normally used in a Likert scale (5-points down to 3), was simplified for two reasons, namely: (i) because the questionnaire was designed mainly to provide an indication about the perceived effect of each characteristic and; (ii) because filling-in the questionnaire was followed by a discussion on the rationale behind each interviewee's choice. Krosnick and Presser (2010) advise that follow-up questions aiming to measure attitude strength can be used to elaborate perceptions and to distinguish '*real opinions from non-attitudes'*. It should be noted that only one of the participants indicated that they were not sure about whether one of the proposed characteristics had an effect on periods of ownership. Because of this, the neutral '*not sure*' category is omitted from the findings presented in Chapter 7. This procedure was performed twice for all characteristics identified as being likely to have an effect on periods of ownership from the literature search – for first and subsequent owners respectively.

Graphical summaries of the frequency distributions of the results are presented in Section 7.2.3. Frequency distributions are often used as a tool for organising and summarising questionnaire data (Downs and Adrian, 2004; Lavrakas, 2008). No further analysis of the questionnaire data was performed as the main function of the interviews and the questionnaire is only to provide additional insights regarding periods of ownership which may have been omitted in the statistical analyses.

3.4. Concluding Remarks

Chapter 3 is dedicated to the overall research design of this study, which aimed at addressing the nature of the data and the requirements set by the research objectives. Although it is recognized that alternative approaches within the survival analysis family can be applied to the data on periods of ownership, such as mixed proportional hazards models, the choice of model is a function of the nature of the data, the research objectives and practicality. The Cox PH model was chosen above all alternatives because of its capability: (i) to accommodate time-to-event data, such as the data on periods of ownership; (ii) to accommodate time-varying covariates; (iii) to estimate the average effect of fixed and time-varying covariates with the minimum possible number of assumptions (robustness). In order to validate the findings regarding the influence of covariates on periods of ownership from the Cox PH model, machine learning techniques from the CART family, such as random survival forests (RSF), were used during the model building process. Furthermore, interviews with industry representatives were proposed in order to: (i) review the choice of characteristics included in the numerical models; (ii) obtain information on the perceived effect of these characteristics and (iii) obtain information on perceived length and patterns of ownership. The purpose of the qualitative element was to ensure that relevant perceptions regarding patterns of ownership and characteristics which influence periods of ownership were considered.

Chapter 4 will now discuss the data gathered regarding the characteristics postulated to influence periods of ownership, which was later used in the statistical analyses.

Chapter 4. Data Used in the Statistical Analyses

4.1. Introduction

Chapter 4 deals with the data collection process, dataset building and the preparation of the data for the statistical analyses. The data collection process is addressed (4.2) by presenting a list of the data providers accompanied by detailed information on the sampling frame[49], the sampling population identified and the overall sample size on ship and company levels. The second part of the chapter provides information on the selection process of characteristics on ship and company level and considerations regarding relevant economic indicators (4.3). Each characteristic is individually analysed in terms of sample distribution and all categories assigned to the raw data are defined and explained in detail in order to avoid any ambiguity. The potential drawbacks and limitations of the available data are also summarised and discussed. Ultimately, the purpose of Chapter 4 is to familiarise the reader with the elements of the final dataset used in the analyses.

4.2. Data Collection

4.2.1. Data sources

The variable of interest in this research is period of ownership in shipping. Gathering information on changes of ownership in shipping is challenging due to the complex structure of shipping companies[50] and the nature of the business. The data collection process that was undertaken for the purposes of this research focused on three levels of data – ship level characteristics, company (ownership) level characteristics and economic indicators.

The data on ship particulars and the commercial records containing each vessel's ownership history were retrieved from Sea-Web – a joint venture between IHS Maritime and Trade[51] and Lloyd's Register. The ownership records were carefully examined to obtain data on changes of ownership as per the definition adopted as part of this research[52], which was then used to calculate the respective periods of ownership. The original records of changes of ownership were then compared to a

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[49] Defined as '*a list or other device used to define a researcher's population of interest*' (Lewis-Beck *et al*, 2004). In the context of this research the sampling frame refers to all the sources and processes used to define the sampling requirements and the sampling population.
[50] See the discussion in Chapter 2, Section 2.4 regarding typical ownership structures in shipping.
[51] IHS Maritime & Trade evolved from the publication Fairplay. For more information see: https://www.ihs.com/products/sea-web-maritime-reference.html.
[52] See the definition of changes of ownership – Chapter 3, Section 3.3.1.

bespoke ownership history dataset kindly provided by Clarkson Research Services Limited (CRSL). The data on company type and historical fleet size as well as all market related information, which includes a range of economic indicators and shipping market data, was also retrieved from the CRSL database (Figure 4.1).

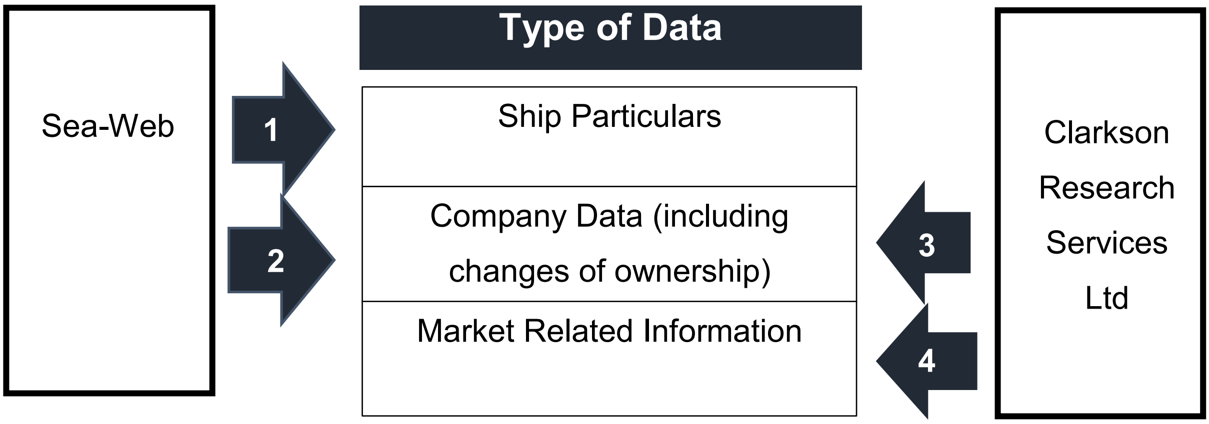

Figure 4.1. Dataset Preparation

According to Glen and Marlow (2009) '*the reputation and reliability of quantitative studies rely totally on the integrity of the data gathered, processed and analysed*'. Although both of the data providers used have outstanding reputations amongst maritime researchers and practitioners, it is still possible for discrepancies to exist between privately owned data providers' resources especially when beneficial ownership and fleet size are concerned (Glen and Marlow, 2009). Therefore, any inconsistencies related to the identity of the group owners or the length of ownership between the original set of Sea-Web data and the data provided by Clarkson Research Services, were further investigated by examining a variety of paper and online resources including company records, annual reports or law cases where appropriate.

4.2.2. Sample requirements and sample size

The sample requirements refer to the characteristics of the target population. The three main segments in shipping - dry bulk, tanker and container are bound by the same ultimate demand and supply forces, however they developed in a different way over time due to technology availability, trade patterns and external factors[53]. Therefore, in order to account for any inherent differences between shipping segments this research investigates periods of ownership in terms of length, patterns and influences on a disaggregated ship level by distinguishing between the three main ship types – bulkers, tankers and container vessels. The commercial records of 3,908 vessels built between 1987 and 2007 have been examined. Upon counting the sales

[53] For more information on fleet development trends in the period 1987 to present, see Appendix B-1.

each vessel has gone through, it was established that 8,042 changes of ownership were recorded. These changes of ownership determine the number of '*ship records'* in the dataset and should not be confused with the number of ships in the dataset on ship level. This research focuses on ocean-going vessels therefore vessels typically employed in the coastal trades were not included in the sample. In terms of bulk carriers and tankers, ships of deadweight[54] less than 30,000 tonnes were not included in the analysis as smaller vessels tend to service the regional trades, as discussed in section 2.2.2. As the volatility of ship prices varies with ship size and smaller vessels' prices are found to be more stable in comparison (Kavussanos, 1996; 1997; Glen and Martin, 1998), a case could be made that investor behaviour would differ between sizes as the opportunities for generating profit from trading the asset itself decreases with the observed volatility. The choice of the deadweight threshold is also based on the fact that the average size of cargo consignment in the dry bulk trade is a little over 30,000 tonnes, which is also the smallest most common parcel size oil products are usually shipped in (Stopford, 2009). The decision to base the size of containers on TEU[55] rather than deadweight stems from the lack of a standard unit for measuring cargo capacity in shipping despite all the attempts that have been made (Glen and Marlow, 2009) and that the container fleet's capacity is usually measured in TEU (Stopford, 2009). A cargo carrying capacity threshold of 1,000 TEU was chosen because smaller vessels are usually employed in short-sea trades and the number of smaller container ships did not increase at the same rate as the fleet of larger ocean-going vessels (Stopford, 2009), which would imply that asset speculation levels vary with size.

The delivery period of the sample was selected specifically to include vessels at the end of their economic life built in the late 80s and vessels that would be about 10 years old at the time of the analysis. One of the main considerations driving the choice of the delivery profile of the sample was based on facilitating further investigation of the results on periods of ownership reported by Stott (2013), especially with regards to length of first ownership, which he found out to be about 10 years.

[54] Deadweight - The weight in tonnes (1000 kg) of cargo, stores, fuel, passengers and crew carried by the ship when loaded to her maximum summer loadline (Sea-Web, 2015a)

[55] The common dimensions of a 20-foot container are 20 feet long, 8 feet wide, and 8 feet 6 inches high. The volume of a 20-foot container is 1,360 cubic feet or approximately 40 cubic metres. The approximate net weight that can be stored in one unit is a little over 47,000 lb or about 21,000 kg.

The first phase of the data collection included 2,910 vessels or all bulkers and tankers of 30,000 dwt and above and all container vessels of 1,000 TEU and above built between 1987 and 1997. However, the number of vessels that fulfil these initial sampling requirements built between 1998 and 2007 – 6,020 vessels – was found to be too large for each vessel's commercial history to be examined individually. Instead, a stratified sampling approach was employed to randomly select nearly 1,000 (998) vessels out of the 6020 (or about 16% of the population) as part of the second phase of data collection. To achieve a representative sample, the stratification was performed based on ship type, size and delivery year. Upon randomly[56] selecting the additional 998 vessels, the total number of ships whose particulars and changes of ownership were recorded amounted to 3,908 vessels in total. A copy of the sample population[57], the stratification calculations and the final delivery profile of the sample is presented in Data Annex Chapter 4, section 2.

Data on 1,124 companies has been gathered based on the ownership history of 2,000 vessels representing the delivery period of the overall sample. The vessel records that were populated with company information contain 1,000 ships from each of the two phases of data collection – ships built between 1987 and 1997 and ships built between 1998 and 2007. The population of older vessels built between 1987 and 1997 was reduced to 1,000 vessels, randomly chosen based on the stratification factors applied earlier – ship type, size and delivery year. The data on company level is therefore based on 2,000 of the vessels originally examined resulting in 3,674 changes of ownership recorded. The owner history records hold the relevant company information and are hereinafter referred to as '*company records'* or just '*records*' in the context of the company level data.

4.3. Definitions of Characteristics

The final list of characteristics described in the next section (Table 4.1) is a product of the literature search and additional characteristics that have been added to the list as a result of the interview stage of this research[58].

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[56] First each vessel from the whole population was assigned a random computer-generated ID number within each strata based on ship type, size and year. Then a random set of numbers with the same limits as each respective strata and corresponding to the number of ships needed from each strata was generated. The vessels that happened to be assigned these latter numbers as IDs were the ones included in the sample.

[57] The sample population represents the vessels that satisfy the sampling requirements in terms of ship type, size and delivery year. A summary is available in Data Annex Chapter 4, section 2.1.

[58] The results from the interviews with shipping professionals are discussed in Chapter 7.

4.3.1. Ship level

The first level of the analysis is concerned with whether certain physical characteristics of the vessels are directly linked to ownership patterns and periods of ownership. It has been argued (see Chapter 2, Section 2.2.2), for example, that investment strategies vary between segments and therefore the typical periods of ownership between the three main ship types are expected to differ. A list of the relevant ship characteristics and ship related data that were included in the dataset originally is presented in Table 4.1.

Category	Characteristic	Definition
Type	Main Type	Bulker; Container; Tanker
	Cargo Type	Based on cargo specialization (e.g. ore carrier)
Size	Deadweight	Weight carrying capacity in tonnes
	TEU	Carrying capacity of a container vessel in twenty foot equivalent units (TEU)
	Size Class	Size class of the ship based on the cargo carrying capacity (e.g. Handy Bulker)
General Information	IMO Number	Unique Ship ID Number[59]
	Status	In service; Broken up; Total loss
	Delivery Year	The year the ship was delivered
	Speed	Vessel operating speed in knots
	Fuel ME	Fuel consumption of the main engine
	Fuel Total	Total fuel consumption
	Number of Owners	Number of owners based on the recorded changes of ownership
Nationality	Builder Country	The country where the ship was built
Dates	Order	Date the ship was ordered
	Deliver	Date the ship was delivered
	Scrap	Date the ship was scrapped
	Sale	Change of ownership
	End of Follow Up	End of the data collection phase

Table 4.1. Ship Level Characteristics

However, in the interest of brevity only information on the characteristics included in the final analyses is presented in the following section. The characteristics that were omitted are highlighted in grey in Table 4.1, namely cargo specialisation, speed and fuel consumption related data. The reasons for the omission of these characteristics from the following analyses include: (i) limited data availability and (ii) lack of evidence regarding an effect on periods of ownership according to the preliminary work

[59] A unique seven-digit number which remains unchanged during the life of the ship. The IMO (International Maritime Organisation) identification number was adopted on 19th November 1987 in IMO Resolution A.600(15) (Source: Sea-web, 2016).

discussed in later chapters. General information about the omitted characteristics on ship level can be found in Data Annex Chapter 4, section 3. The preliminary work on the effect of these characteristics is discussed in later chapters.

a) Ship Type

The three main ship types were included in the data collection, namely – dry bulk carriers, tankers and container vessels. Within these three broad categories there is further fragmentation based on the specific purpose or cargo specialisation of the vessel. There are numerous types of ships based on what type of cargo they were designed to carry serving many niche trades. However, this research is focused on some of the most popular and conventional types of vessels in order to avoid introducing bias via the inclusion of niche special purpose vessels, whose trading patterns might differ significantly (Table 4.2). The detailed ship types were retrieved from Sea-Web and the accompanying definitions are presented in Appendix B-2.

Type	Cargo Specialisation	No. of vessels
Bulker	Bulk Carrier	1479
	Ore Carrier	90
	Wood Chips Carrier	89
Container	Container ship (fully cellular)	1212
Tanker	Chemical Products Tanker	216
	Crude Oil Products Tanker	222
	Crude Oil Tanker	424
	Products Tanker	176

Table 4.2. Ship Type Sample Profile

Haralambides *et al.* (2004) warn that special care should be dedicated to the classification of ship types when working with more than one data provider as different sources have their own specific rules regarding fleet classification. The authors give as an example chemical carriers, which are not always included in tanker fleet statistics. This could pose a serious issue if compiling the dataset was based on data aggregation alone. However, in this research different types of data corresponding to the vessels included in the sample were assembled based on the unique IMO number of each ship, which neutralises any problems regarding ship type classification frameworks.

b) Ship Size

The reason for the inclusion of ship size in the list of relevant characteristics is to further investigate whether periods of ownership differ between ship sizes as it has been suggested that there is clear size differentiation within shipping segments[60]. Classifying vessels by size is a challenging task due to the lack of uniformity, which extends beyond the choice of a standard unit for measuring capacity. The presence of size classification inconsistencies between data providers is well known within the industry (Haralambides *et al.*, 2004; Glen and Marlow, 2009). Originally the data on ship particulars, including vessel size, was retrieved from Sea-Web. However, the size categories used by Sea-Web are very detailed, sometimes with a whole category based on merely 10,000 dwt tonnes difference. This level of precision could be very helpful to a shipowner or a broker, however in this case it only decreases the sample size per ship size unnecessarily. Instead, a more straightforward size classification has been employed differentiating between the main sizes based on deadweight or TEU capacity respectively. The custom classification decreased the original IHS Sea-Web size categories from 22 to 12 (Table 4.3).

Type	Size	Size in units	No.	% of Type	% of Total
Bulker	Handy	30-60,000	657	40%	17%
	Panamax	60-100,000	565	111%	14%
	Capesize	> 100,000	436	26%	11%
Container	Handy	1-2,000	509	42%	13%
	Sub-Panamax	2-3,000	225	19%	6%
	Panamax	3-4,000	186	15%	5%
	Post-Panamax	> 4,000	292	24%	7%
Tanker	Handy	30-60,000	427	41%	11%
	Panamax	60-80,000	78	8%	2%
	Aframax	80-120,000	258	25%	7%
	Suezmax	120-200,000	115	11%	3%
	VLCC	> 200,000	160	15%	4%

Note: The unit size for Bulkers and Tankers is DWT; the unit for Containers is TEU.

Table 4.3. Vessel Size Sample Profile

A more detailed description of the IHS Sea-Web size categories along with a comparison between the chosen custom (aggregated) categories and the data provider's framework is provided in Appendix B-2.

c) General Information

Status

The status of the vessels part of the sample that have not been scrapped at the time of data collection is not a constant as it may change at any given point in time even during the data collection process itself. Therefore, the status of all the ships,

[60] See Chapter 2, section 2.2.2.

especially the ones whose information was gathered during the first phase of data collection in 2013, has been updated at the end of every phase of data collection. A list of the relevant dates is presented in Table 4.4.

Delivery Period	No. of Vessels	% of the Sample	Broken Up	In Service	Total Loss	End of Follow Up
1987 – 1992	1125	28.8%	676	435	14	01/03/2015
1993 – 1997	1785	45.7%	264	1510	11	01/01/2014
1998 – 2007	998	25.5%	6	992	0	01/05/2015
1987 – 2007	3908	100%	946	2937	25	-

Note: The end of the follow up period marks the date that the status of the ships belonging to the specific delivery period was last updated.

Table 4.4. Vessel Status

Number of Owners

Determining the total number of owners is crucial to matching the length of the periods of ownership with the relevant company data. This process is imperative for the analysis of periods of ownership. The total number of owners[61] (denoted as 'NoO') equals the sum of the number of sales ('NoS') and the original owner.

$$\mathbf{NoO} = \mathbf{NoS} + \mathbf{1}$$

Equation 4.1. Total Number of Owners

The number of owners is thus directly dependent on the number of sales detected and recorded during the data collection phase. The average number of owners and the smoothed densities per owner number are presented in Figure 4.2 as an RDI plot (Raw data, Description and Inference). The points represent the raw data, according to which the number of container ships with 5 or 6 owners in total is very limited. The average number of owners is represented by the thick horizontal line on top of each bar. The smoothed density of the data is shown by the shapes surrounding the points, also referred to as '*bubbles*' or '*beans*'[62]. There is a clear indication that container vessels have the least amount of owners on average, with a mean of 1.7 and a total number of owners rarely exceeding 4. Bulkers are the most traded vessel type with up to 8 owners in total and an average of 2.35 owners, followed by tankers with up to 7 owners and a mean of 2.

[61] 'Owner' refers to Group Owner or Group Company as opposed to Registered Owner.
[62] Based on Kampstra et al (2008).

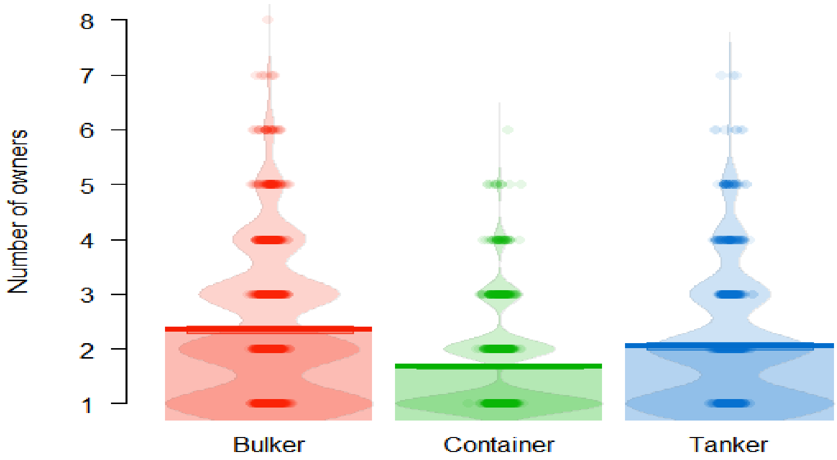


Figure 4.2. Number of Owners According to Ship Type

These results are in line with the findings on average number of owner changes according to Bijwaard and Knapp (2009) and Stott (2013)[63], who also found containers to have the lowest number of owners on average, followed by tankers and bulkers.

d) Nationality – builder area

The nationality aspect on a ship level is represented by the area where the ship was built. Japanese shipyards were generally regarded as superior to other popular shipbuilding nations and described as the '*world leaders in commercial shipbuilding since 1956*' (Lyu and Gunasekaran, 1993). However, the shipbuilding world has changed significantly since the early 1990s and Japan is no longer the world leader in shipbuilding output or in world deliveries by value, overtaken by China and Korea respectively (OECD, 2015; OECD, 2016). According to UNCTAD (2015) more than 90% of the gross tonnage delivered in 2014 was built in either China, Korea or Japan, which is the reason why these three countries were each assigned a separate category when classifying the builder country by geographical area. The shipping output by country and delivery year according to the sample on ship level is presented in Figure 4.3.

[63] Bijwaard and Knapp (2009) report that on average containers have 1.45 owner changes, followed by tankers with 1.53 owner changes and bulkers with 2.03 owner changes. The results are based on 5,063 containers, 12,533 tankers and 7,264 bulkers. However, a different methodology has been used for determining what constitutes a 'change of ownership', therefore the results are only provided here as an indication of a trend rather than a benchmark.

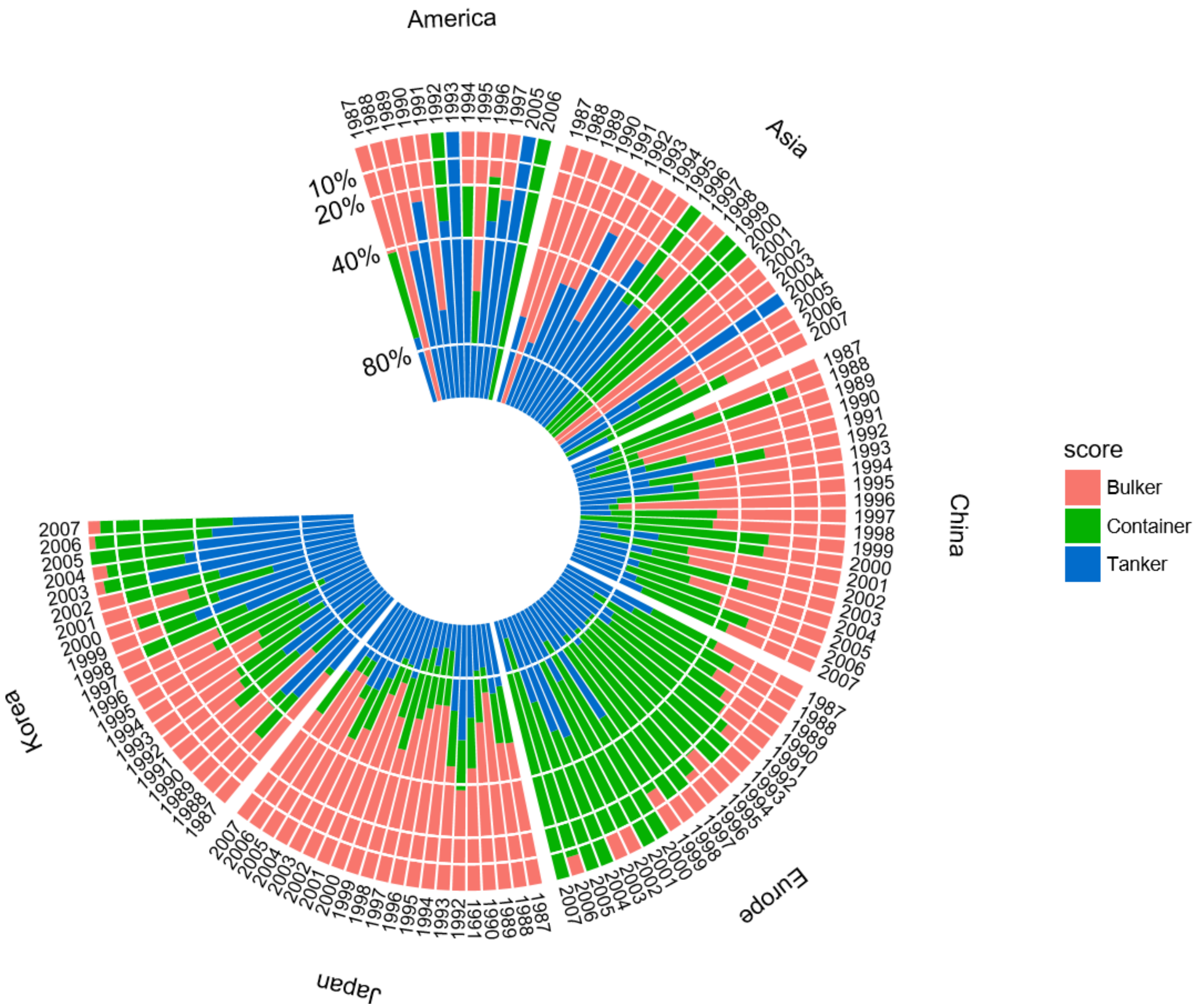


Figure 4.3. Shipping Output by Area, Ship Type and Delivery Year

Each bar of the polar histogram represents the proportional distribution of ships by type delivered in the respective year in one of the main geographical areas identified – America, Asia, Europe, China, Japan and Korea. For example, according to the first bar corresponding to 1987 American-built ships, 41% of the ships built in America in 1987 according to the sample are bulkers, 37% are containers and 22% are tankers, whereas all the ships built in America the following year (1988) according to the sample are bulkers. Presenting the data in such a way gives a clear indication that the sample's behaviour is consistent with the expected ship type specialisation by geographical area. According to UNCTAD (2015) China has been focusing on building bulk carriers followed by container ships and tankers. Korea's main contribution in recent years has been in the container and oil tanker segments whereas Japan is still specialising in building bulk carriers (UNCTAD, 2015). Any missing years by geographical area in Figure 4.3 are attributed to limited sample size falling within certain geographical areas, such as America. The sample distribution by area is presented in Figure 4.4.

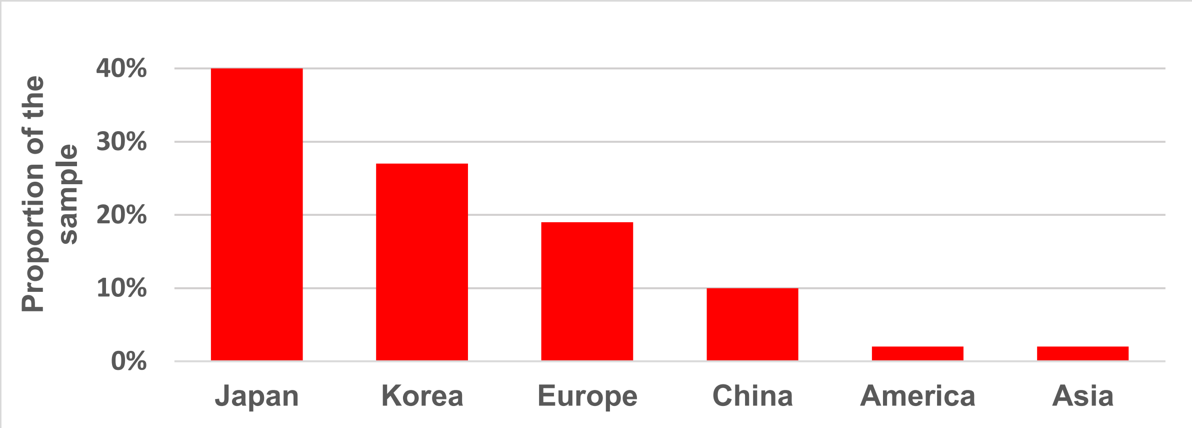


Figure 4.4. Sample Profile by Builder Country

According to Figure 4.4, 40% of the vessels in the sample are built in Japan, which despite the fact that Japan has been overtaken by Korea and China in shipbuilding output in recent years, is of no surprise given the delivery profile of the sample and the fact that about 75% of the ships were built before 1998. The reason for the higher number of European-built ships compared to Chinese-built ships could also be explained by the fact that there is a substantial number of newer container vessels (built after 1997) included in the sample, many of which were built in Europe, and that China's leap towards the world's top shipbuilding nation started in 2007 (Figure 4.5).

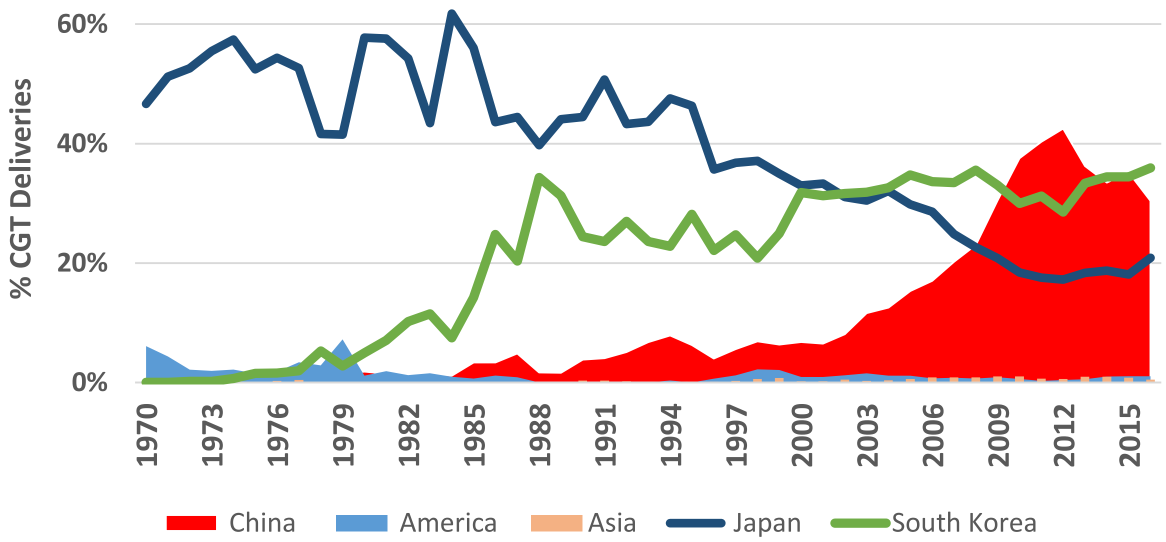


Figure 4.5. World Shipbuilding Output by Area (% CGT)[64]

[64] CGT is defines as: 'Compensated gross tonnage, (cgt), is a unit of measurement intended to provide a common yardstick to reflect the relative output of merchant shipbuilding activity in large aggregates such as "World", "Regions" or "Groups of many yards' (OECD, 2007, p.2).

Regardless of the shift in the shipbuilding output by country in recent years, Japanese-built ships have always been regarded as better quality ships with higher resale value. Therefore, including the data on builder country is meant to facilitate a further investigation of whether the country where the ship was built has an effect on the behaviour of shipowners in terms of buying and selling of vessels.

e) Dates

There are five main dates associated with ship level data – the date the ship was ordered, delivered, potentially sold, scrapped and the end of the follow up period[65]. For all the vessels included in the sample the data on order and delivery date is available. Some of the ships have never been sold and have remained with their original owner for the duration of the follow up period or until scrapped. About 24% (see) of the sample on periods of ownership consists of vessels that have been scrapped and, therefore, the full commercial history of these vessels is available. For the purposes of this research, the event of interest is the sale of a vessel. If a vessel has not been sold by the end of the follow up period, then the observation corresponding to the relevant owner period is denoted as '*censored*', which means that it is incomplete. The data of interest – or the dependent variable in this study – is the period of ownership of vessels. The aforementioned dates included in the dataset were instrumental in calculating the relevant period of ownership corresponding to each shipowner as per the recorded commercial history of the vessel. The algorithms presented in Table 4.5 were used to determine the periods of ownership.

First Owner		
Total No. of Owners = 1	Scrapped	Scrap Date - Delivery Date
	In Service	End of Follow Up - Delivery Date
Total No. of Owners ≥ 2		$\text{Sale Date}_{(\text{Owner1})}$ - Delivery Date
Intermediate Owners		
1< Owner X < Last Owner		$\text{Sale Date}_{(\text{Owner X})} - \text{Sale Date}_{(\text{Owner (X-1)})}$
Last Owner		
Last Owner	Scrapped	$\text{Scrap - Sale Date}_{(\text{Last Owner})}$
	In Service	$\text{End of Follow Up - Sale Date}_{(\text{Last Owner})}$

Table 4.5. Calculating Periods of Ownership per Owner Number

[65] The end of the follow up period is also referred to as the end of the data collection phase.

An existing flaw in determining last owner period of ownership must be noted. As changes of ownership which occur shortly before a vessel proceeds to a ship-breaking yard are not counted as actual changes of ownership[66], the duration of periods of ownership for data records where the scrap date has been used as the basis of the calculation are inflated by several months. Such discrepancies also arise from the back-log of vessels to be demolished accumulated in ship-breaking yards during busy periods and the precision with which such data is recorded by the data provider. Bearing this in mind, the reported period of ownership corresponding to last owners should be taken as an indication of the likely duration of ownership as the periods of ownership at this stage of the vessels' economic life are relatively short and additional several months could have an impact on the results presented in later chapters. However, in the case of calculating periods of ownership corresponding to first owner for vessels that remain with their original owner throughout their whole economic life and are eventually scrapped, several months of additional time is deemed to be negligible in determining periods of ownership.

Scrapped vessels comprise 25% (967 ships) of the sample on ship level. A typical ship has a lifetime of 25 to 30 years, however, there is no specific age that vessels are scrapped at. Physical deterioration of an asset is a gradual process, however technical obsolescence can reduce the useful economic life of vessels (Stopford, 2009). On the other hand, the decision to scrap or keep a vessel can be influenced heavily by the level of the freight markets, the scrap prices, and the increase of the maintenance costs due to age amongst other reasons. Stopford (2009, p. 159) gives as an example 2007 when the average scrapping age for tankers was 27 years and 32 years for bulk carriers, however, he does point out that the spread is usually quite wide. According to the brokers at CRSL during a booming market the average scrapping age increases up to 30 years, whereas the decrease in freight rates is usually associated with a drop in scrapping age to 25 years or less (SIW, 2013). The explanation provided states that owners tend to scrap old tonnage to avoid the cost of the fifth special survey, whereas during a booming market many are likely to bear the maintenance costs in order to benefit from favourable market conditions.

The average scrap age of vessels by ship type according to the sample is presented in Figure 4.6 as an RDI plot.

[66] See Chapter 3, section 3.5.1. for a discussion on what constitutes a change of ownership in the context of this research.

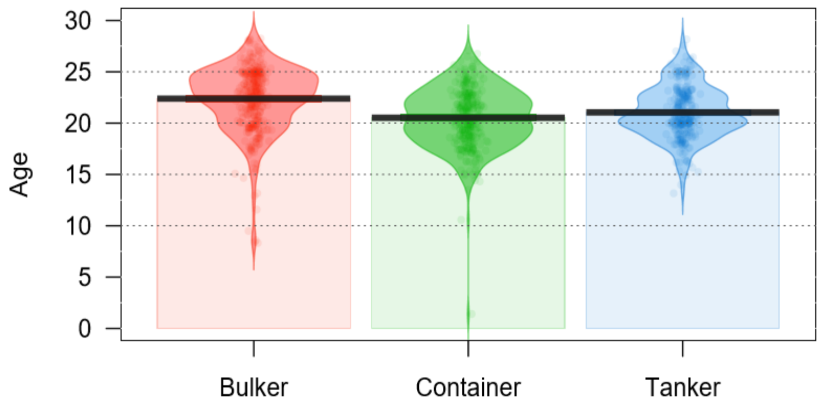


Figure 4.6. Average Scrap Age by Ship Type

The average scrap age for bulkers, represented as the thick horizontal line on top of the respective bar, is about 23 years although the most frequent age range that bulkers get scrapped at is between 23 and 25 years according to the density of the raw data. The average scrap age of tankers and containers is about 20 years. In the case of tankers, the majority of vessels are scrapped even earlier. This phenomenon can be explained by the phasing out of single hull tankers[67]. In terms of size, smaller ships have higher scrap age on average across all ship types[68].

4.3.2. Company level

The second level of analysis considers the characteristics of the owner company such as company type, fleet size and nationality. All the relevant company related information that has been assembled as part of this research is presented in Table 4.6. In the interest of brevity only information on company level characteristics included in the final analyses is presented in the following section. The characteristics that were omitted are highlighted in grey in Table 4.6, namely company status, year the company was founded, main sector, nationality of registration of the company and a set of variables related to fleet size. The reasons for the omission of these characteristics from the following analyses include: (i) limited data availability and (ii) lack of evidence regarding a significant effect on periods of ownership according to the preliminary work discussed in later chapters. General information about the omitted characteristics on company level can be found in Data Annex Chapter 4, Section 3.

[67] For more information on the phasing out of single hull tankers and how this may have impacted the sample used in this research, see Appendix B-3.
[68] The average scrap age by ship size and builder area is shown in Data Annex Chapter 4, Section 1.

Category	Characteristic	Definition
General Information	Ownership Status	Group Company or Registered Owner
	Comp IMO Number	Unique Group Company ID Number[69]
	Company Status	Active or Inactive
	Year Founded	Year the Group was founded
Type	General Type	Private, Public, Financial, State
	Detailed Type	CRSL Primary Company Type Classification (activity)
	Main Sector	The majority of vessels in the Company's Portfolio
Nationality	Registration	The country where the Company is legally registered
	Control	The country of ultimate economic benefit
Size	Owned Fleet	Number of ships owned by the company*
	Newbuildings	Number of ships on order *
	Total Fleet	Total number of owned fleet and newbuildings*
	Shipmanaged	Number of ships shipmanaged by the company*
	Registered	Number of ships the Company is a Registered Owner for *
	Chartered In	Number of ships Charetered IN by the Company*
	Chartered Out	Number of ships Charetered OUT by the Company*
	Operated	Number of ships Operated by the Company*
	Registered Owners	Number of Registered Owners part of the Company*
	Owned fleet Start	Historical Fleet Size at Start Date
	Owned fleet Stop	Historical Fleet Size at Stop Date
Dates	Start Date	Start Date for the relevant owner. It equals the delivery date (1st owner) or a change of ownership (owners > 1).
	Stop Date	Stop Date for the relevant owner. It equals a change of ownership; the ship being broken up or the end of the data collection.

*At the time of data collection.

Table 4.6. Company Level Characteristics

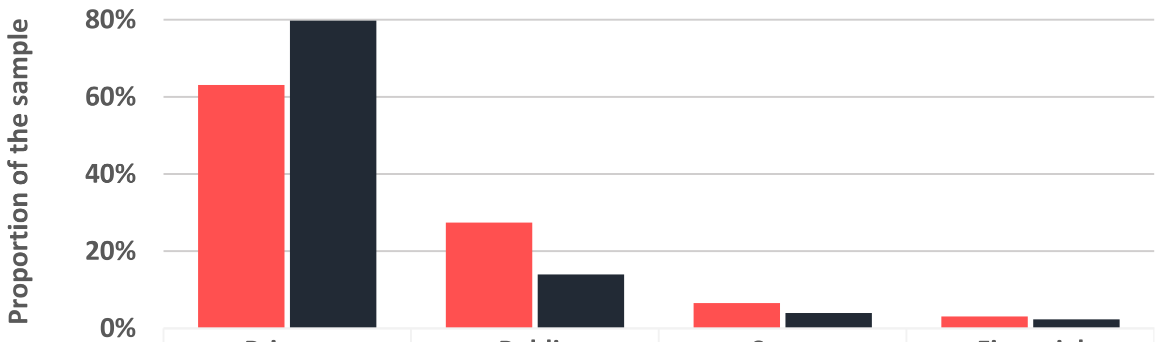
a) Company Type

Main Company Type

Data on primary company type was provided by CRSL, according to which main company type is defined in relation to the core activity of the company. For example, even if an oil major has a publicly listed element, the core activity of this company is still recorded as an oil major. According to CRSL's main company type classification, the dataset was grouped into 17 separate categories (see Appendix B-4). Although these categories proved to be extremely useful, they were deemed to be too many to be included as levels of company type in the main analysis. Instead, a new

69 The IMO unique Company and Registered Owner Identification Number Scheme was introduced in 2004 through the adoption of resolution MSC.160(78). The details of the scheme are in IMO Circular Letter No.2554 Rev 1, dated 7th February 2007. Lloyd's Register - IHS issues these numbers from its database on behalf of the IMO. The number is unique to the Company and/or Registered Owner (Sea-web, 2015b).

classification was developed (‘*General Type*’) based on the 4 main categories that were identified – private, public, financial and state companies. Re-grouping the CRSL’s primary company type data into 4 categories out of the original 17 was achieved through Sea-web data on full company name, which includes an abbreviation that indicates the relevant business entity of a company. The nationality of registration of the companies was also considered as business entities and their names differ significantly around the world. All this information was then translated into one of the chosen general company types with the help of an extensive list of the world’s business entities. For example, an Italian registered company, whose full name ends with S.r.l. (*Società a responsabilità limitata*) is the closest to an equivalent of a private limited company known as ‘Ltd.’ in the UK. Although company laws and company business entities differ around the world and subtle differences are likely to exist, this unsophisticated framework was found to be robust enough in determining whether the company is private or public. However, financial and state companies are special cases and on occasion had to be identified with the help of the CRSL data and additional online company history searches. As Figure 4.7 illustrates, the dataset is mostly comprised of private and public companies. The private company category is composed of mostly small to medium companies of less than 20 ships (80% of the companies in that category), which explains why the proportion of company records is lower than the one corresponding to the number of companies in the dataset. On the other hand, public (62%) and state (60%) companies are predominantly large. Interestingly, as a result of the random sampling based on delivery year and ship particulars and the smaller sample size, only 35% of the financial companies are considered large, however they alone account for 72% of the financial company records.

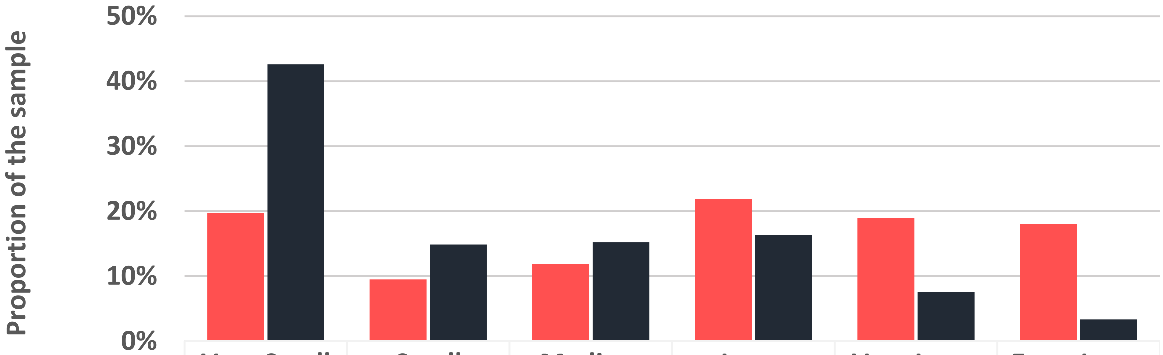


	Private	Public	State	Financial
Records	63%	27%	7%	3%
Companies	80%	14%	4%	2%

Figure 4.7. Main Company Type Distribution

b) Company Size

Company size data was obtained from both data providers – Sea-web and CRSL. For most of the company records, the size classification of companies matched. For the rest of the entries, which consist mostly of companies that were not included in the ownership history data provided by CRSL, a hybrid approach was used – the records were grouped using CRSL's classification framework but based on the total fleet size data (including newbuildings) recorded from Sea-web at the time of the data collection. CRSL's size categories are presented in Figure 4.8.



	Very Small (1-5)	Small (6-10)	Medium (11-20)	Large (21-50)	Very Large (51-100)	Extra Large (>100)
Records	20%	10%	12%	22%	19%	18%
Companies	43%	15%	15%	16%	8%	3%

Figure 4.8. Company Size Distribution

Looking at the proportional distributions of the separate size categories it can be concluded that there are two broad categories – smaller (very small, small and medium) and larger (large, very large and extra large) groupings. It is of no surprise that the number of smaller companies is higher than the number of large ones and that in spite of this, the number of company records corresponding to larger companies is higher.

The number of very small companies accounts for 43% of all the companies included in the dataset, which although not surprising, is quite a high proportion. It should also be noted that nearly 56% of the very small companies are either single ship companies or companies that did not own any ships at the time of the data collection. In order to distinguish between companies which used to own vessels but switched to operation/management or downsized, and companies whose records are potentially incomplete, the historical fleet size for each company at the time when the ship was bought (Owned Fleet Start) and sold (Owned Fleet Stop) was added to the dataset. The data on the historical fleet sizes was kindly provided by CRSL. Unfortunately, the timeseries regarding fleet size start from January 1996, which is 9 years after the older vessels, included in the sample, entered in operation. Furthermore, the data is quite limited covering only 42% of the number of records in the dataset in terms of fleet size when the vessels were bought, which had a severe impact on the data usability in the main analysis. The rest of the variables included in the '*Size*' category (see Table 4.6), such as number of vessels owned, chartered in and chartered out for example, were retrieved from Sea-web at the time of data collection. It should be noted that most of these variables, such as number of ships on order and number of ships operated by the company for example, vary with time and it should be borne in mind that the company size category is a '*snapshot*' of the company's fleet at the time of data collection. The nature of the data on company size makes the categories corresponding to very small and small companies very sensitive to any changes in the fleet.

c) Company Nationality

The question of ownership nationality in shipping is complex. Often the vessels, as well as the companies that own them, are registered in the country of origin, where the majority of the benefits from the operation of the ship are then absorbed. However, with the fragmentation of ownership structures in shipping for liability purposes and the rise of flags of convenience, many shipowners choose to register their tonnage and respective representative entities responsible for it, in offshore locations. In order to examine the impact of nationality on periods of ownership, two separate types of nationality data have been incorporated into the analysis for each ownership record – the country, where the company is registered, and the country where the economic benefit ends up. According to Table 4.7 the first five countries own more than half of the world fleet in terms of tonnage (UNCTAD, 2015).

		DWT (in Million Dwt)				Number of ships		
No	Country/Area	Nation Flag	Foreign Flag	Total	% of world Fleet	Nation Flag	Foreign Flag	Total
1	Greece	70.4	209.0	279.4	16.1	796	3,221	4,017
2	Japan	19.5	211.2	230.7	13.3	769	3,217	3,986
3	China	73.8	83.7	157.5	9.1	2,970	1,996	4,966
4	Germany	12.5	109.5	122.0	7.0	283	3,249	3,532
5	Singapore	49.0	35.0	84.0	4.8	1,336	1,020	2,356
6	Korea	16.0	64.2	80.2	4.6	775	843	1,618
7	Hong Kong, China	56.1	19.2	75.3	4.3	727	531	1,258
8	USA	8.7	51.5	60.2	3.5	789	1,183	1,972
9	UK	12.5	35.9	48.4	2.8	477	750	1,227
10	Norway	17.1	29.3	46.4	2.7	848	1,009	1,857

Source: Adapted from UNCTAD (2015, p.36)

Note: Propelled seagoing vessels of 100 GT and above.

Table 4.7. World Fleet Ownership (as of 01/01/2015)

It should be noted that the ownership structure of the fleet changes with time. For example, over the last decade countries like Germany, Norway and the USA lost a big portion of their market share giving way to Asian countries such as China, Korea and Singapore (UNCTAD, 2015).

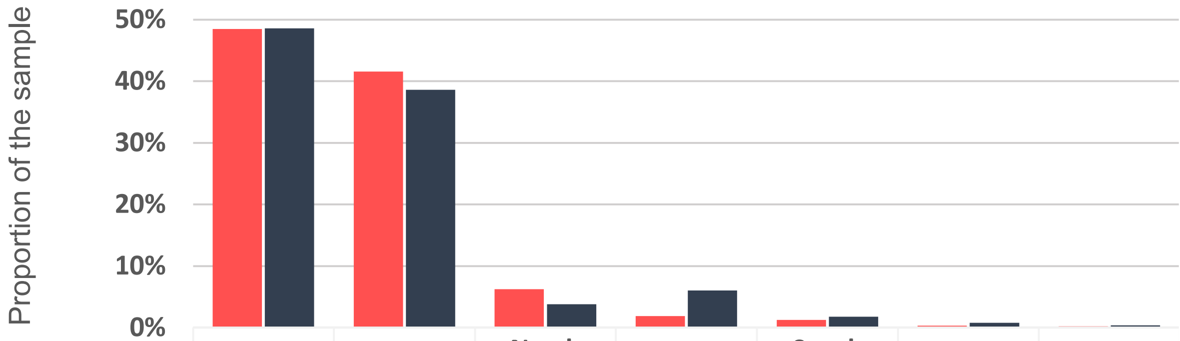
To facilitate the analysis by nationality, some different classifications were considered. The most straightforward classification employed was geographical, achieved by sorting the data by geographical area. The areas were based on UNCTAD's framework for geographical region and composition (UNCTADSTAT, 2016). However, this classification did not render a balanced sample as there are regions with a rich history in owning and operating ships, such as Europe, and regions with traditions in maritime related activities, such as Oceania, but with little experience in owning ocean-going ships. The details surrounding the grouping by geographical area are presented in Appendix B-4.

The second classification of countries is based on a hybrid between UNCTAD and UN frameworks for development status groupings proposed by Bijwaard and Knapp (2009) distinguishing between economies in transition, least developed, developing, developed and OECD countries. It should be noted that, all of the OECD countries are also developed countries apart from Chile, Mexico and Turkey, which are developing. Therefore, the category '*developed*' countries contains all developed countries which are not OECD member states. However, in order to test whether any significant differences can be detected between the hybrid classification (including OECD membership) and the standard UNCTAD one, a separate sub-category grouping countries only based on their development status was included. The classification categories are further discussed in Appendix B-4.

The third classification of countries was based on the framework for classifying ship registers proposed by Alderton and Winchester (2002), grouping the data into five categories: old open registers, new open registers, international registers, emerging maritime nations and traditional maritime nations. It is believed that the framework proposed by Alderton and Winchester (2002) is indicative of the maritime traditions within certain nations and as such is a valuable tool for analysing the nationalities of registration and control. Alderton and Winchester's (2002) grouping of countries is presented in Appendix B-4.

Nationality of Control

Nationality of Control reflects the '*nationality behind the company regardless of location, and invariably where the primary economic contribution ultimately ends up*' (Sea-Web, 2016a, p. 7). About 75% of all records and about 70% of all companies in the dataset are registered in the same country where the ultimate benefit ends up, which means that the nationality of registration is the same as the nationality of control for the relevant dataset entries. According to the data on company level gathered as part of this research, 20% of the owner history records of the whole sample belong to companies that generate economic contributions in Greece, followed by Japan (12%), Germany (11%), China (6%), Korea (4%), Singapore (4%), China-Hong Kong (4%) and Denmark (3%). In terms of the number of companies, the nationality of control for 22% of the total number in the dataset are registered in Greece, followed by Japan (9%) and Germany (9%), China (5%), Singapore (4%), China-Hong Kong (4%) and Norway (4%). According to Figure 4.9 the beneficial ownership is concentrated predominantly in Europe and Asia, followed by North America.



	Europe	Asia	North America	Unknown	South America	Africa	Oceania
Records	48%	42%	6%	2%	1%	0%	0%
Companies	49%	39%	4%	6%	2%	1%	0%

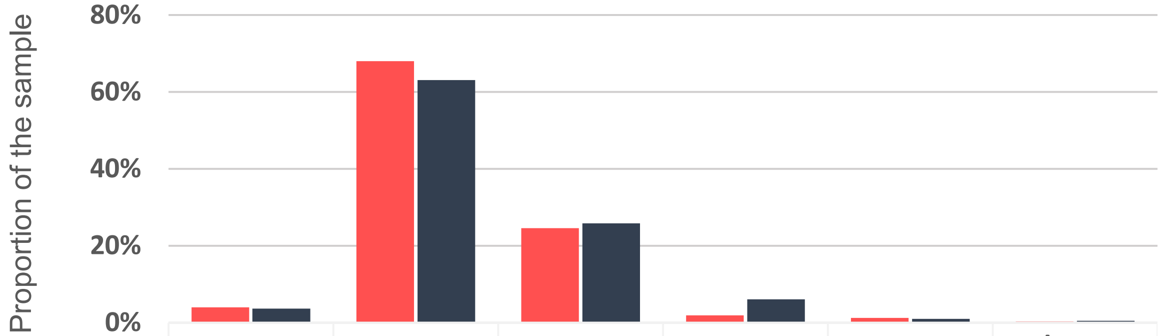
Note: The category 'South America' comprises of Central and South America as the number of entries for Central America are about 1% of the sample for both 'records' and 'companies'.

Figure 4.9. Nationality of Control by Geographical Area

It should be noted that although North America's contribution seems modest compared to the proportions of the sample accounting for Europe and Asia, the category is made up of fewer countries in comparison and it mostly represents USA companies. The same applies for the South America category, which is mostly comprised of a few big public and state companies. In comparison with the distribution of nationality of registration[70], it appears that Africa has gone from the third most popular area for registering companies to the least likely destination of beneficial ownership. It is believed that this phenomenon is mostly due to the Liberian register's requirement for the entity responsible for the vessel to be a Liberian corporation or a foreign maritime entity registered in Liberia. The category titled 'Unknown' in all the figures representing nationality of control (Figure 4.9 and Figure 4.10) refers to companies for which the data on nationality of control is missing. All of the entries that fall into that category belong to the number of records where the data on Group owner is limited and the Registered owner information has been used instead[71]. The proportional difference between records and number of companies indicates that all of the aforementioned entries belong to one ship companies, mostly registered in countries such as Panama, Liberia and the Marshall Islands.

Figure 4.10 represents nationality of control according to development status.

[70] Descriptive statistics on nationality of registration can be found in Data Annex Chapter 4, section 4.3.
[71] See Section 4.3.2. Company Level – c) Ownership Status for more information.

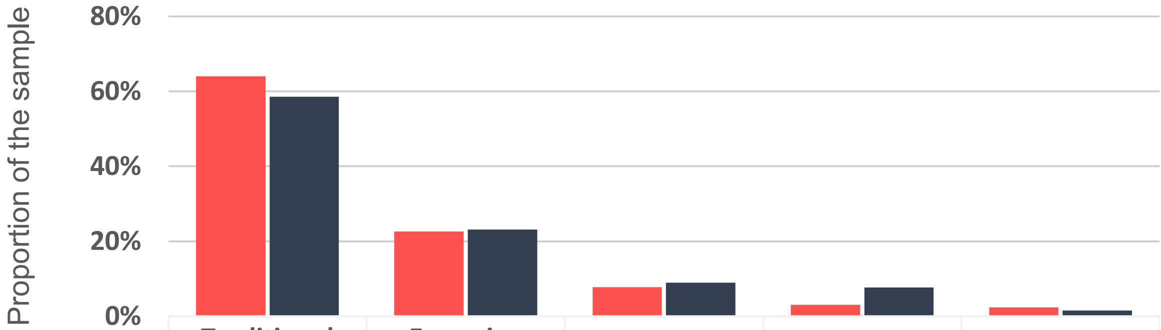


	Developed countries	OECD	Developing countries	Unknown	Transition	Least developed countries
Records	4%	68%	25%	2%	1%	0%
Companies	4%	63%	26%	6%	1%	0%

Note: Developed and OECD countries are grouped together as all OECD countries except for Chile, Mexico and Turkey are also developed.

Figure 4.10. Nationality of Control by Development Status

The ultimate benefit appears to be highly concentrated in developed countries (especially OECD countries). In comparison with the distribution of nationalities of registration, the proportion of developing countries is about 10% lower, which suggests that registering a company in an offshore location (a developing or least developed country) is still a common strategy amongst shipowners. This notion is further confirmed by the proportional distributions according to maritime traditions presented in Figure 4.11.



	Traditional Maritime Countries	Emerging Maritime Nations	International Registers	Unknown	Old Open Registers
Records	64%	23%	8%	3%	2%
Companies	59%	23%	9%	8%	2%

Note: The classification is based on the framework proposed by Alderton and Winchester (1999,2002) presented in Appendix B-4.

Figure 4.11. Nationality of Control by Maritime Traditions

The most striking difference in comparison with nationalities of registration is the fact that the old open registers' category has gone from the second most popular type of countries for registering companies to the least likely type of countries where the ultimate benefits would be concentrated. The entries classified as '*Unknown*' in Figure 4.11 include all the records where information about the nationality of control is missing and the countries which were not originally classified by Alderton and Winchester (2002) such as Monaco, Montenegro and the Czech Republic.

To summarise, the main company level characteristics that were selected based on the review of data availability and relevance to the research questions, are the following: (i) company type; (ii) company size and (iii) nationality (of registration and control).

4.3.3. Economic indicators

The final level of analysis considers economic indicators that describe the state of the shipping markets as well as global trends. The list of economic indicators considered as part of this research is presented in Table 4.8.

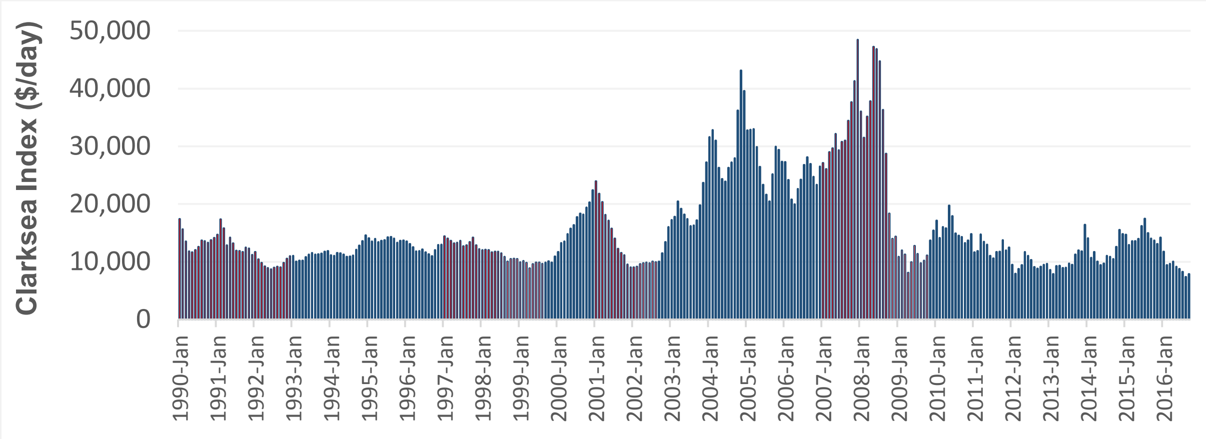
Economic indicators	**Variable**
Shipping market indicators	Freight Rates
	Newbuilding prices (NB)
	Change in NB prices
	Second-hand prices (SH)
	Change in SH
	Demolition Prices
Global economic indicators	Economic growth
	Exchange rate
	Inflation
	Interest rates (LIBOR)
	Oil price
	Bunker price

Table 4.8. Economic Indicators

The monthly data on economic indicators is obtained from CRSL based on ship type. However, most economic indicators are highly correlated, which reinforced the decision to select the economic indicator that is believed to be directly related to periods of ownership and the decision to buy or sell. Bijwaard and Knapp (2009) consider a range of economic indicators and conclude that earnings is the most important factor in determining availability of cash flow, which drives strategic decisions such as buying or selling of ships. Abouarghoub *et al.* (2012) argue that freight earnings '*trigger activities within shipping markets*' and are the main reason behind the decision to purchase, resale or scrap a vessel. Furthermore, according to the industry professionals interviewed as part of this research, freight rates and ship type were chosen as the two single most important characteristics that influence periods of ownership[72]. Based on the reasons listed above, it was decided that earnings should be included as a measure of the state of the shipping market in the numerical models. Earnings were chosen over freight rates as they provide a more accurate representation of profit as they are estimated from voyage freight rates where the current bunker costs, estimated port costs and total commission are deducted (SIWa, 2016). The data on earnings was obtained from Clarksons Research Limited under the form of i) ClarkSea index and ii) monthly data on average earnings by ship type, often used in maritime research as indicators for earnings (Drobetz *et al*., 2013; Kavussanos and Tsouknidis, 2016). The Clarksea Index is a weighted average of the daily earnings of the main ship types where the weighting is based on the number of vessels in each fleet sector (Figure 4.12).

The profitability of the freight markets depends mainly on the interaction between the supply and demand of available shipping capacity. However, there are also additional factors that could lead freight rates to rise or fall dramatically such as seasonal factors, port congestions, political instability and unexpected changes in bunker prices (OECD, 1991). There have been several major crises globally that have had a serious impact on the earning potential in shipping since the late 80s. All of these periods are associated with a sudden change in the supply and demand balance, which resulted in a shock to the system causing a significant drop in freight rates and therefore in earnings. The four most notable such periods are highlighted in red in Figure 4.12. As can be seen from Figure 4.12, the periods associated with a drop in the average daily earnings of the main ship types are roughly the early 1990s, 1998, 2001 and 2008. These periods are ultimately linked to the financial crisis of the early 1990s; the Asian crisis, which started in 1997; the 'Dot.com' crisis of the early 2000s followed by the credit crisis, the remnants of which are still having an impact on the global economy[73].

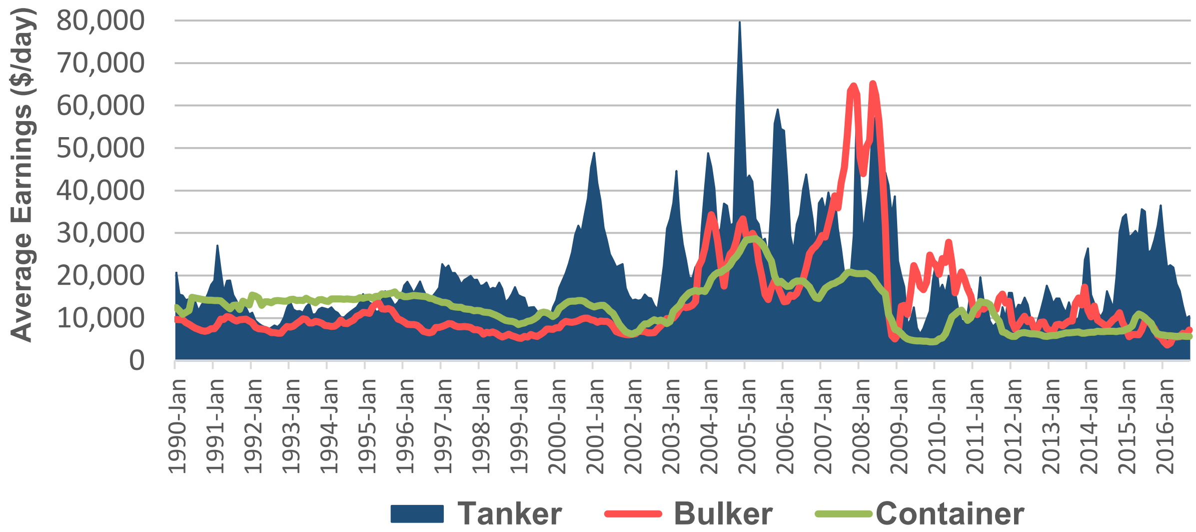
[72] See Chapter 7, section 7.4.3 for a summary on the results from the interviews.
[73] For more information on the main shipping crises see Appendix B-5.



Data: CRSL (2016)

Figure 4.12. Clarksea Index ($/day)

The Clarksea Index provides a good general indication of the state of the freight market, however there are differences between shipping segments in the short term as different commodities are subjected to specific trade patterns and external factors (Stopford, 2009). Therefore, the Clarksea index is used in the additive model including all ship types, whereas on disaggregate ship type level the respective earnings corresponding to the appropriate ship type are used in order to account for the differences between earnings across segments in the short term. The average earnings in the dry bulk, tanker and container sector are presented in Figure 4.13, which illustrates how ship earnings vary across segments in the short term.



Data: CRSL (2016)

Figure 4.13. Average Earnings by Ship Type (in $/Day)

4.4. Concluding Remarks

Over the course of this chapter the data collection process was described starting with an introduction to the two main data providers used – Sea-Web and CRSL. A brief discussion, highlighting the quality and reliability of shipping data, aimed at bringing up the challenges associated with research in the realm of maritime economics, especially in terms of determining the ultimate ownership of vessels, is provided (Section 4.2.1). The chosen sampling frame and sample sizes are discussed on ship (3,908 ships) and company level (1,124 companies based on the ownership records of 2,000 ships) (Section 4.2.2).

The bulk of Chapter 4 is dedicated to introducing and describing the different characteristics considered as part of this research on ship and company level. The techniques used to group and classify the characteristics are explained in order to avoid any future ambiguity. Section 4.3 aims at familiarising the reader with the data gathered for the purpose of this research by providing a brief overview of the quantity of data available, the way it was retrieved, classified and analysed. Furthermore, the distribution between data records on company level, which correspond to the number of changes of ownership, is discussed and compared to the distribution of companies in the final dataset (Section 4.3).

The aim of Chapter 4 was to provide information on the rationale behind the sampling frame, sample size, selection of characteristics and the overall structure of the final dataset.

Chapter 5. Investigation on the Influence of Ship Level Characteristics on Periods of Ownership

5.1. Introduction

Chapter 5 is dedicated to the examination of periods of ownership on ship level. The first part of the chapter provides a brief overview of ships' life histories and periods of ownership (Section 5.2). It also introduces the techniques that have been chosen for data analysis. The second part of the chapter contains the analyses on potential effects of ship characteristics based on periods of ownership data (Section 5.3). The section is divided into separate analyses, stratified by owner number and ship type (Section 5.3.1 - Section 5.3.4). The initial analysis is dedicated to periods of ownership corresponding to the first owner (Section 5.3.1) and is organised in the following way:

(i) a brief overview of periods of ownership according to ship type (Section 5.3.1a);

(ii) exploratory work on the individual effect of the ship level characteristics considered as part of this research (Sub-Section 5.3.1b);

(iii) an introduction of the regression model that has been chosen (including a practical example) followed by the results on the effects of ship characteristics in relation to first owner period (Sub-Section 5.3.1c).

As the considerations for the omission of certain ship level characteristics from the analysis on first owner level (Sub-Section 5.3.1b) are valid for subsequent owners as well, the structure of the following analyses (Section 5.3.2 – Section 5.3.4) is simplified. In the interest of brevity, parts of the exploratory work and additional findings, are presented in Data Annex 5. Finally, all results are summarised in relation to the research questions being examined in this chapter (Section 5.4) and a brief discussion is provided on the chosen statistical methods and structure of the analyses (Section 5.5).

5.2. Periods of Ownership According to Ship Level Characteristics

The analyses summarised in the present chapter investigates the question whether and how periods of ownership vary based on ship characteristics. A list of the information on ship level gathered as part of this research and collated into a dataset has been provided in the chapter dedicated to data (see Chapter 4, Table 4.1.), accompanied by a brief overview of each variable's main characteristics. The information on ship level is grouped in the following main categories:

- Ship Type;
- Ship Size;
- General information – including vessel status, delivery year, speed, fuel consumption and number of owners;
- Shipbuilder nationality (Builder Area);
- Relevant dates – the dates that the ship was ordered, delivered, potentially sold or potentially scrapped as well as the end of the follow up period.

The dataset on ship level consists of 3,908 ships upon the examination of whose ownership history 8,042 changes of ownership were recorded. Stott (2013) provides evidence that the behaviour of owners varies between first and subsequent owners based on an examination of the periods of ownership of 795 vessels built in the late 1980s and early 1990s. According to the findings, first owners were found to keep vessels for much longer than subsequent owners and it is suggested that this phenomenon could be linked to special surveys that are mandated and carried out every 5 years by classification societies (Stott, 2013). Maintenance costs increase with the age of the vessel as well as the probability of technical obsolescence or the introduction of new regulatory requirements, which might prompt owners to replace a ship rather than to invest in expensive retrofit.

The following sections aim to familiarise the reader with the essence of the data on periods of ownership on ship level by providing an overview on: (i) ships' life histories and (ii) periods of ownership.

5.2.1. Overview of ships' life histories

The terms '*ships*' and '*records*' are not being used interchangeably. The term '*ship records*'[74] is associated with the number of owners a vessel has had and each record corresponds to a specific owner and a specific ship. For example, if a hypothetical ship, "*Theseus*", has had three owners in total, then "*Theseus*" will be included in the final dataset on ship level three times as the period of ownership with each individual owner has been calculated separately. Thus, a record related to "*Theseus*" will appear in each of the subsets corresponding to periods of ownership associated with the first owner, the second owner, and the third owner respectively All three ship records, technically all belonging to Theseus, are treated as independent observations. All three records represent the same ship and the ship's economic life is a function of the

[74] As defined in Chapter 4, Section 4.2.2. Sampling frame and sample size

three records. This concept is illustrated in Figure 5.1, where the economic life of four randomly chosen Panamax bulkers, ships number 1040, 1223, 777 and 801 in the dataset, is shown as a string of transitions between owners.

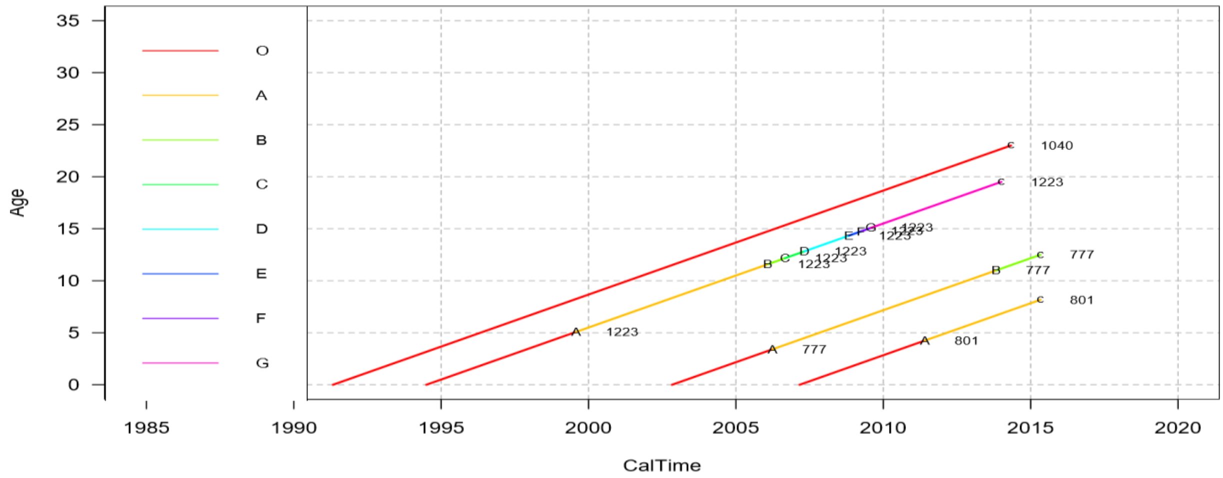


Figure 5.1. Life Histories Example – Lexis diagram[75]

The first state, denoted as 'O' is the period of ownership corresponding to the first (original) owner. Later changes of ownership corresponding to subsequent owners are denoted "A" to "G" respectively. For example, ship number 777 was built in 2003, remained with the first owner until 2006 when it was sold to the second owner. In 2013, ship 777 was sold to a third owner, who was still in a possession of the vessel at the end of the follow up period in 2015. On the other hand, ship number 1040 was delivered in 1990 and it has never been sold during the follow up period.

Table 5.1 illustrates the distribution of ships and ship records according to the number of owners within each segment. According to the data, 54.5 % of all container ships (660 out of 1212) included in the dataset were never sold during the follow up period. It should be noted that 25.5% of the whole dataset on ship level consists of ships built between 1998 and 2007, which suggests that the youngest vessels included in the sample were 7.5 years old at the end of the data collection phase

Ship Type	No. of ships		No. of ships (S) and No. of Records (R) according to owner number															
			1		2		3		4		5		6		7		8
	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S
Bulker	1658	3896	533	1658	466	1124	360	659	188	299	74	110	29	37	7	8	1
Tanker	1038	2117	422	1038	331	616	165	285	74	119	36	46	7	10	3	3	NA
Container	1212	2029	660	1212	356	552	141	196	42	55	12	13	1	1	NA	NA	NA
Total	3908	8042	1615	3908	1153	2292	666	1140	304	473	122	169	37	48	10	11	1

Table 5.1. Number of Ships and Ship Records According to Ship Type and Number of Owners – ship level

[75] The purpose and use of Lexis diagrams are described in Chapter 3, section 3.3.2.a), p 48.

The main analysis regarding periods of ownership according to the overall research design adopted as part of this research is stratified by owner number[76]. However, although this facilitates the investigation of periods of ownership by owner number, it also ignores the fact that a ship's economic life is finite and it is also a function of the respective periods of ownership. This section provides a brief overview of ships' life histories, which aims to complement the findings on length and patterns of ownership according to owner number by approaching periods of ownership from a multistate point of view. The collective history of the sample by vessels' age is presented as a state distribution plot, where '*state*' refers to being in the possession of an owner from the owner sequence[77] of each vessel (Figure 5.2).

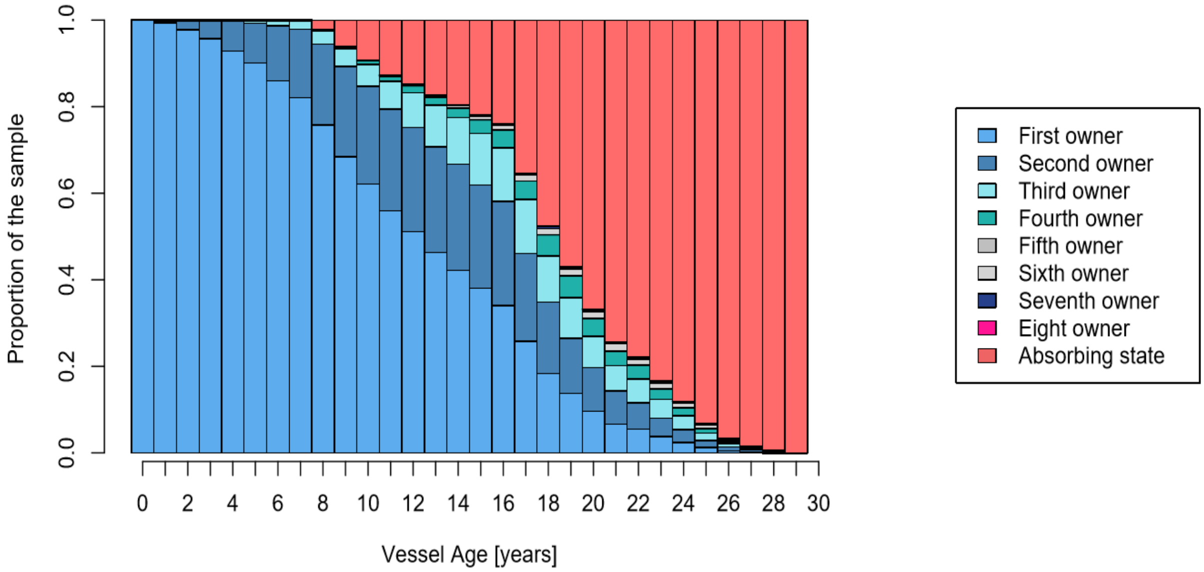
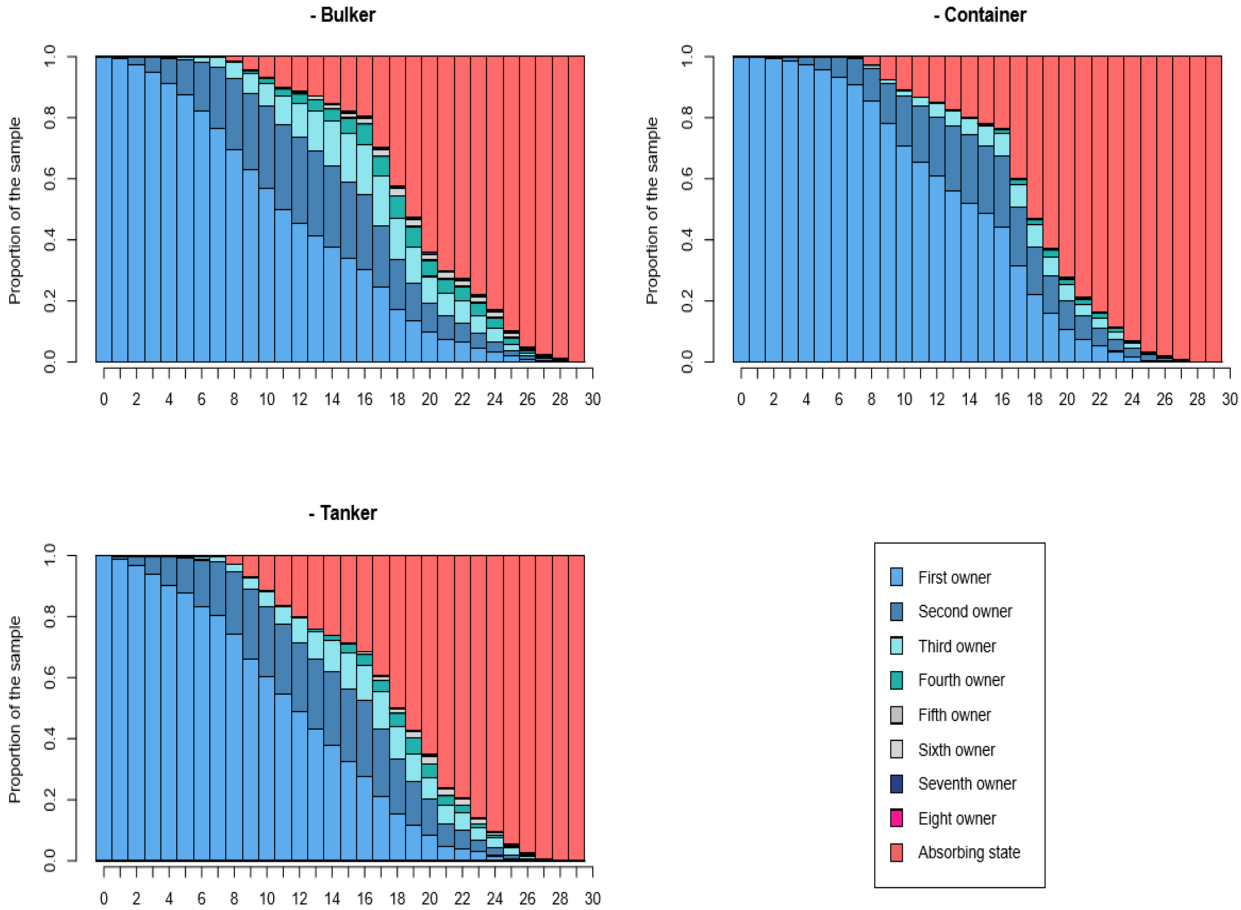


Figure 5.2. State Distribution – all vessels

For example, at age 15 years 40% of all vessels included in the sample were still with their first owner, 25% were with their second owner, about 10% were with their third owner and about 0.5% were in the possession of later owners. The '*absorbing state*', which constitutes about 20% of the vessels at age 15, refers to vessels that are either scrapped or have not reached the age in question at the end of the follow up period. In the case of 15 year-old vessels, however, the number of vessels in an absorbing state represents mainly vessels that have not reached 15 years of age as the number of vessels scrapped at this stage is small in comparison. As the follow up period for the sample spans from 1987 to 2015, the oldest ship in the sample is a 28 years old bulk carrier, which was delivered in 1987 and followed until 2015.

[76] For a discussion on the topic see Chapter 3, section 3.3.2.
[77] In this context *sequence* refers to '*sequence of state occupancies (attributes)*' (Willekens, 2005, p2), where state occupancies represent periods in the possession of specific owners.

Comparing the state distributions by ship type reveals that the proportion of container vessels that have remained with their first owner at any given age is higher than that of bulkers or tankers until the vessels reach 17-18 years of age at which point the proportion of vessels that remain with the first owner is similar across ship types (Figure 5.3).



**The horizontal axes represent vessels' age in years*

Figure 5.3. State Distribution by Ship Type

Moreover, a smaller proportion of container vessels seem to have more than two owners in total in comparison with tankers and, especially, bulkers.

The proportion of vessels within the absorbing state at an early age is driven by the study design as the delivery profile of the sample consists of vessels built between 1987 and 2007. The prominent increase in vessels within the absorbing state after the age of 16 years is caused by the effect of scrapped vessels, discussed later (see Figure 5.7). Figure 5.4 (i) illustrates owner sequences based on the data on periods of ownership corresponding to the first 10 vessels according to the order of appearance in the database. The sequence frequency plot (Figure 5.4 (ii)) shows the 10 most frequent owner sequences where the bar width is proportional to the frequencies (Gabadinho *et al.*, 2011).

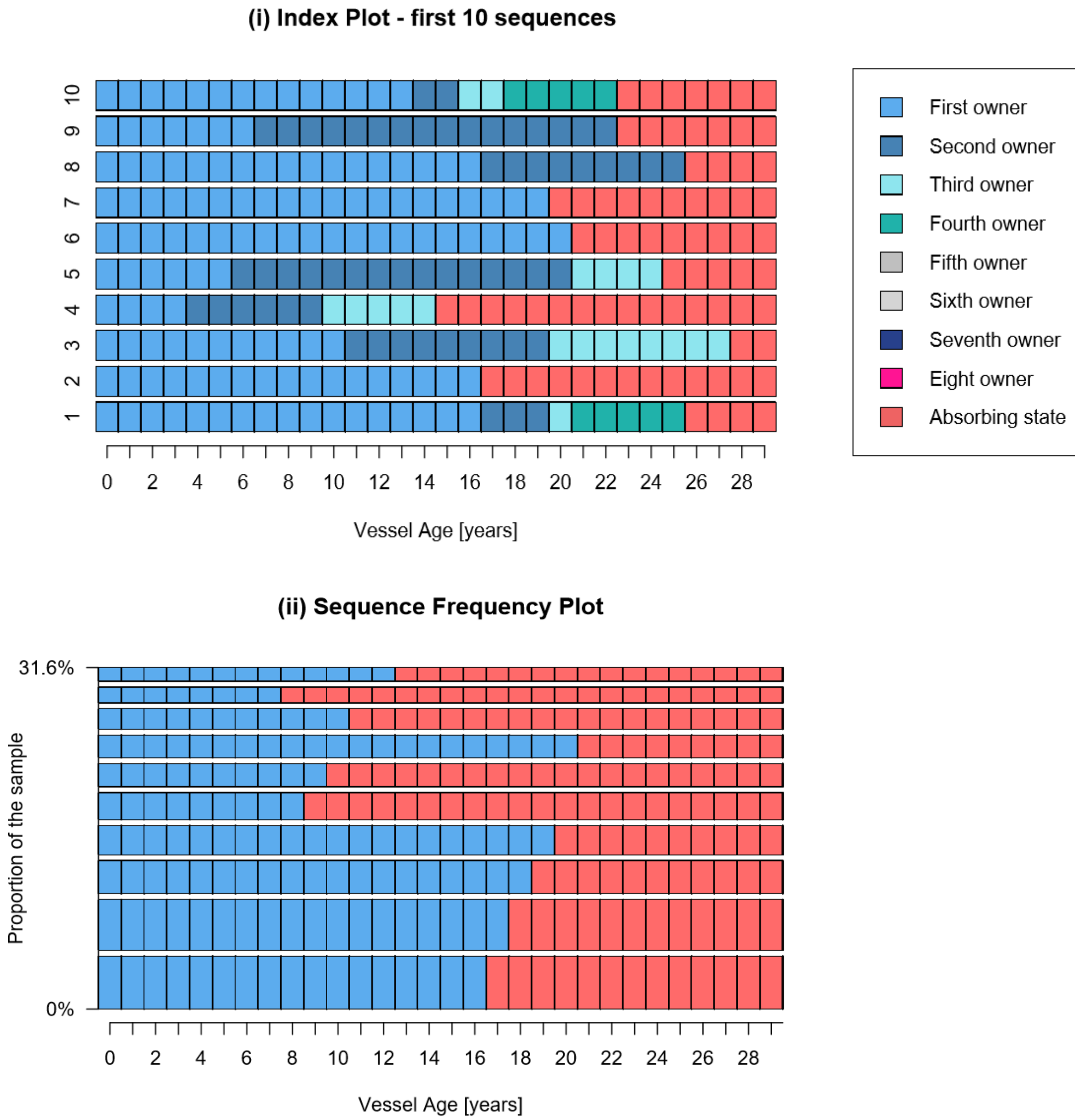


Figure 5.4. Owner Sequences

According to the sequence frequency plot, the ten most frequent sequences represent 31.6% of the sample and all involve vessels that have only had a single owner.

Detailed information on sequence frequency and median age by ship type is summarised in Table 5.2. As the start of the follow up period for all vessels is the ships' delivery date, the age at entry is 0. The median age at exit is either: (i) the vessel's age at the end of the follow up period for ships that were still in service at the end of the data collection phase or (ii) the scrapping age for ships that were scrapped before the end of the follow up. The first four columns indicate the sequence ID number, followed by the number of ships that experienced that ownership sequence, their proportion of the overall sample and the cumulative proportion of the current and previous sequences respectively.

(i) Bulkers

Seq ID	No.	%	Cum %	Total No. of Owners	Status*	Changes of ownership							Median Age at Exit
						1	2	3	4	5	6	7	
1	414	25.0	25.0	1	In service								16.7
2	395	23.8	48.8	2	In service	11.4							17.2
3	267	16.1	64.9	3	In service	7.6	14.2						18.6
4	135	8.1	73.1	4	In service	7.3	11.1	16.08					19.6
5	118	7.1	80.2	1	Scrapped	22.1							22.1
6	93	5.6	85.8	3	Scrapped	10.2	17.2	23.0					23.0
7	71	4.2	90.1	2	Scrapped	15	23.2						23.2
8	55	3.3	93.4	5	In service	6.4	9.5	14.8	17.5				19.9
9	54	3.2	96.7	4	Scrapped	8.7	13.8	18.0	23.2				23.2
10	22	1.3	98.0	6	In service	4.3	9.1	12.1	13.2	17.5			19.6
11	17	1.0	99.0	5	Scrapped	6.6	11.0	15.6	18.7	23.6			23.6
12	7	0.4	99.5	6	Scrapped	6.3	10.3	13.5	16.4	21.5	24.2		24.2
13	5	0.3	99.8	7	In service	5.4	9.8	12.0	14.0	14.5	17.7		23.1
14	2	0.1	99.9	7	Scrapped	5.0	6.9	10.8	15.7	18.4	20.5	22.8	22.8
15	1	0.0	100	8	In service	5.0	11.5	12.1	12.8	14.3	14.7	15.0	19.5

* As of the end of the data collection

(ii) Tankers

Seq ID	No.	%	Cum %	Total No. of Owners	Status*	Changes of ownership							Median Age at Exit
						1	2	3	4	5	6	7	
1	350	33.8	33.8	1	In service								13.1
2	239	23.1	56.8	2	In service	11.2							16.8
3	98	9.5	66.3	3	In service	7.6	16.0						19.3
4	92	8.9	75.1	2	Scrapped	13.5	20.7						20.7
5	72	6.9	82.1	1	Scrapped	20.2							20.2
6	68	6.6	88.6	3	Scrapped	8.5	15.6	20.6					20.6
7	41	4.0	92.6	4	In service	7.2	13.1	18.0					20.5
8	31	3.0	95.6	4	Scrapped	7.3	13.3	16.2	20.8				20.8
9	22	2.1	97.7	5	In service	7.6	11.9	16.0	19.5				23.3
10	14	1.4	99.0	5	Scrapped	7.1	9.3	15.4	17.9	21.5			21.5
11	5	0.5	99.5	6	In service	6.1	12.7	14.4	16.3	19.8			22.7
12	2	0.2	99.7	7	In service	3.8	6.3	13.0	16.7	19.4	22.8		25.3
13	2	0.2	99.9	6	Scrapped	5.1	11.6	14.2	15.6	18.5	23.5		23.5
14	1	0.1	100.0	7	Scrapped	8.3	11.5	14.3	14.8	17.0	19.7	21.1	21.1

* As of the end of the data collection

(iii) Containers												
Seq ID	**No.**	**%**	**Cum %**	**Total No. of Owners**	**Status***	**Changes of ownership**						**Median Age at Exit**
						1	**2**	**3**	**4**	**5**	**6**	
1	494	40.8	40.8	1	In service							16.2
2	267	22.0	62.8	2	In service	11.9						17.4
3	165	13.6	76.4	1	Scrapped	19.5						19.5
4	101	8.3	84.8	3	In service	8.2	15.9					18.7
5	89	7.3	92.1	2	Scrapped	12.2	21.4					21.4
6	40	3.3	95.4	3	Scrapped	10.9	16.3	21.5				21.4
7	22	1.8	97.2	4	Scrapped	9.8	14.2	18.3	21.6			21.6
8	20	1.6	98.9	4	In service	7.5	13.1	17.1				19.9
9	7	0.5	99.5	5	In service	6.2	10.1	16.1	17.8			18.8
10	5	0.4	99.9	5	Scrapped	7.0	14.8	15.5	18.7	22.9		22.9
11	1	0.1	100	6	Scrapped	2.7	13.5	14.2	14.9	17.7	22.8	22.7

* As of the end of the data collection

Table 5.2. Owner Sequence Frequency per Ship Type and Median Age at Changes of Ownership

The sequences are ordered based on their proportion of the sample, which means that the first sequence in the list corresponds to the most frequent ownership sequence by ship type. The median ages at all potential changes of ownership are displayed in years. For example, the most frequent sequences for bulk carriers are vessels with one, two and three owners that were still in service at the end of the follow up (Table 5.2.(i)). Such bulkers constitute 64.9% of the sample.

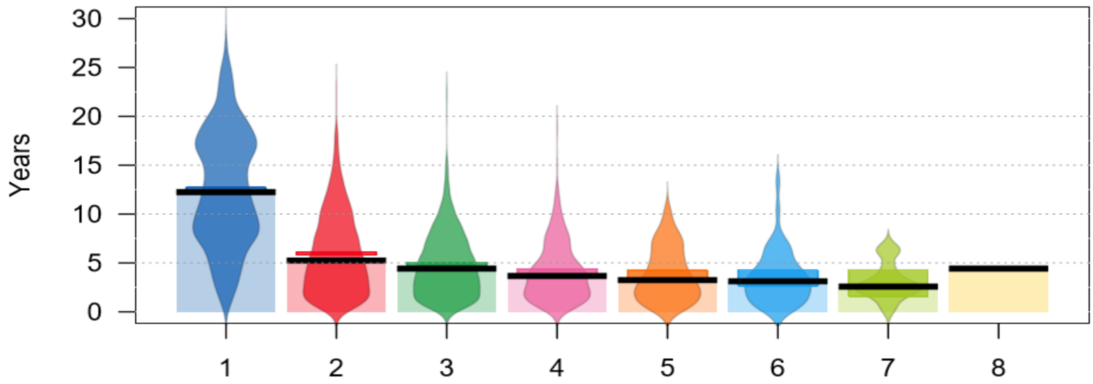
The most frequent owner sequence for all ship types constitutes vessels that are still in service and have not experienced a sale by the end of the follow up period. For bulkers such vessels comprise 25% of the sample, for tankers – 33.8%, whereas for container ships 40.8 % of all containers have remained with their first owner as of the end of the follow up. It appears that container vessels are generally kept longer by their respective owner in comparison with the two other ship types for earlier owners. However, as container vessels have a lower scrap age[78] on average, the median periods of ownership corresponding to the first and second owner for vessels that were scrapped before the end of the follow up are shorter than those for bulkers and tankers.

[78] The scrap age of vessels is discussed in Chapter 4, section 4.3.1e)

The descriptive overview of ships' life histories reveals that half of the sample (55.3%) is comprised of vessels that have had either one (32.2%) or two (23.1%) owners in total and were still in service at the end of the follow up period.

5.2.2. Overview of periods of ownership

The median and average periods of ownership by owner number according to all ship records are presented in Figure 5.5. One of the advantages of RDI[79] plots is that they show the smoothed density of the raw data as a shape around the data points. The period of ownership corresponding to the first owner - *first owner period* hereinafter, has two distinctive density intensive regions which appear to be within the regions 8-10 years and 17-19 years. This phenomenon is attributed to certain inherent characteristics of the data on periods of ownership discussed later in this section.



Owner No	1	2	3	4	5	6	7	8
Median Period (Years)	12.3	5.3	4.4	3.7	3.3	3.1	2.6	4.1
Average Period (Years)	12.6	5.9	4.9	4.1	3.8	3.5	3.1	4.1

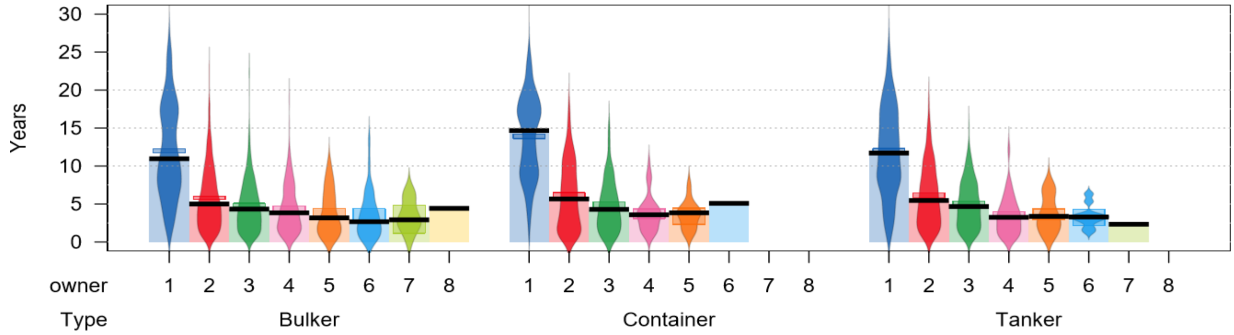
Note: The black line on top of each bar represents the median, whereas the colourful box near the top of the bars corresponds to the 95% confidence interval (CI) for the mean

Figure 5.5. Period of Ownership by Owner Number – ship level

Since the number of observations corresponding to later owners (>5 owners) is quite small (Table 5.1), the confidence intervals, represented by rectangular boxes around the mean, increase. Generally, the periods of ownership decrease with the owner number increasing. The only exception is the last owner period (8) but this is due to the fact there is only one record corresponding to the eighth owner (Table 5.1). Apart from the difference according to owner number, Stott (2013) also reports that the average length of ownership for vessels built between 1987 and 1992 varies across ship types with fully cellular container vessels outperforming bulkers and tankers,

[79] Raw data, Inference and Description (RDI) plots. For more information on how to read RDI plots and their functionality, refer to Chapter 4, section 4.3.1. – General Information.

especially in the case of first and second owners. Figure 5.6 confirms that bulk carriers have the highest number of owners as discussed earlier[80], whereas container vessels have fewer owners and slightly longer periods of ownership on average. Generally speaking, the periods for all ship types decrease with each subsequent owner.



Note: No exact numbers are quoted for median periods of ownership by owner number as subsequent sections are dedicated to summarising the findings.

Figure 5.6. Period of Ownership by Ship Type and Owner Number – ship level

As it can be seen from Figure 5.6, the confidence intervals corresponding to later owners, especially those after owner four, increase as the number of observations available decreases (Table 5.1). The density of first owner period data is particularly interesting, especially in the case of bulkers and containers. According to Figure 5.6 there are two density intensive regions corresponding to first owner period for both ship types. In the case of bulkers, the highest number of observations is concentrated in the region 5-10 years followed by period of ownership in the range 15-20 years. In the case of container vessels, the opposite can be observed – the highest density of observations is in the region 15-10 years, followed by a spike close to 10 years. For tanker vessels, the density is more gradually distributed between vessels sold by the first owner at age ranging between 10 to 20 years. This phenomenon could partially be attributed to the very nature of the data on periods of ownership, which comprises of complete and incomplete observations, and the delivery profile of the sample.

One of the most challenging aspects of examining periods of ownership accurately is the presence of censored observations. Censored observations, also referred to as incomplete data, correspond to the data records which have not experienced the event of interest. According to the definition adopted as part of this research, the event of interest in the analysis on ship level is termination of ownership, which manifests itself as a sale to (i) another owner (change of ownership) or (ii) to a scrap yard (end of the

[80] See Chapter 4, Section 4.3.1.c).

economic life of the vessel). In other words, censored observations represent the records of vessels that were (i) in the possession of the respective owner number and (2) still in operation at the end of the follow up period. Calculating the average periods of ownership based on all observations could be misleading as the information reflects a snapshot of the past, especially bearing in mind that censored observations account for at least 25% of the observations based on ship type and owner number (Figure 5.7)[81].

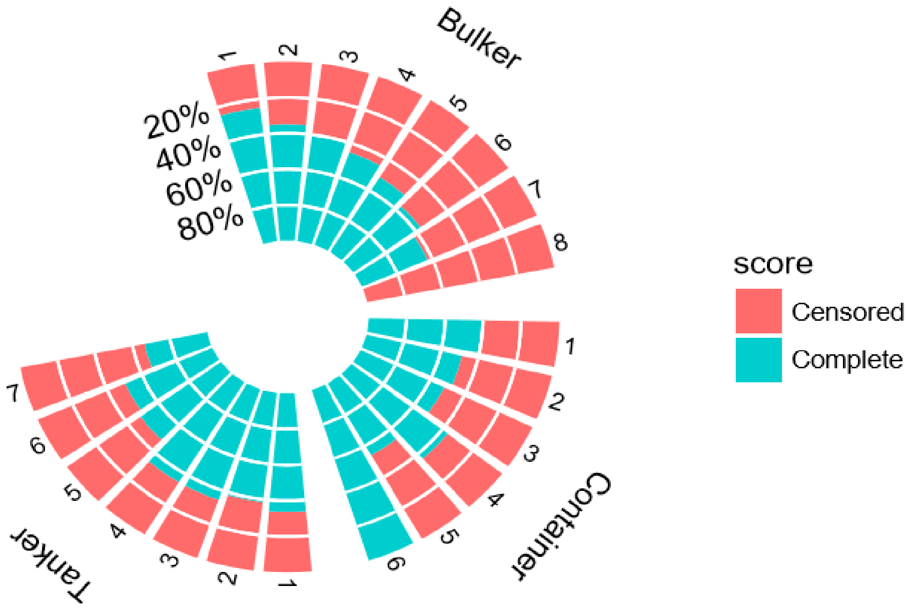


Figure 5.7. Distribution of Complete and Censored Observations by Ship Type and Owner Number

Figure 5.8 splits complete observations into vessels that have been scrapped and sold and shows the distribution of periods of ownership by ship type and owner number. Only the distributions corresponding to the first three owners are shown in Figure 5.8 as the number of records per each 1-year interval of ownership decreases substantially for later owners[82]. The number of records, instead of density, is shown as it is indicative of sample size and it highlights the difference between '*ships*' and '*ship records'*, discussed earlier.

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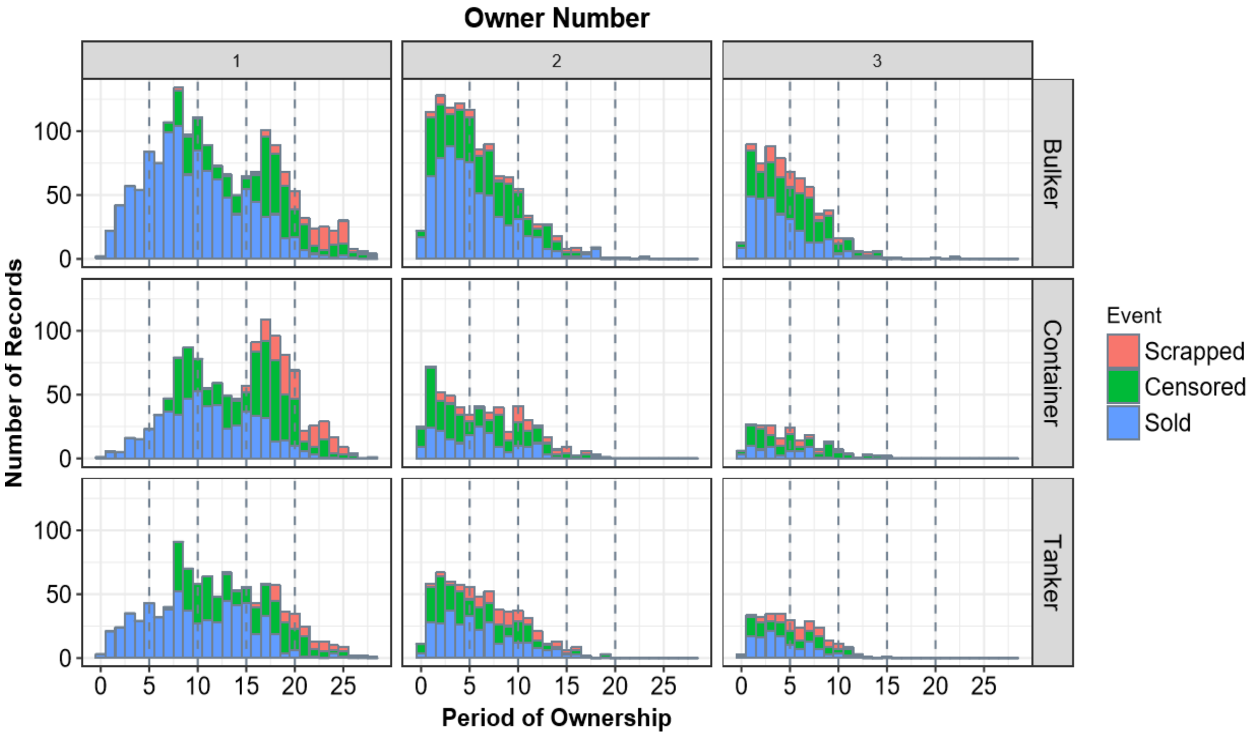
[81] The lowest proportion of censored observations by ship type and owner number is 25% corresponding to 1st owner period for bulkers apart from 6th owner period for containers where there are no censored observations. However, there is only 1 observation for 6th owner period for containers, therefore this category has been ignored when reporting the findings on distribution of censored observations.

[82] The distribution of periods of ownership according to later owners as well as frequency based distributions for all owners are presented in Appendix 7-1.



Note: Only data corresponding to 1st, 2nd and 3rd owner is included as the number of records for later owners (4-8) decreases. 7340 ship records were used for generating the figure (91% of all ship records). Owner number refers to records of vessels and should not be confused with total number of owners.

Figure 5.8. Distribution of Periods of Ownership by Ship and Event Type (owner number 1-3) – ship level

Records marked as '*scrapped*' refer to ships that were sold to scrap yards during the follow up. Figure 5.8 is not analysed in detail as there are subsequent sections dedicated to periods of ownership by ship type. However, it should be noted that the most prominent bars within each Event[83] category are the modes within each of these categories. For example, the most common period of ownership corresponding to first owner for bulkers that were subsequently sold (by the first owner) is 8 years. From the distributions corresponding to first owner periods it can be concluded that a relatively high number of container ships (~50) were scrapped between the ages of 15 and 20 years and that many ships were still in the possession of the first owner (censored) at that age. The relatively high number of containers scrapped by the first owner could be a product of certain attitudes amongst owners. For example, it is received wisdom amongst shipping professionals that many owners in the container sector would rather

[83] The event of interest is termination of ownership, which manifests as a sale to another owner or a scrap yard. 'Event' here is a hybrid category where the records are split into censored (incomplete) and complete – scrapped or sold.

scrap than sell to the competition if the need arises as one of the most important aspects of competition in the sector is based on capacity.

Figure 5.7 and Figure 5.8 aimed at familiarising the reader with the presence of censored data and the distribution of censored and complete observations on ship level. Bearing in mind that the medians and means reported in Figure 5.5 are based on all ship records, regardless of whether they are denoted as complete or censored, the information presented there should be regarded as indicative of patterns but further analysis on the effect of censored observations is needed.

In the light of the evidence that periods of ownership vary by ship type as reported by Stott (2013) and that the preliminary findings on periods of ownership based on all the data on ship level included in this study (Figure 5.5 and Figure 5.6), the following analyses are stratified by owner number.

5.3. Periods of Ownership Analysis by Owner Number

5.3.1. Periods of ownership corresponding to first owner

a) Length of ownership – first owner

In the case of periods of ownership corresponding to the first owner, censored observations represent vessels that: (i) have never been sold and (ii) were still in operation at the end of the data collection. In terms of first owner period, 25% of the bulker, 40% of container and 33% of tanker records on ship level are censored. The average period of ownership for censored records by ship type is longer in comparison to that of complete records (Figure 5.9).

In terms of censored records, the youngest vessels within this category are the vessels delivered in 2007, which were about 7.5 years old at the end of the data collection phase and represent the density bubbles in the region around year 10 (Figure 5.9). Most bulkers and containers that have never been sold and were still in operation appear to be aged[84] between 15 and 20 years. The censored tanker records appear to have two large density bubbles around year 10 and between 15 and 20 years. The median period of ownership, depicted as the line on top of each bar, is between 13.1 years (tankers) and 16.9 years (bulkers) for censored records. In comparison, the first

[84] In the case of first owner period, the length of the period of ownership and the age of the vessel are interchangeable as the delivery date of the ship is the date when the ship enters into operation.

owner median period according to the data on complete records varies between 9.6 years (bulkers) to 12.6 years (containers).

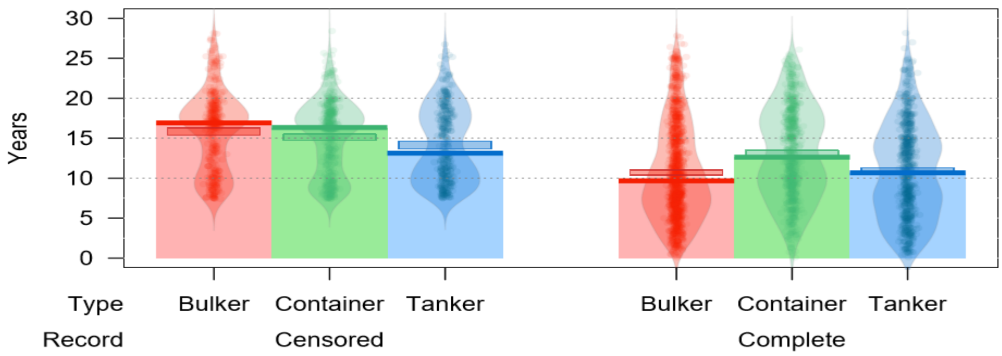


Figure 5.9. Period of ownership by ship type – 1st owner, complete and censored records

Figure 5.9 shows that censored and complete observations follow different patterns. As periods of ownership corresponding to censored observations are generally longer[85] than the periods corresponding to complete data, considering these censored and complete observations together increases the average periods of ownership by ship type (Table 5.3). The reason for this is the fact that the censored observations in this case represent the ships that have never been sold and were still in operation at the end of the data collection. However, in the case of first owner periods, there are vessels that also had never been sold but were scrapped before the end of the follow up period, which determines their status as *'complete'*, since they experienced the event of interest – termination of ownership. The proportions and the average periods of ownership of such records – complete records corresponding to single owner vessels, are presented in Table 5.3 and compared to the average period of ownership of censored observations and complete observations with more than one (multiple) owners. The single owner complete records represent a small proportion of the total number of records within each type (6.9% of tankers, 7.2% of bulkers, 13.7% of containers), however when added to the rest of the complete observations they increase the average period of ownership by 2 years for container vessels and an additional year for both bulkers and tankers.

[85] Periods of ownership corresponding to censored records tend to be longer than the average period of ownership of complete records, however this is not always the case as some records belong to young ships that had not reached an age sufficient to surpass the average periods corresponding to complete records.

Type	Record	Owners	Average period of ownership	No. of records	% of the Total	Total No. of records
Bulkers	Censored	Single	15.8	414	25.0%	1658
	Complete	Multiple	9.6	1125	67.9%	
		Single	21.2	119	7.2%	
Tanker	Censored	Single	14.2	350	33.7%	1038
	Complete	Multiple	9.8	616	59.3%	
		Single	20.5	72	6.9%	
Container	Censored	Single	15.1	494	40.8%	1212
	Complete	Multiple	11.1	552	45.5%	
		Single	19.8	166	13.7%	

Note: The category '% of the Total' refers to the proportions of censored and complete records within each ship type.

Table 5.3. Average Periods of Ownership by Ship Type – 1st owner, complete and censored observations

In order to quantify and compare the differences between groups within the overall dataset, the employment of additional statistical tests is necessary. There are different types of techniques that can be considered based on the number of independent and unrelated groups taken into account. For example, the standard tests for comparing two groups are two sample t-test or one way analysis of variance (ANOVA) for two or more groups. However, the data on periods of ownership is a measure of the time until the event of interest occurs or alternatively until the end of the follow up period. Such type of data is known as time-to-event or survival data[86]. The standard statistical procedures for comparing independent groups, however, are not designed to handle censored observations (Hosmer *et al.*, 2008). As an alternative to descriptive statistics and standard procedures for group comparison, the '*survival*' of vessels was investigated, where the survival probability refers to the probability of a vessel remaining with its owner for time greater than the specified time t[87].

The Kaplan-Meier estimator is used to generate a graphical display of the survival probability of ship records. In order to illustrate the main characteristics of a Kaplan-Meier plot, the survival probability of all vessels irrespective of number of owners is presented in Figure 5.10. The median survival time for all vessels is 10.3 years.

[86] For more information on time-to-event data, see Chapter 3, Section 3.5.1.
[87] For a more detailed discussion on the choice of methods, see Chapter 3, Section 3.5.

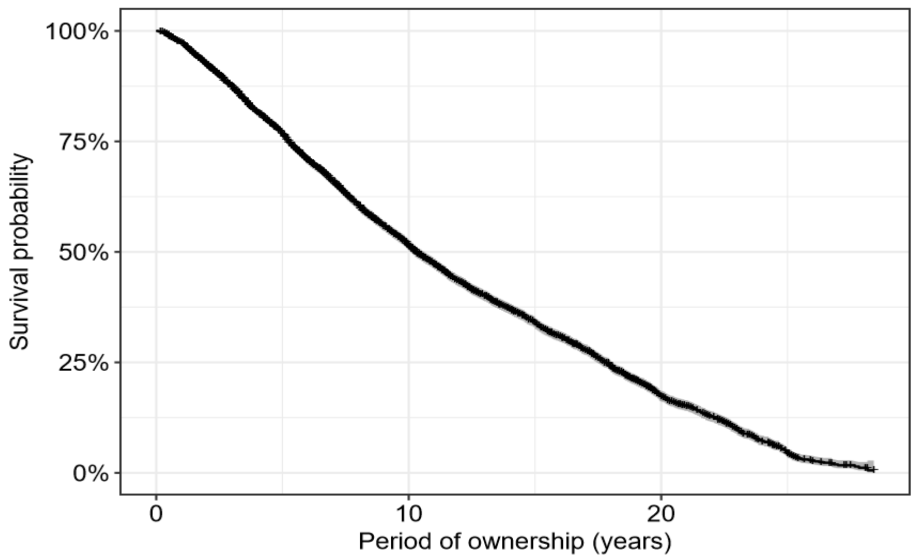


Figure 5.10. Survival Probability for All Ships – Kaplan-Meier

The survival probabilities based on 5-year intervals are shown in Table 5.4. The data used represents all ship records (8042) as the analysis needs to take into account the periods of ownership corresponding to each owner of every ship. The number of events refers to the number of records that have experienced the event of interest (termination of ownership – a sale to either a subsequent owner or a scrap yard) and thus it is equal to the number of complete records. According to Figure 5.10 and Table 5.4, the probability of a ship to remain with its owner[88] after year 10 is 0.52 or 52% based on the pooled periods of ownership irrespective of owner number.

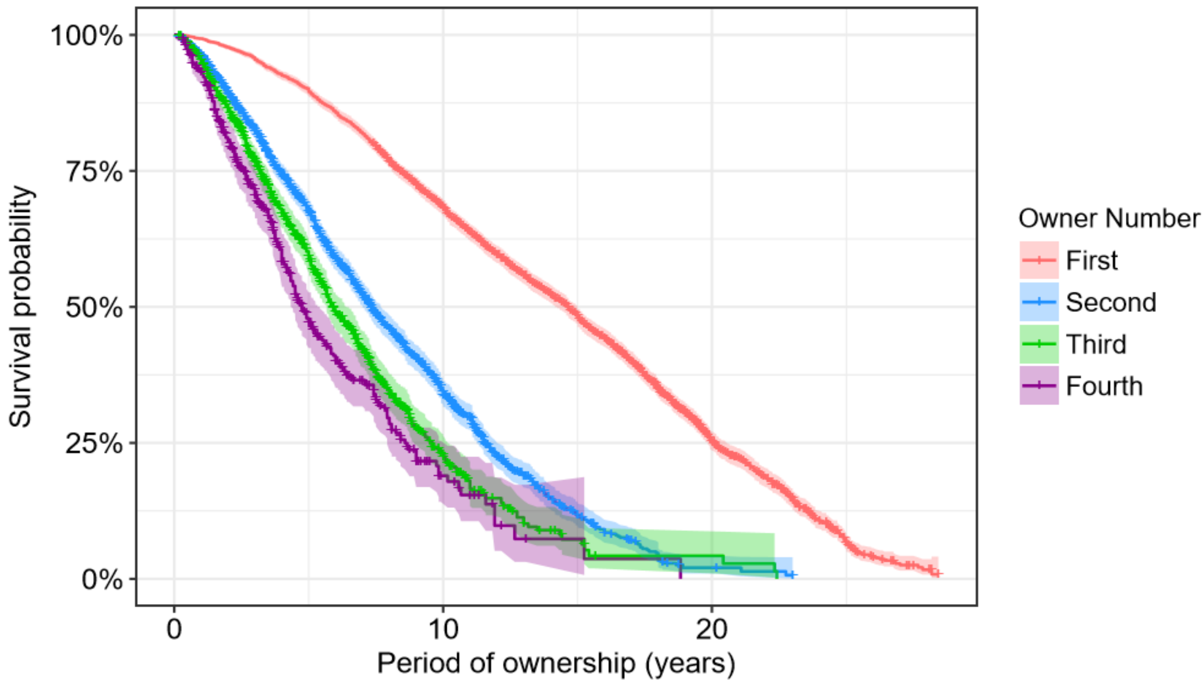
Period (years)	No. At Risk	Events	Survival	CI
0	8042	0	1.00	1.00 – 1.00
5	5404	1748	0.77	0.76 – 0.78
10	2914	1632	0.52	0.51 – 0.53
15	1562	891	0.34	0.33 – 0.35
20	407	597	0.17	0.16 – 0.19
25	50	210	0.05	0.04 – 0.06

Table 5.4. Survival Probability for All Ships at 5-year Intervals

The purpose of Figure 5.10 is solely to introduce the techniques chosen to estimate the survival probability of vessel records due to the presence of censored observations. However, in order to provide a more realistic estimate of periods of ownership, other factors, such as owner number and ship type, should be taken into account as established earlier.

[88] Or alternatively the ship's survival probability with the respective owner.

Figure 5.11 illustrates the difference between periods of ownership based on owner number. In general, if a survival curve is above all other survival curves it means that the proportion of observations which have not experienced the event of interest, is higher for that specific group. The probability of a ship remaining with the first owner is substantially higher than the probability of a ship remaining with its subsequent owners at all times. For example, the probability of a ship remaining with the first owner at year 10 is 0.68, with second owner – 0.34, third owner – 0.23, whereas for fourth owner the probability of survival is only 0.19 (Figure 5.11).



Type	Records	Events	Median	CI	Survival Probability by Time (years)		
					5	10	15
First	3908	2650	14.7	14.2 - 15.0	0.90	0.68	0.49
Second	2292	1393	7.3	7.0 – 7.8	0.68	0.34	0.12
Third	1140	674	6.0	5.7 – 6.4	0.59	0.23	0.07
Fourth	473	277	4.8	4.4 – 5.4	0.47	0.19	0.07

Note: Only data on periods of ownership corresponding to the first four owners has been included as the number of records corresponding to later owners is relatively small.

Figure 5.11. Survival Probability by Owner Number for All Vessels– Kaplan-Meier

It should be noted that higher survival probability equals a lower probability to experience the event or in the context of this research – to experience termination of ownership. Therefore, when estimated or predicted survival is reported, the probability of survival and the probability of experiencing the event are both used in order to avoid repetition. Based on the Kaplan-Meier plot, the survival curves corresponding to different owner numbers exhibit different patterns of survival, however further tests are required to determine whether the difference is statistically significant (Hosmer *et al.,* 2008). The most frequently used test is commonly referred to as the '*log-rank test'*, which is based on the Mantel-Haenszel log-rank test. However, other variations, based on the weights that the tests apply to the j^{th} failure time, exist[89]. The test statistics obtained from performing the Mantel-Haenszel and the Gehan-Breslow statistic with the Peto and Peto modification (denoted G-B Peto & Peto) are presented in Table 5.5[90].

Tests	Chi Square	DF	P-value
Mantel-Haenszel (Rho=0)	1523	3	<0.00001
G-B Peto & Peto (Rho=1)	1631	3	<0.00001

Note: According to R documentation on the function survdiff used to calculate the above test statistics, the function is based on G-rho family of Harrington and Fleming (1982).

Table 5.5. Survival Probability by Owner Number – Log-rank test and variations

Together, the Kaplan-Meier estimator (Figure 5.11) and the results from the log-rank tests (Table 5.5) indicate that the survival curves corresponding to different owner numbers are statistically different. The survival curve corresponding to first owner is the one that stands out the most in Figure 5.11 as the probability of a vessel remaining with the first owner is noticeably higher at all times. First owner periods are the most complex ones to analyse based on the presence of not only censored observations but also complete observations that include single owner vessels as well as multiple owner vessels. Because of this phenomenon first owner periods have been the focus of more a rigorous analysis as provided below.

b) Estimation of the individual effect of ship characteristics – first owner

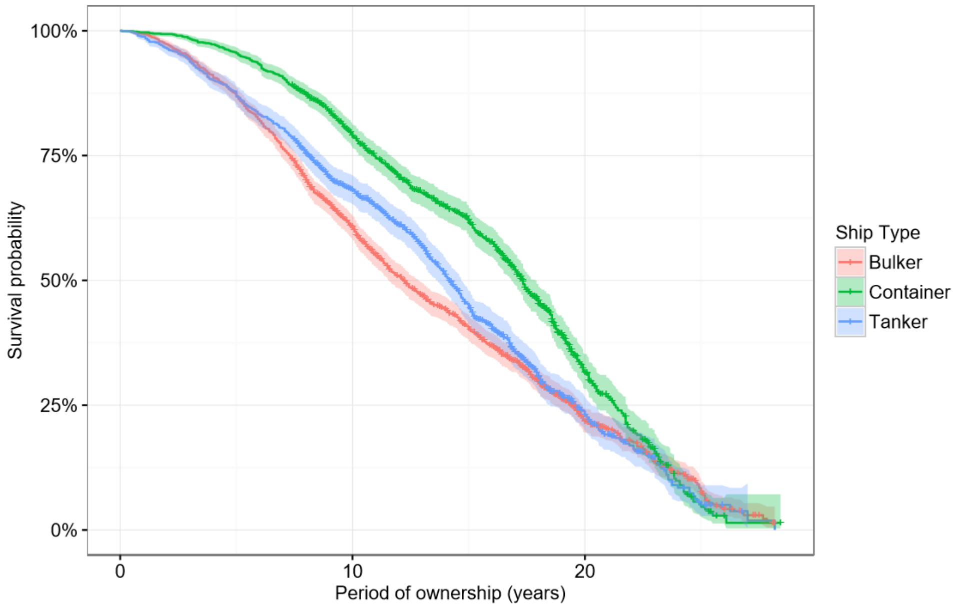
As discussed earlier in Section 5.2, there is evidence from previous studies that periods of ownership, apart from owner number, vary also by ship type and size (Stott, 2013). Therefore, the following section is dedicated to exploring how these characteristics, as well as other variables included in the ship level data, might affect periods of ownership. The following ship level characteristics, however, have been omitted from the following analyses: cargo specialisation, speed and fuel consumption. The main reasons for this include: (i) lack of evidence regarding a significant effect on periods of ownership, (ii) limited sample size, and (iii) a strong

[89] The most popular variations of the log-rank test are discussed in Chapter 3, Section 3.3.2.b).
[90] Pairwise comparisons of survival by owner number can be found in Data Annex Chapter 5, section 2.

relationship with other characteristics. The estimated survival curves of these omitted characteristics and a more detailed discussion on the decision to omit them from subsequent analyses can be found in Data Annex Chapter 5, section 3.

Ship Type

According to the Kaplan-Meier plot container vessels appear to be less likely to be sold by the first owner at almost any given time (Figure 5.12). Bulkers and tankers seem to have relatively similar survival probabilities (Figure 5.12). Descriptive statistics such as the number of records, events and the median survival as well as the survival probabilities at years 10, 15 and 20 according to ship type are presented in Figure 5.12. Judging by the survival curves, bulkers are the most likely ones to experience the event on average, followed by tankers and containers respectively.



Type	Records	Events	Median	CI	Survival Probability by Time (years)		
					10	15	20
Bulker	1658	1244	12.2	11.6 - 12.8	0.61	0.41	0.22
Container	1212	718	17.3	16.8 - 17.9	0.79	0.62	0.32
Tanker	1038	688	14.2	13.7 - 14.7	0.68	0.45	0.23

Figure 5.12. Survival Probability by Ship Type, 1st owner period – Kaplan-Meier

The test statistics obtained from performing the Mantel-Haenszel and the G-B Peto and Peto tests are presented in Table 5.6. Although bulkers and tankers appear to have similar survival curves, according to the log-rank tests performed (P-value <0.00001), the three ship types' survival curves are statistically different. This is an indication that the probabilities to remain with the first owner corresponding to the three ship types are statistically different. If the estimated survival curves cross, however, this serves as an indication that the proportional hazards assumption might be violated. In such cases, the tests designed to estimate whether the difference between groups is statistically significant or not, might have low validity (Hosmer *et al*., 2008, p. 59).

Tests	Chi Square	DF	P-value
Mantel-Haenszel (Rho=0)	78.1	2	<0.00001
G-B Peto & Peto (Rho=1)	131	2	<0.00001

Table 5.6. Survival Probability by Ship Type, 1st owner – Log-rank test and variations

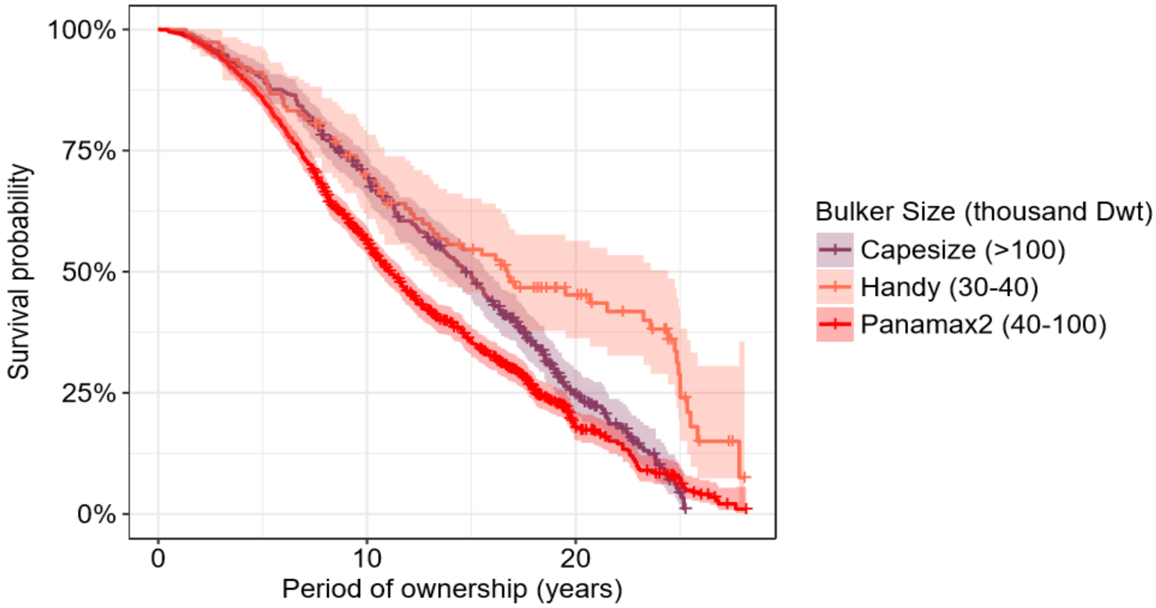
Crossing survival curves, and the implications the phenomenon might have on the proportional hazards assumption, is a topic that has received considerable attention by researchers and medical professionals over the years (Hosmer *et al*., 2008, Schemper, 1992, 1999, 2009; Allison, 2010; Bouliotis and Billingham, 2011)[91]. However, as the purpose of this research is to establish whether certain characteristics affect periods of ownership, the fact that the survival curves for certain ship characteristics cross is recognized, but the results from the log-rank tests are reported nevertheless, as potential violation of proportional hazards will be explored in more detail later in this and following chapters in relation to the results from the final models.

Ship Size

The original ship size categories[92], assigned to vessels during the data preparation phase for all ship types were used at first to generate the estimated survival curves. However, it was established that some of the original size categories behave in a very similar manner in terms of first owner periods (see Data Annex Chapter 5, section 4). In order to highlight the differences in survival of ships according to their size, various size combinations have been tested (Data Annex Chapter 5, section 4). The results reported here are based on the empirically re-assigned size categories as the main purpose of the following section is data exploration. In the case of bulk carriers, it appears that vessels classified by the data providers as Handymax (40-60,000 dwt) behave similarly to Panamax ships (60-100,000 dwt), which led to combining the two categories under '*Panamax2*' (40-100,000 dwt). This re-grouping led to the classification presented in Figure 5.13. According to Figure 5.13, middle-sized bulkers (40-100,000 dwt) have the lowest median survival at 11.1 years and are more likely to

[91] For more detailed discussion on crossing survival curves see Chapter 3, section 3.3.2.b).
[92] The originally chosen ship size categories are presented and discussed in Chapter 4, section 4.3. Variable Definition, sub-section 4.3.1. Ship Level – b) Ship Size.

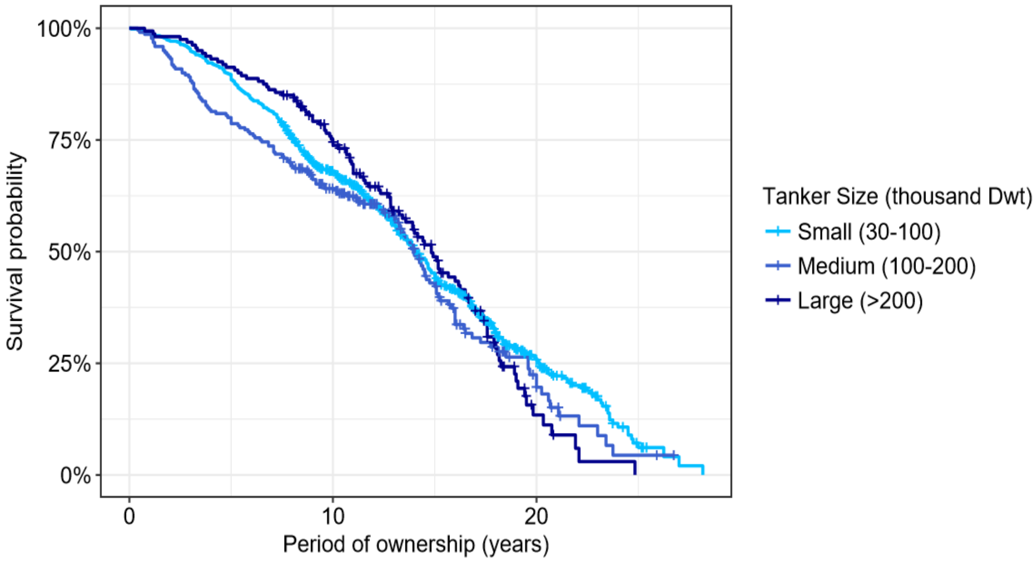
be sold by the first owner at any given time than ships from the other two categories. Capesize bulkers are kept generally longer than the middle-sized bulkers. The most interesting finding is that small Handy bulkers (30-40,000 dwt) behave similarly to Capesize vessels (the largest dry bulk type of vessel) until year 12, after which their probability of remaining with the first owner is remarkably higher than the survival probabilities of the rest of the bulkers. Generally speaking, smaller vessels have a longer economic life, therefore their average scrapping age is higher than that of bigger vessels (see Data Annex Chapter 4, section 1).



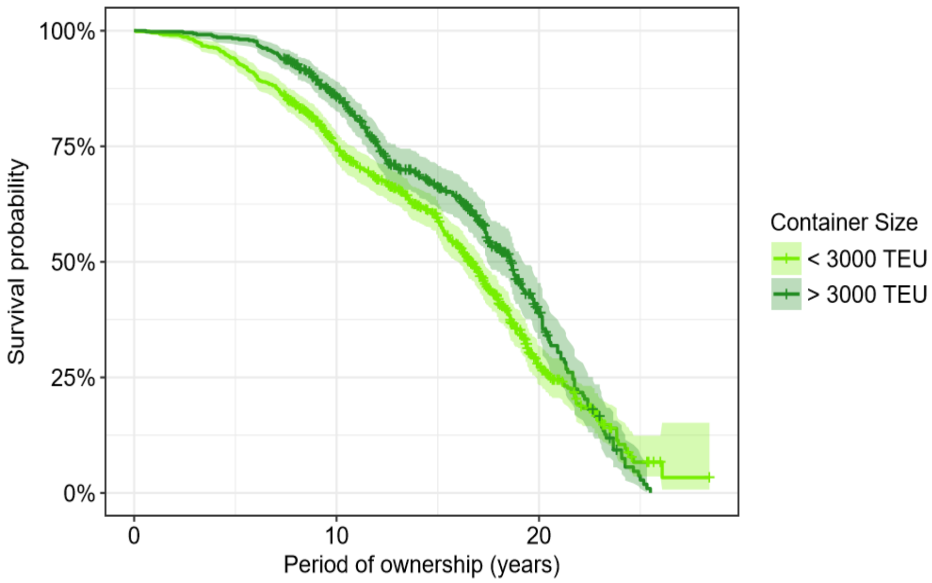
Bulkers .000 dwt	Records	Events	Median	Tests	
				Mantel-Haenszel	G-B Peto & Peto
Handy (30-40)	113	70	16.7	p=2.77e-09	P=1.88e-08
Panamax2 (40-100)	1109	845	11.1		
Capesize (>100)	436	329	14.7		

Figure 5.13. Survival Probability by Ship Size – Bulkers, 1st owner period – Kaplan-Meier

Due to the fact that the analysis on periods of ownership on ship level does not distinguish between a change of ownership and the vessel being sold for scrap as the event of interest is defined in both cases as termination of ownership, it is possible that the longer economic life of smaller vessels has an impact on the observed results. In the case of bulk carriers this could be a potential explanation for the difference between Handy and Capesize bulkers, but it would not explain the difference between Handy and Panamax bulkers as both categories have a very similar average scrapping age (Data Annex Chapter 4, section 1). Figure 5.14 reviews the survival probabilities of tanker and container ships based on aggregated size categories.



Tankers	Records	Events	Median	Tests	
				Mantel-Haenszel	G-B Peto & Peto
Small (30-100)	658	442	14.1		
Medium (100-200)	220	139	14.0	p=0.108	P=0.266
Large (>200)	160	107	14.8		



Containers	Records	Events	Median	Tests	
				Mantel-Haenszel	G-B Peto & Peto
<3000 TEU	733	461	16.6	P=0.00462	P=0.00005
>3000 TEU	478	256	18.6		

Figure 5.14. Survival Probability by Ship Size – Tankers and Containers, 1st owner period – Kaplan-Meier

The difference between the survival curves of tankers in terms of size is not significant based on the log-rank tests but the results were included as the size categories for tankers resemble those for bulkers. Large vessels were found to have higher survival probability until year 15 but shortly after small vessels' probability of remaining with the first owner surpasses the ones corresponding to the other two tanker size categories.

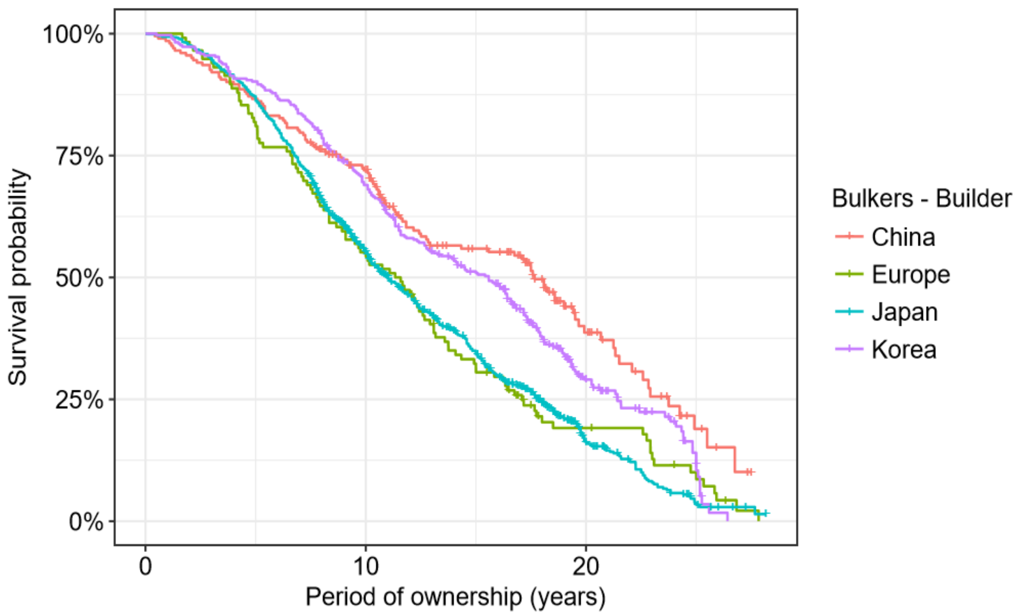
In terms of container vessels, the difference between the survival curves of small containers (<3,000 TEU) and large containers (>3,000 TEU) seems to be significant with larger vessels remaining with the first owner longer (Figure 5.14).

Builder area

The nationality aspect on ship level is represented by the country or area where the ship was built[93]. A review of the data on periods of ownership corresponding to bulk carriers in relation to builder area reveals that European and Japanese-built bulkers have a lower probability of remaining with their first owner than Korean and Chinese-built ones (Figure 5.15).

However, based on the position of the survival curves presented in Figure 5.15, further tests were conducted (Data Annex Chapter 5, section 4.2) that suggest that there is a certain similarity between the survival probabilities of European and Japanese-built bulkers as well as between Korean and Chinese-built bulkers. This result is interesting given that Japanese and European ships are traditionally regarded as higher quality assets so one would assume that owners, especially dedicated operators, would tend to keep the vessels that are easier to maintain. However, the counter argument is that such vessels also have higher resale value, thus presenting an opportunity for asset play. Furthermore, it is likely that the type of company owning the ships might also have an effect as there are large shipping corporations with substantial fleets in Asia, often backed by state interests, whose main purpose is often linked to servicing their domestic needs. It should also be noted that European-built bulkers constitute only 7% of the whole sample, a relatively small number, which will decrease even further when any further stratification is applied.

[93] The distribution of vessels based on builder nationality is reviewed in Chapter 4, section 4.3.1.c).



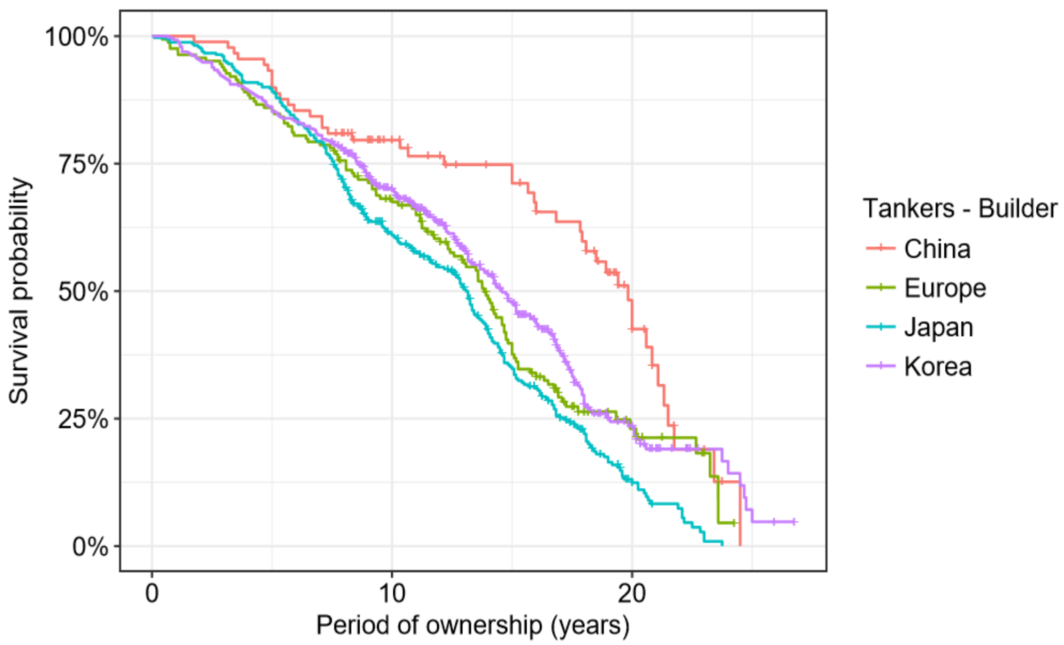
Bulkers	Records	% of Sample	Events	Median	Tests	
					Mantel-Haenszel	G-B Peto & Peto
China	202	13%	114	17.7		
Europe	116	7%	104	11.5	P=1.58e-11	P=2.07e-09
Japan	950	59%	740	11.0		
Korea	336	21%	246	15.6		

Figure 5.15. Survival Probability by Builder Area – Bulkers, 1st owner period – Kaplan-Meier[94]

Figure 5.16 shows the estimated survival of tankers according to where they were built.

In general, tankers built in Japan appear to have lower survival probability compared to ships built in other areas (Figure 5.16). European and Korean-built tankers exhibit similar survival probability, whereas Chinese-built tankers have the highest overall survival probability.

[94] Figure 5.15 explores only the survival probabilities of bulkers built in China, Europe, Japan and Korea (1604 ship records). The data on bulkers built in America and Asia (areas other than China, Japan and Korea) was not included as their combined sample size is too small (0.3%).

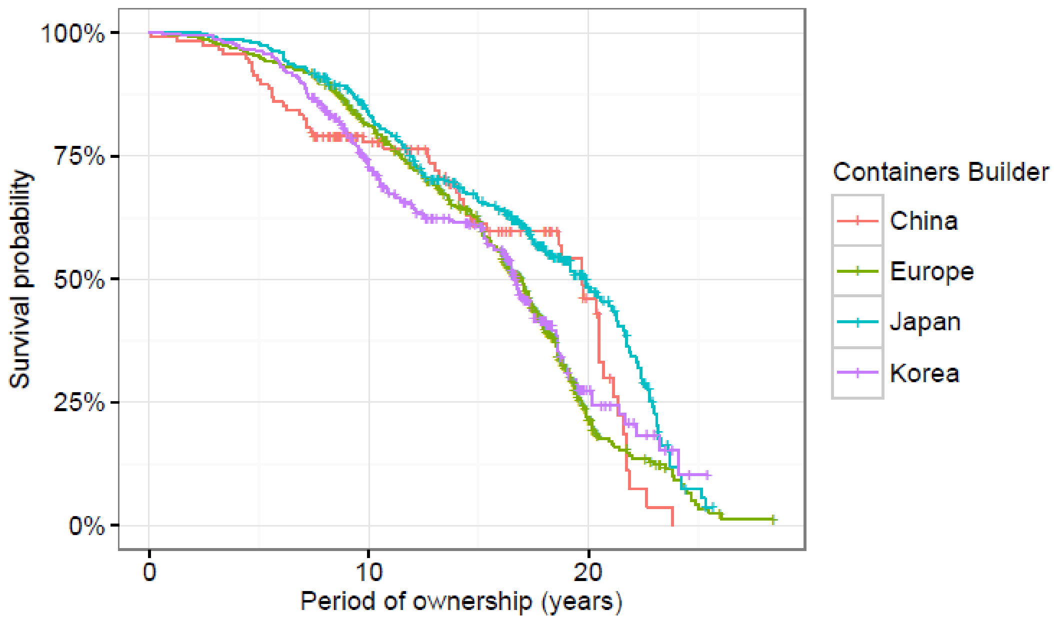


Tankers	Records	% of Sample	Events	Median	Tests	
					Mantel-Haenszel	G-B Peto & Peto
China	89	9%	44	19.8		
Europe	164	17%	117	13.8	P=4.28e-07	P=3.58e-05
Japan	330	34%	262	13.1		
Korea	391	40%	229	14.6		

Figure 5.16. Survival Probability by Builder Area – Tankers, 1st owner period – Kaplan-Meier[95]

In the case of containers, Chinese and Japanese-built ships seem to have higher survival probabilities followed by ships built in Europe and Korea in relation to first owner periods (Figure 5.17). According to the results based on all original and aggregated size categories[96], the trends highlighted in Figure 5.17 seem to be generally consistent. For example, Korean-built ships appear to be the most likely ones to experience termination of ownership while in the possession of the first owner. Chinese-built vessels generally tend to have very high probability of survival, however, the effect of the limited sample size of container ships built in China during the delivery profile of the sample (1987 - 2007) should not be ignored.

[95] Figure 5.16 explores only the survival probabilities of tankers built in China, Europe, Japan and Korea (974 ship records). The data on tankers built in America and Asia (areas other than China, Japan and Korea) was not included as their combined sample size is too small (0.06%).
[96] The originally chosen ship size categories are presented and discussed in Chapter 4, section 4.3. Variable Definition, sub-section 4.3.1. Ship Level – b) Ship Size. The aggregated size categories for containers are small (<3,000 TEU) and large (>3,000 TEU) as presented in Figure 5.11.



Containers	Records	% of Sample	Events	Median	Tests: Mantel-Haenszel	Tests: G-B Peto & Peto
China	114	10%	55	19.7		
Europe	459	39%	320	16.9	P=0.000282	P=0.000736
Japan	299	25%	166	19.9		
Korea	315	27%	166	16.7		

Figure 5.17. Survival Probability by Builder Area – Containers, 1st owner period – Kaplan-Meier[97]

Overall, there are similarities in the estimated survival patterns corresponding to tankers and bulkers. Japanese-built vessels are the most likely to experience termination of ownership on average, whereas Chinese-built ships are the least likely to be sold to a subsequent owner or a scrap yard by the first owner. In the case of container vessels, the differences in the survival of different groups of vessels based on builder area are not as distinctive.

It should be noted that the effect of builder area might act as a proxy for company level characteristics, such as company type and owner nationality, which will be explored in later chapters.

Delivery Year

The effect of delivery year should be considered as it controls for calendar time in the analyses of periods of ownership. In order to investigate the effect of delivery year on

[97] Figure 5.13 explores only the survival probabilities of containers built in China, Europe, Japan and Korea (1187 ship records). The data on containers built in America and Asia (areas other than China, Japan and Korea) was not included as their combined sample size is too small (0.02%).

periods of ownership, the delivery profile of the vessels included in the sample is organised into delivery cohorts. The delivery profile (1987-2007) is split into two 10-year intervals in order to investigate whether any broad trends can be identified. Figure 5.18 presents the survival probabilities by delivery cohorts comprised of vessels built between: (i) 1987-1996 and (ii) 1997-2008.

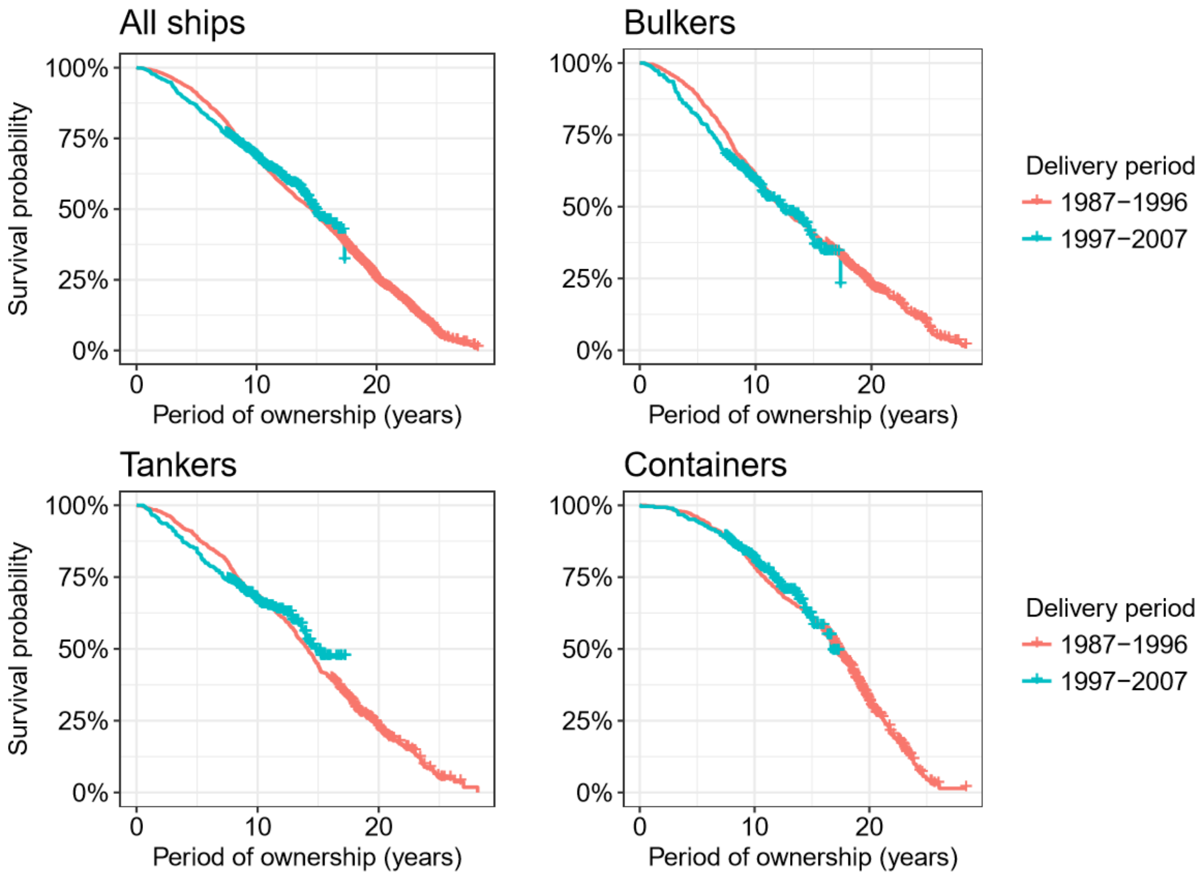


Figure 5.18. Survival Probability by Delivery period –1st owner period – Kaplan-Meier

Although the difference between the survival curves of vessels from the two broad delivery cohorts is not striking, there is evidence that the effect of delivery year might vary across segments.

The section on estimating survival probabilities based on period of ownership data corresponding to the first owner aimed at introducing the main ship characteristics, which are postulated to influence periods of ownership. The graphical display of survival curves complemented by the statistical tests designed to quantify the differences between various groups within each variable, such as comparing different ship sizes for example, constitute the exploratory analysis, which is the first step of the model building process.

However, the main drawback of the Kaplan-Meier estimator is the fact that it could be used to estimate the effect of one variable at a time. In order to consider the effects of multiple variables on the probability of a vessel experiencing the event of interest, a regression model needs to be employed. The type and specification of the model employed in this chapter is presented in the following section.

c) Results by Ship Type – first owner

The preferred model for investigating the effects of ship characteristics on the period of ownership is the Cox proportional hazards (Cox PH) model, discussed in Section 3.3.2.

Earlier in this chapter, the survival probabilities of vessels were examined based on the individual effects of a range of ship characteristics. In this section, the effect of all ship characteristics on first owner period is investigated simultaneously. The Cox model presented below is based on the main ship characteristics presented in Table 5.7. The aim of the model is exploratory; therefore it is referred to as the '*main effects Cox model*' for first owner period. The main effects Cox model aims to provide an overall idea of the effect of the chosen covariates before the analysis is stratified further and to familiarise the reader with the basic rules for the interpretation of the Cox models' output. The Cox PH model has been generated with the function *coxph* available in the '*survival*' package[98]. As the idea of the main effects model is just to provide an indication of which of these characteristics should be investigated further when the model is stratified, none of the numeric covariates listed in Table 5.7 - ship size and delivery year - were grouped to represent certain categories.

	Covariate	Levels	Records	Events
Factor	Ship Type	Bulker (base)	1658	1244
		Container	1212	718
		Tanker	1038	688
	Builder Area	Japan (base)	1579	1168
		China	405	213
		Europe	739	541
		Korea	1042	641
		Other	143	87
Numeric	Ship Size (as DWT)	NA	3908	2,650
Integer	Delivery Year	NA	3908	2,650

Table 5.7. List of Covariates – Main Effects Cox Model – 1st owner

98 '*survival*' package, version 2.40-1.

There are several established methods for handling tied survival times, namely the Breslow, the Efron and the '*exact'* method[99]. The default method in the coxph function used for generating the main effects Cox PH model is the Efron method.

The main effects Cox PH model on ship level specifies the hazard at time *t* for each subject as a function of the covariates listed in Table 5.7. The output of the main effects Cox PH model on ship level is presented in Table 5.8. The first column in the output (*Coef (β)*), refers to the linear predictor (β) corresponding to each covariate and is hereinafter referred to as '*coefficient*'. If the coefficient is negative, it means that one-unit increase in the covariate reduces the hazard or the probability of the subject experiencing the event for numerical variables. In the case of categorical covariates, a negative coefficient means that the factor level in question represents a category, which is less likely to experience the event than the chosen baseline category. The second column in Table 5.8 refers to the exponential values of the linear predictors, which are interpreted as multiplicative effects on the hazard.

Covariate	Coef (β)	Exp(coef)	Se(coef)	Z	Pr(>|z|)	Lower .95	Upper.95
Ship Type (base: Bulker)							
Container	-0.464	0.629	0.052	-8.756	<2e-16***	0.566	0.697
Tanker	-0.031	0.969	0.049	-0.634	0.526	0.879	1.067
Builder Area (base: Japan)							
China	-0.512	0.598	0.075	-6.836	8.16e-12***	0.517	0.693
Korea	-0.237	0.788	0.050	-4.723	2.32e-06***	0.714	0.870
Europe	-0.027	0.972	0.056	-0.497	0.619	0.870	1.085
Other	-0.540	0.582	0.114	-4.737	2.17e-06***	0.465	0.728
DWT	-0.003	0.996	0.004	-1.158	0.247	0.990	1.002
Delivery Year	0.003	1.003	0.004	0.767	0.443	0.994	1.012
Concordance = 0.588 (se = 0.006)				Likelihood ratio test = 168.7 on 9 df, p=0			
n= 3908, number of events= 2650				Wald test = 161 on 9 df, p=0			
				Score (logrank) test = 163.3 on 9 df, p=0			

* Signif. codes: 0='***'; 0.001='**'; 0.01='*'; 0.05='.' ;0.1=' '

Table 5.8. Main Effects Cox PH Model – 1st owner

A unit increase in deadweight, which in this case is 10,000 tonnes, reduces the hazard of the ship experiencing the event of termination of ownership by a factor of 0.996 (*Exp(coef)* for DWT) on average. Based on the above, larger vessels are 0.4% less likely to be sold[100] on average, however, the difference is not statistically significant

[99] For a detailed discussion on the Efron, Breslow and the 'exact' method refer to Chapter 3, section 3.3.2. b).

[100] The event of interest is the termination of ownership, which could be represented by a sale to another owner or to a scrap yard. However, for convenience and brevity's sake, results on probabilities regarding termination of ownership are reported as the probability of sale, i.e. vessels that are less or more likely to be sold.

(P-value=0.247). The coefficients for delivery year are positive, which indicates that a unit increase (1 year) results in a higher likelihood that a vessel will experience the event. However, just as in the case of size, the difference is not statistically significant (P-value=0.443). The column denoted as '*Se(coef)*' presents more information on the standard errors associated with the coefficients. In order to test the null hypothesis, that the linear predictor (β) is 0 or that the exponential of the sum of $\beta_i X_i$ is 1 respectively, most statistical packages use Wald Z-tests by default (Vittinghoff, 2005). The Z-statistics and associated P-values for the main ship level covariates are presented in the columns titled *Z* and *Pr(>|z|)* respectively, whereas the last two columns represent the lower and upper limit of the confidence intervals corresponding to the exponential coefficients.

Based on the description of the main effects Cox PH model output, presented in Table 5.8, it appears that the hazard of a container ship experiencing termination of ownership is about 63% of the hazard of bulker carriers experiencing the event. Tanker vessels seem to be less likely to experience the event on average than bulkers but the difference between these ship types is not statistically significant (P-value=0.52). Further investigation confirms that tankers are also significantly more likely to be sold than containers[101].

The results regarding builder area suggest that Japanese built ships are the most likely to experience the event, followed by European-built ships and Korean-built ships. Ships built in China and in areas, grouped under '*Other*' (America and the rest of Asia), are the least likely to be sold. For example, the hazard of a vessel built in China experiencing the event is about 60% of the hazard of a vessel built in Japan experiencing the same event, age for age.

The summary output provides also the P-values corresponding to three alternative tests, designed to check the validity of the '*omnibus'* null hypothesis (Fox and Weisberg, 2011) stating that the covariates have no effect on survival; namely the likelihood ratio test, the Wald test and the score (logrank) test. The tests render similar results given a large enough sample size. As they are asymptotically equivalent, often only the P-value for the likelihood ratio test is presented. In the case of the main effects model, presented in Table 5.8, all three test statistics agree and therefore the null

[101] The results comparing container vessels (baseline) with bulkers and tankers are presented in Data Annex Chapter 5, section 5.1.

hypothesis that the covariates included in the model do not affect the probability of termination of ownership, is rejected. The main effects Cox PH model corresponding to periods of ownership for first owner, presented in Table 5.8, is a simple additive model where no interactions have been considered and model fit has not been formally discussed. The aim of including the output of this generalised model, however, is two-fold: (i) to introduce the Cox PH model; and (ii) to familiarise the reader with the general interpretation of the output of a Cox PH model. Although the difference between the effects of the three ship types is only significant when comparing containers to bulkers and tankers according to the main effects Cox model (Table 5.8), there is a natural segregation of the market based on ship type[102]. In the interest of clarity, three separate models were developed based on each ship type considered in this study in order to capture any significant effects on periods of ownership within each main sector of the shipping industry.

All model outputs and relevant model diagnostics referring to first owner data can be found in Data Annex Chapter 5, section 5.

Bulkers – first owner

The following section aims at examining the effects of different ship level covariates on first owner period within the bulker segment of the fleet. The Cox model used to estimate these effects is herein after referred to as the Bulkers Cox PH model for first owner or simply '*Bulkers-1st owner model'*. Table 5.9 presents a list of the covariates considered for this stage of the analysis. The data on delivery year is split into five categories as a bias reducing method since in the case of first owner the range of periods of ownership is the widest (Seppa and Hakulinen, 2009). The split is arbitrary – based on 5-year delivery cohorts, however the youngest vessels in the sample were split into two additional categories (2002-2004 and 2005-2007) in order to separate the vessels delivered before and after the start of the shipping boom of 2003-2008. The split year is 2004 to account for the back log of shipbuilding orders. The covariates were first analysed on a univariate level, followed by the chosen model building procedure[103] incorporating purposeful selection as described by Hosmer and Lemeshow (2008) in relation to AIC[104]. According to the analysis on a univariate level,

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[102] The main ship types and inherent differences are discussed in Chapter 2, section 2.2.2.a).

[103] For more information on the chosen model building process for this study and the model selection techniques used (such as RSF), see Chapter 3, section 3.3.2. b).

[104] AIC stands for 'Akaike Information Criterion' discussed in Chapter 3, section 3.3.2.b).

all ship level covariates, described in Table 5.9 have a significant effect on first owner period within the bulker segment (at 0.05 level).

Covariate Type	Covariate	Levels	Records	Events
Factor	Ship Size	Handy (30-60 000 dwt)	657	476
		Panamax (60-100 000 dwt)	565	439
		Capesize (>100 000 dwt)	436	329
	Builder Area	Japan	950	740
		China	202	114
		Europe	116	104
		Korea	336	246
		Other	54	40
	Delivery Period	1987-1991	442	413
		1992-1996	679	532
		1997-2001	267	181
		2002-2004	136	72
		2005-2007	134	46

Note: The data on bulkers built in America and Asia (areas other than China, Japan and Korea), usually presented under the category named 'Other', was not included in the model as the sample size is too small (3%).

Table 5.9. List of Covariates - Bulkers - 1st owner

The optimal multiplicative model identified was then analysed with the help of techniques from the classification and regression trees (CART) family under the form of '*random survival forests*' (RSF) in order to substantiate the choice of covariates. The minimal depth, a high dimensional measure of the effect of covariates, is estimated for the covariates included in the optimal model in order to validate the choice of covariates (Figure 5.19).

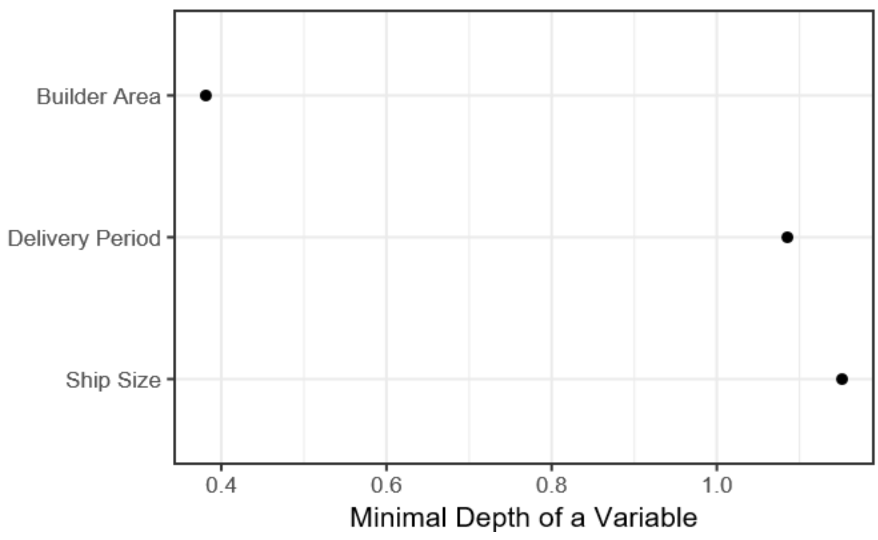


Figure 5.19. Minimal Depth - Bulkers - 1st owner

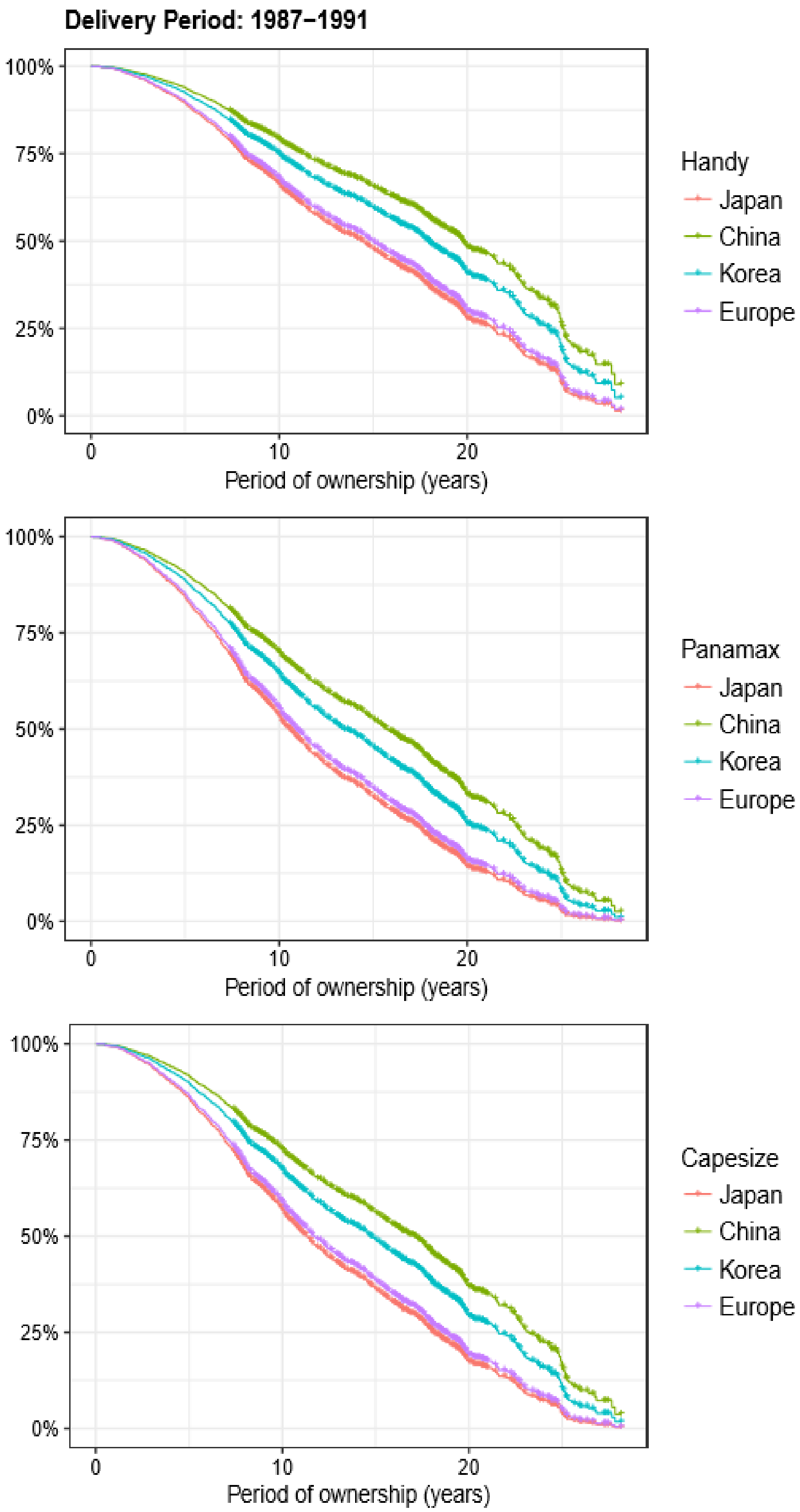
According to the results from the random survival forests algorithm presented in Figure 5.19, all the covariates included in the final model – builder area, delivery year and ship size, are significant[105]. These results are a product of the log-rank splitting rule applied to 10,000 survival trees.

The main findings from the Cox PH model for bulkers corresponding to first owner period, Bulkers-1st owner, are presented visually with the help of predicted survival curves, which show the probability of survival of vessels, similar to the Kaplan-Meier plots reviewed earlier. However, the predicted survival curves[106] show the probability of survival based on the effect of all the covariates included in the model under investigation. These curves allow for the comparisons between the predicted survival probabilities for specific categories such as a Chinese-built Handy bulkers delivered in the period 1987-1991 compared to the ones built between 1997 and 2001. Figure 5.20 highlights the probability of bulkers built in the period 1987 to 1991 remaining with the first owner based on ship size and builder area.

There is no significant difference between European and Japanese-built bulkers in the early 1990s regardless of ship size. On average, Chinese-built bulkers are the least likely to be sold by the first owner, whereas bulkers built in Japan are the most likely ones to be sold (Figure 5.20). This is somewhat surprising given China's ship-building reputation compared to the rest of the Asian countries. This phenomenon will be investigated further when company level data is added to the model as it is possible that the majority of the Chinese-built ships in the sample are owned by Chinese companies backed by state interests, dedicated to serving their domestic trade and thus the vessels are rarely traded speculatively. A potential explanation regarding the low probability of survival of Japanese-built bulkers, apart from the effect of company type and size, is the generally higher resale value of Japanese-built ships which might encourage shipowners, tempted by the idea of profit generation through trading assets, to sell.

[105] In the case of models containing non-significant covariates a vertical dashed line representing the statistical significance threshold appears in the plot area and separates significant from non-significant covariates. As a rule of thumb, the closer the dot representing a covariate is to the left vertical axis, the more significant the covariate's effect is.

[106] Predicted survival curves are sometimes referred to as adjusted survival curves in the literature. However, according to some this is not accurate when referring to the average survival of a specific group of records (Therneau *et al.*, 2015).



Note: Overlapping survival curves – Japan and Europe.

Figure 5.20. Predicted Survival Curves by Ship Size - Bulkers Cox PH model - 1st owner

Amongst all bulkers built between 1987 and 1991, Handy bulkers are the least likely ones to be sold on average, followed by Capesize bulkers. Panamax bulkers are the most frequently traded type of bulker from the ones built between 1987 and 1991. Delivery period as a covariate was found to have an effect in the Handy bulker category with Handy bulkers delivered at a later stage of the delivery profile of the sample being more likely to be sold age for age. This change in the survival of Handy vessels is clearly visible in Figure 5.21, which depicts the predicted survival curves of bulkers of different sizes within each builder area. The opposite is true of Capesize bulkers as the probability of sale of later Capesize vessels is lower than that of Capesize built earlier, age for age.

The data on bulkers built in America and Asia (areas other than China, Japan and Korea), presented under the category named '*Other*', was not included due to sample size limitations. Such vessels represent 3% of all bulkers and this number decreases with the stratification by bulker size.

To summarise the results from the Bulkers Cox PH model corresponding to first owner period, it appears that all the covariates described in Table 5.9, namely ship size, delivery year, and builder area; have a significant effect on periods of ownership corresponding to the first owner.

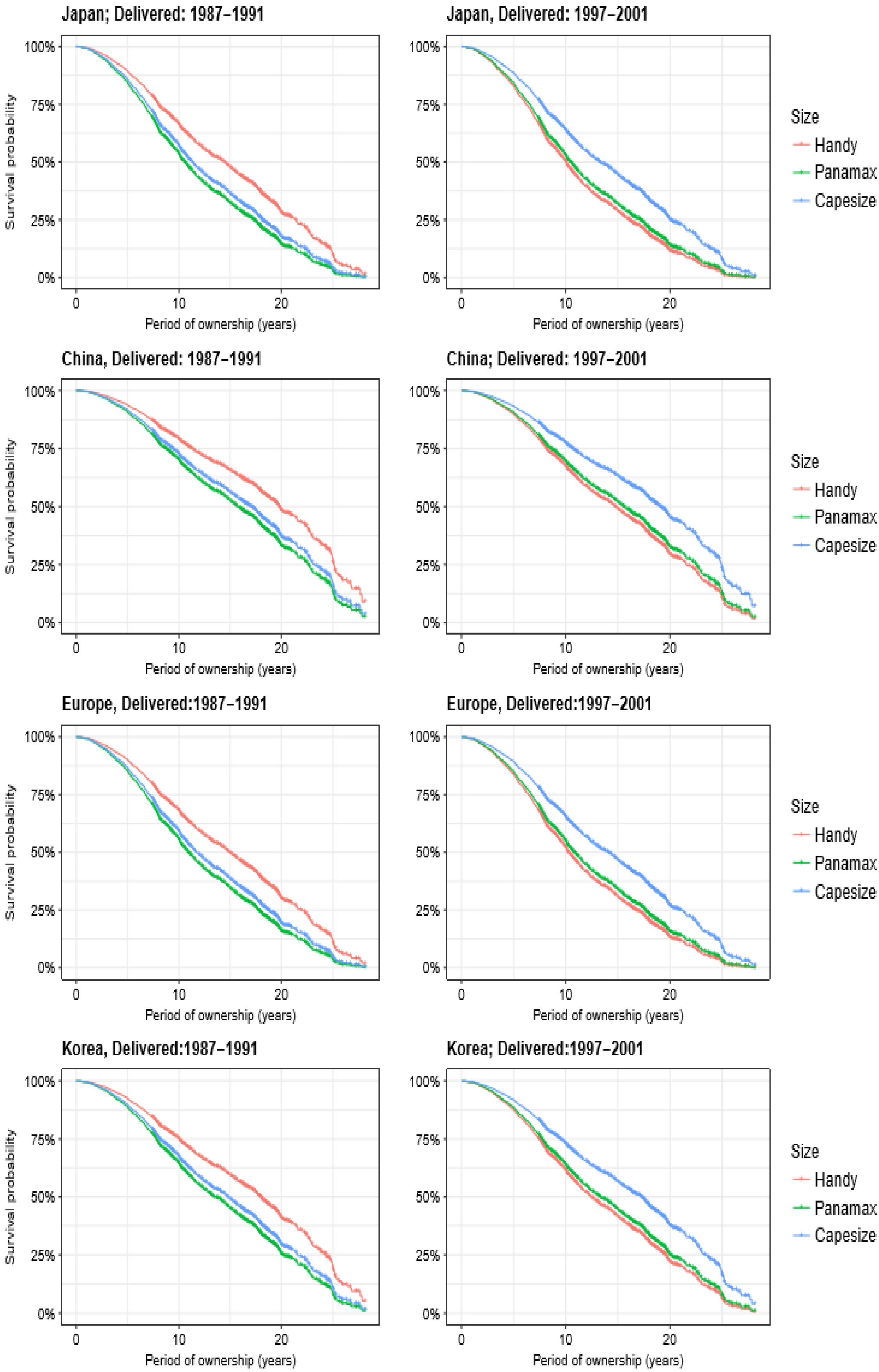


Figure 5.21. Predicted Survival Curves by Builder Area – Bulkers Cox PH model – 1st owner

Tankers – first owner

This section examines the effects of different ship level covariates on first owner period within the tanker segment of the fleet. The Cox model used to estimate these effects is hereinafter referred to as the Tankers Cox PH model for first owner or simply '*Tankers-1st owner model*'. The list of covariates included in the model is presented in Table 5.10.

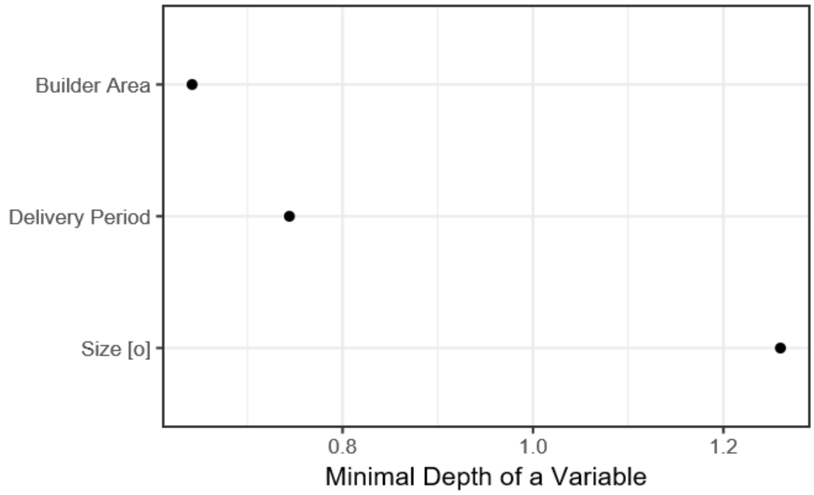
Covariate Type	Covariate	Levels	Records	Events
Factor	Ship Size	Handy (30-60 000 dwt)	427	264
		Panamax (60-100 000 dwt)	78	45
		Aframax (80-120 000 dwt)	258	194
		Suezmax (120-200 000 dwt)	115	78
		VLCC (>200 000 dwt)	160	107
	Builder Area	Japan	330	262
		China	89	44
		Europe	164	117
		Korea	391	229
		Other	64	36
	Delivery Period	1987-1991	246	237
		1992-1996	379	282
		1997-2001	152	88
		2002-2004	121	41
		2005-2007	140	40

Table 5.10. List of Covariates - Tankers - 1st owner

The data on delivery year of the vessels was divided into the same five categories adopted as part of the Bulkers-1st owner PH model, discussed earlier, as a bias reducing technique.

All three covariates described in Table 5.10 are found to have a significant effect on the probability of termination of ownership for tankers based on first owner period data. The optimal model was then analysed with the help of techniques from the classification and regression trees (CART) family under the form of '*random survival forests'* (RSF) in order to validate the choice of covariates.

Figure 5.22 presents the minimal depth scores of the covariates included in the model.



Note: The results are based on the log-rank splitting rule applied to 10,000 survival trees.

Figure 5.22. Minimal Depth - Tankers - 1st owner

Figure 5.22 confirms that each of the covariates included in the final Tankers-1st owner model have a significant effect on the period of ownership corresponding to first owner.

The probability of vessels remaining with their first owner increases for tankers built at a later stage of the delivery period regardless of size (Figure 5.23; Figure 5.24). The only exception to this rule are Panamax tankers, whose probability of survival drops significantly with the increase of delivery year (Figure 5.23).

In terms of the predicted survival of tankers according to builder area, large tankers have the highest predicted survival of all of the Japanese-built tankers (Figure 5.23). Chinese-built Handy and Aframax tankers have very high predicted survival. Panamax tankers built in Europe are the most likely tankers to be sold amongst all tankers built in the period 1997-2001, whereas Handy tankers built in Europe and China have very high survival probabilities.

It should be noted that some survival curves presented in Figure 5.23 and Figure 5.24 overlap, such as Chinese-built Handy and Aframax tankers delivered between 1987 and 1991. The survival probabilities of overlapping categories are similar, sometimes almost indistinguishable.

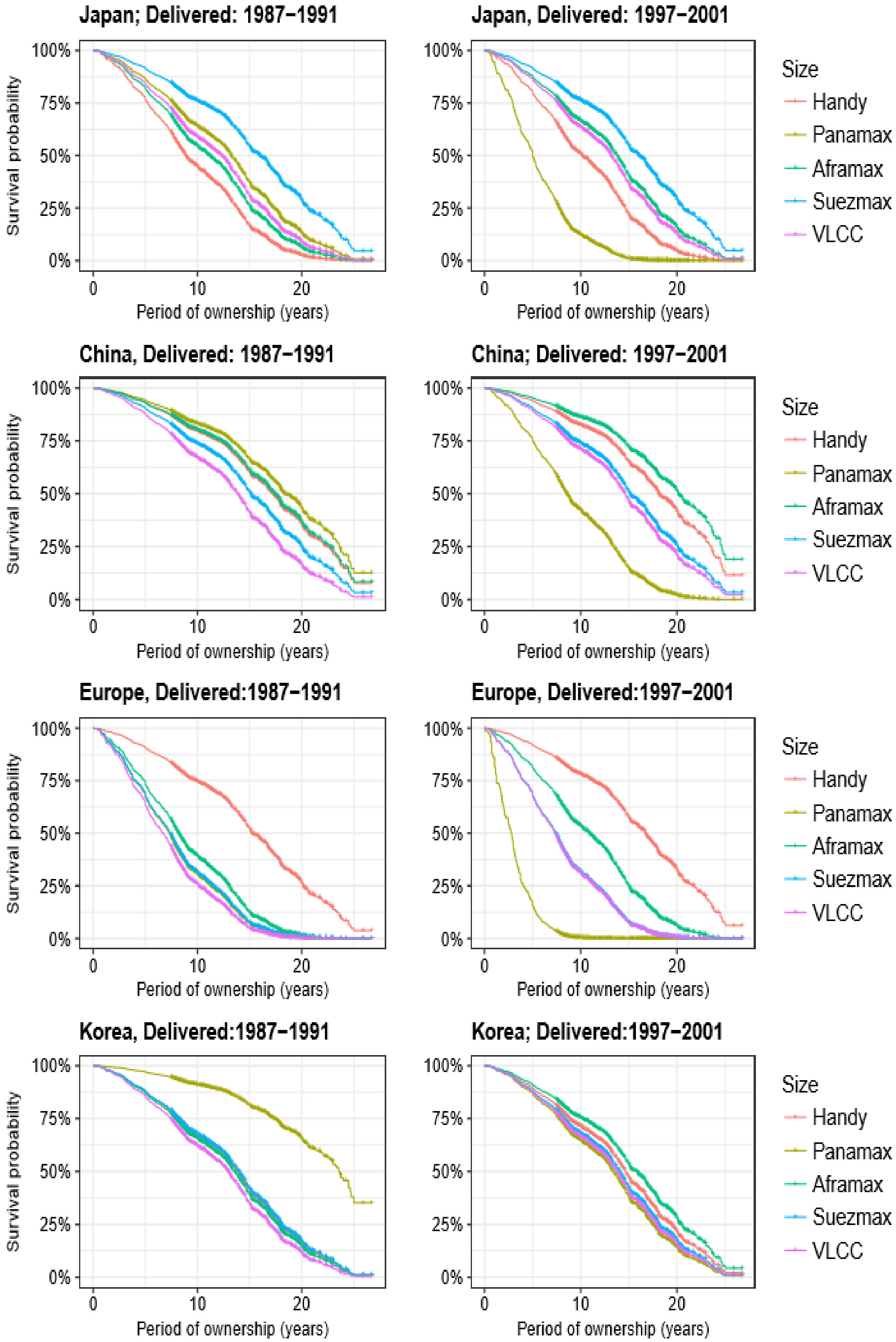


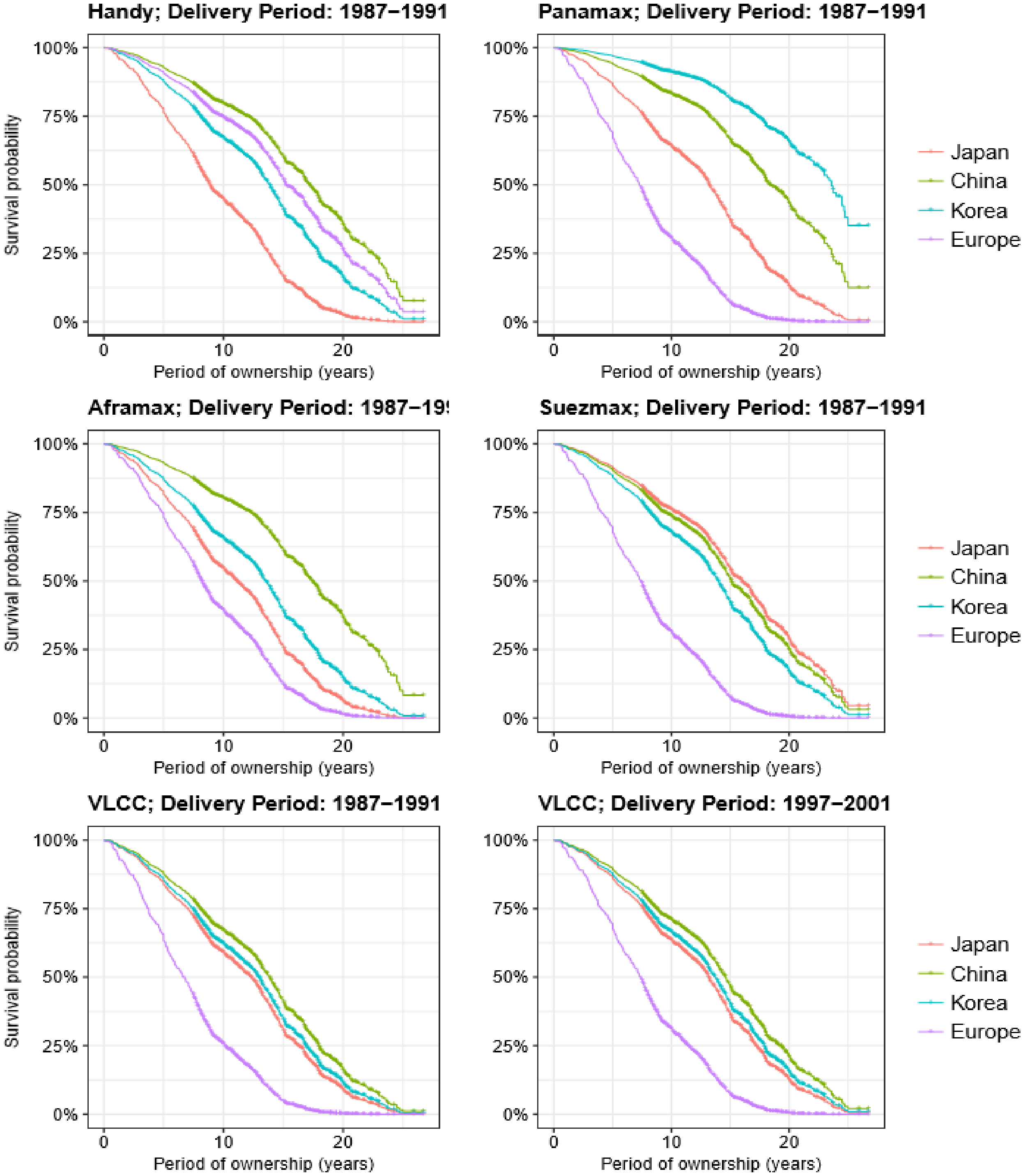
Figure 5.23. Predicted Survival Curves by Builder Area – Tankers Cox PH model – 1st owner

Chinese-built vessels have the highest survival probability on average. Korean-built tankers have a consistent and relatively high predicted survival, being equal to or slightly lower than that of Chinese-built tankers in most cases. Japanese and European-built tankers have the lowest predicted survival rates on average with Japanese tankers being the most likely ones to be sold in the smaller tanker categories (Handy, Panamax and Aframax), whereas European-built tankers seem to be the most likely ones to be sold in the Suezmax and VLCC tanker size categories (Figure 5.23).

It should be noted that the survival of European-built tankers is affected by the delivery year of the vessels and it increases with time in the smaller tankers' category. According to Figure 5.24 in the Handy tanker category, Japanese-built vessels are the ones at the highest risk of being sold by first owner and the rest of the builder area categories perform very similarly. In the Panamax and Aframax categories, tankers built in China and Korea follow a very similar trend and are significantly less likely to be sold than Japanese and European-built tankers on average. In the Suezmax and the VLCC categories, most builder areas perform very similarly and there are no significant differences between the survival probabilities of tankers built in China, Korea and Japan. However, European-built ships, as in most other size categories, are the most likely ones to be sold.

To summarise, according to the results from the Tankers-1st owner PH model all three covariates tested, namely ship size, builder area and delivery period, have a significant effect on the probability of termination of ownership by the first owner on average.

The global test designed to check whether the proportional hazards assumption is violated for the model as a whole, indicates that in the case of Tankers-1st owner PH model the proportionality assumption is not violated. However, there is evidence that the effect of certain covariates included in the model might vary with time, such as for the Suezmax tankers.



Note: Two different delivery periods are presented for VLCCs in order to illustrate the effect of delivery period.

Figure 5.24. Predicted Survival Curves by Ship Size – Tankers Cox PH model - 1st owner

Containers – first owner

The last ship type reviewed in terms of periods of ownership corresponding to first owner, are container vessels. The data is based on the ownership history of 1212 fully cellular containers. The list of covariates considered for the model is presented in Table 5.11.

Covariate Type	Covariate	Levels	Records	Events
Factor	Ship Size	Handy (1-2,000 TEU)	489	319
		SubPanamax (2-3,000 TEU)	220	132
		Panamax (3-4,000 TEU)	186	135
		PostPanamax (>4,000)	292	121
	Builder Area	Japan	299	166
		China	114	55
		Europe	459	320
		Korea	315	166
		Other	25	11
	Delivery Period	1987-1997	933	654
		1998-2003	114	31
		2004-2008	165	33

Table 5.11. List of Covariates - Containers - 1st owner

However, the builder category entitled '*Other'*, which includes vessels built in America and Asia[107], comprises only 25 records, which were excluded due to the limited sample size. The final dataset includes 1187 containers. The size categories for container vessels are based on the TEU capacity rather than on the deadweight capacity as it is a better measure of size in the container sector as discussed in Chapter 4, section 4.2.2.

Delivery period categories were devised from the delivery period categories used in the Bulkers and Tankers 1st owner PH models discussed earlier. However, as there is no difference between certain categories used in previous models, such as vessels built between 1987-1991 and vessels built between 1992-1997, these were pooled together (1987-1997) for efficiency and sample size considerations.

The covariates included in the final model are ship size, builder area and delivery period (Table 5.11). The model building and covariate selection procedures are a combination of: (i) exploring all the ship characteristics, which were postulated to influence survival, with the use of classical model building based on purposeful selection optimised with the help of AIC; and (ii) analysing the list of covariates to be included in the final model with the help of CART based techniques, namely random

[107] Countries other than China, Korea and Japan.

survival forests. The three covariates included in the final model are all significant according to their minimal depth score (Figure 5.25).

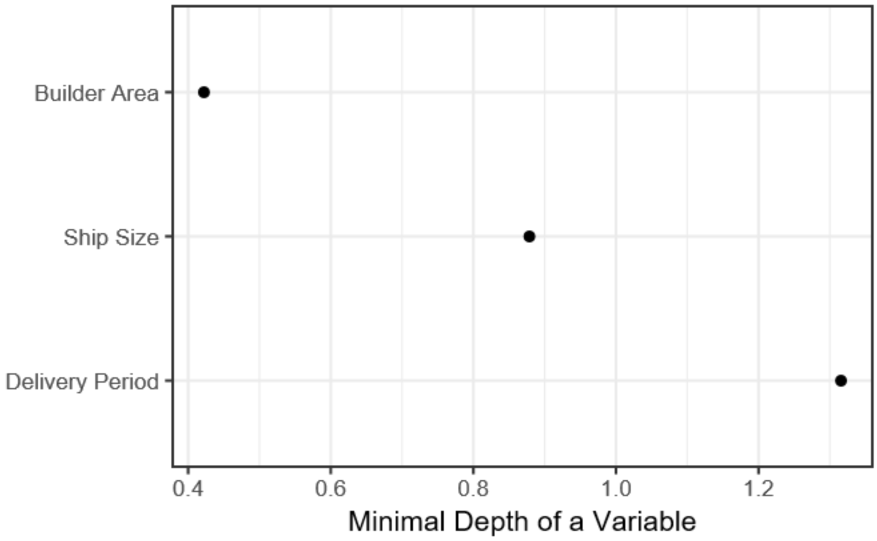


Figure 5.25. Minimal Depth - Containers - 1st owner

Predicted survival was found to increase with delivery period. Figure 5.26 depicts the predicted survival probabilities according to delivery period and how they vary by ship size for vessels built in a specific area. Generally, within the Handy containers category, the predicted probability of vessels to remain with their first owner decreases as vessels built at a later stage were found to be more likely to be sold by the first owner. However, in the Panamax and Post-Panamax categories, the effect of delivery period is the opposite and vessels built in the early 2000s are significantly less likely to be sold than similar ships built in the late 1980s. These trends, concerning the patterns of survival for vessels of different sizes built in the beginning or the end of the delivery period, are consistent within each builder area. Overall, Post-Panamax vessels exhibit the highest predicted survival on average, whereas Sub-Panamax and Handy containers are the most likely ones to be sold regardless of where they were built (Figure 5.26).

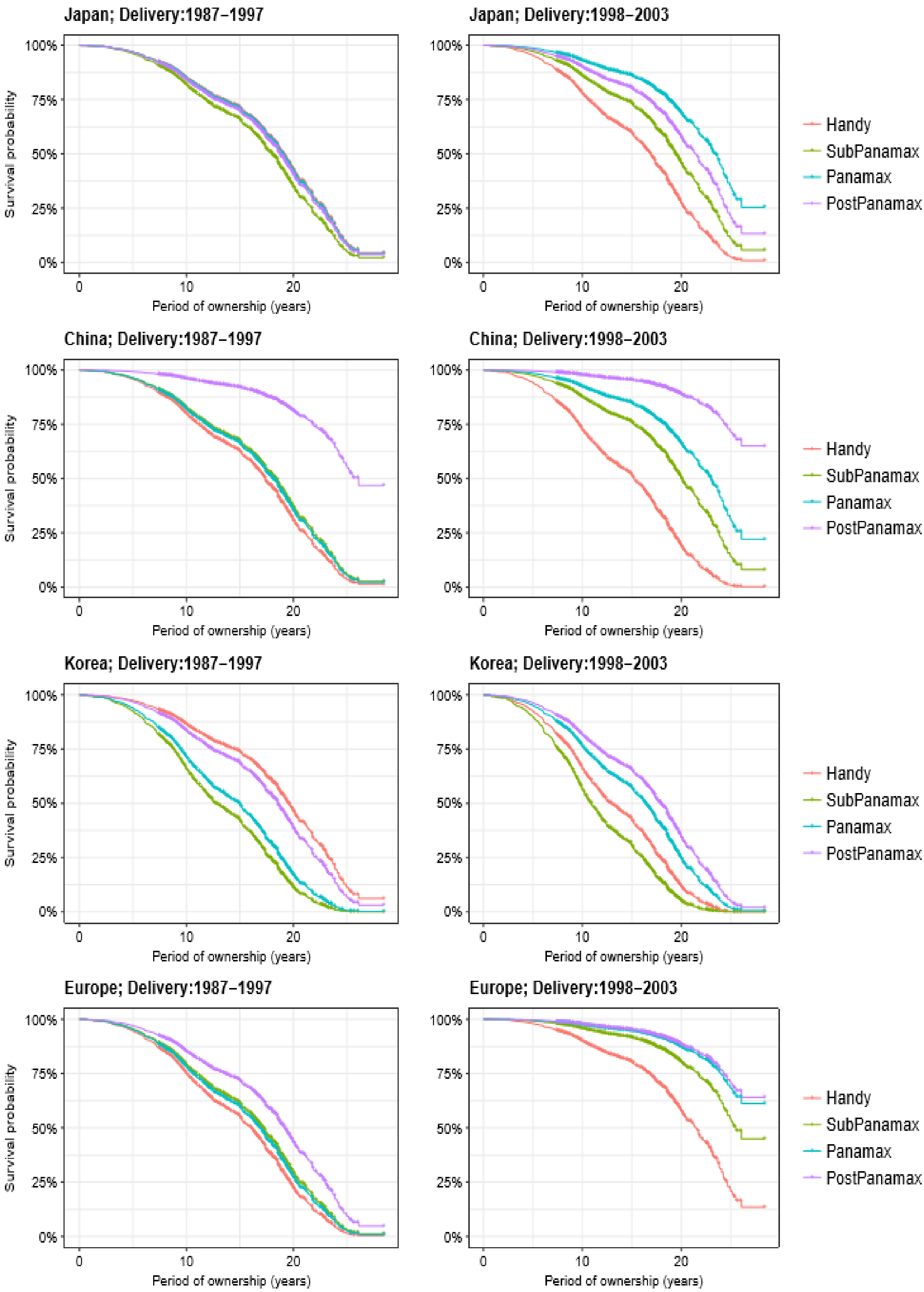


Figure 5.26. Predicted Survival Curves by Builder Area - Containers Cox PH model - 1st owner

Figure 5.27 presents the predicted survival of containers of different sizes based on builder area. As the effect of delivery year on survival has already been discussed in this section, only the predicted survival of ships built in the period 1987-1997 is presented in Figure 5.27. Amongst all Handy containers, Japanese and Korean-built ones are more likely to remain with the first owner for longer than the ones built in China or Europe. In the Sub-Panamax and Panamax categories, Korean-built ships are the most likely ones to be sold in comparison with ships built in any other area. In the Post-Panamax category, no real difference in the rate of the predicted survival can be detected between ships built in Japan, Korea and Europe. However, Chinese-built Post-Panamax container ships seem to have a much better survival probability.

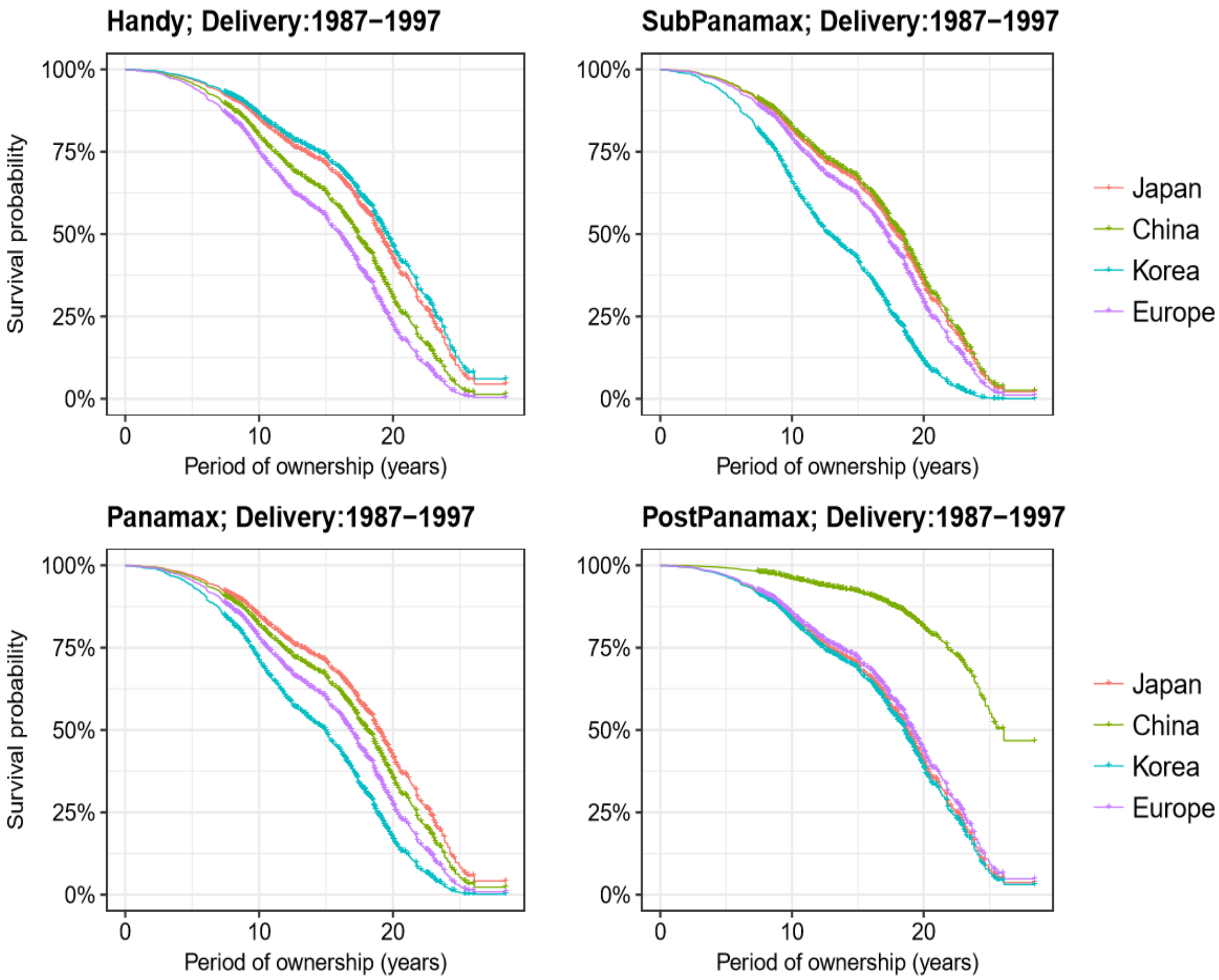


Figure 5.27. Predicted Survival Curves by Size - Containers Cox PH model - 1st owner

In the case of Container-1st owner PH model presented here, the proportionality assumption does not hold for European-built vessels. There is also evidence that the effect of ship size, in the Handy and Sub-Panamax categories, varies over time.

Although this means that the conclusions drawn with regard to the trends associated with the predicted survival for these three covariate levels might not be constant over time, there is no doubt that ship size and builder area affect the probability of sale of termination of ownership.

According to the results from the model, the predicted survival of European-built ships increases for vessels built during the period 1998-2003 and it decreases for vessels built during the period 2004-2008. It should be noted that the sample size of European-built containers delivered after the year 2000 is small. Another likely explanation might be the fact that Europe as a builder area is not as homogenous as the other three categories because it includes a number of different countries such as Germany, Poland, Italy, Denmark, Romania and others. This, coupled with a relatively small sample size, might be affecting the results.

To sum up, as a result of the analysis on periods of ownership, corresponding to the first owner, it was concluded that ship type has an effect on survival as container ships are significantly less likely to be sold by the first owner than are bulkers or tankers.

Upon stratifying the model by ship type it was concluded that the characteristics identified as having a significant effect on the survival of bulkers, tankers and containers in terms of first owner periods are ship size, delivery year and builder area.

5.3.2. Periods of ownership corresponding to second owner

a) Length of ownership – second owner

The aim of the following section is to investigate whether the probability of termination of ownership corresponding to the second owner, subsequently referred to as second owner period, is affected by the following ship characteristics: ship type, ship size, builder area, and delivery year.

In the case of periods of ownership corresponding to the second owners, censored observations represent vessels that were still in operation at the end of the data collection period and were in the possession of the second owner at that moment in time. In contrast to first owner periods, where censored observations constituted vessels that have remained with their original owner until the end of the data collection and thus have substantially longer periods of ownership than vessels having more than one owner, the variations between second owner periods corresponding to complete and censored observations are not as great (Figure 5.28).

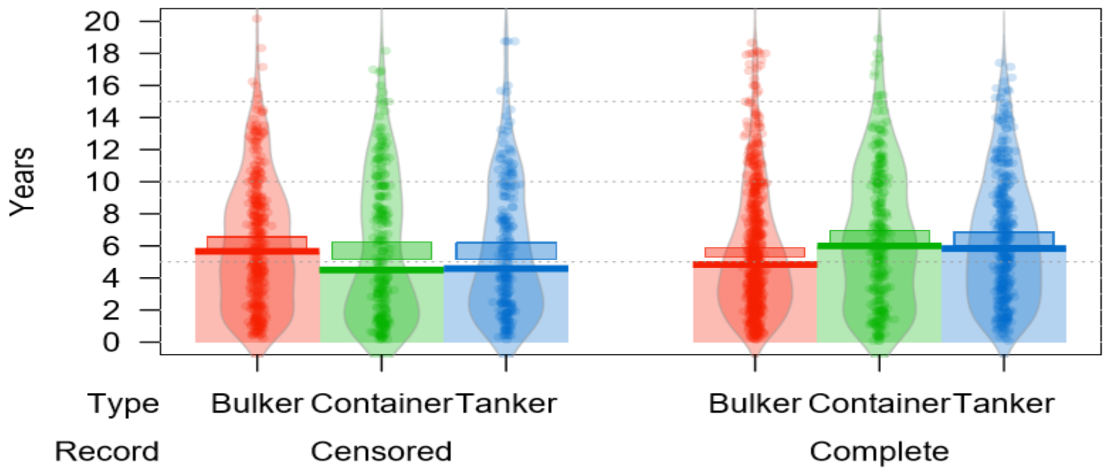
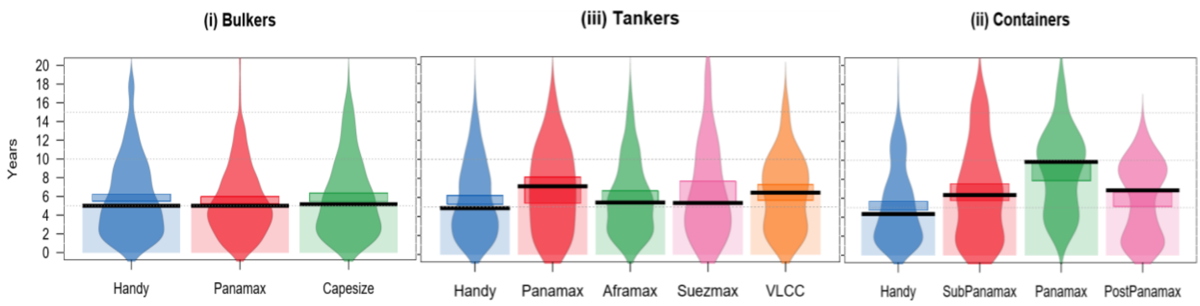


Figure 5.28. Period of Ownership by Ship Type – 2nd owner, complete and censored records

Furthermore, the periods of ownership corresponding to censored observations are not necessarily longer as in the case of first owner periods. According to Figure 5.28 the median periods of ownership by ship type within the censored observations category are in fact shorter when compared to the periods of ownership of complete observations within the container and tanker segments of the fleet. This effect could be explained by the fact that the majority of the censored observations within these two ship types could belong to younger vessels that have not yet had the opportunity to be kept by the second owner for very long. For example, ships built in 1995, which have remained with their first owner for about 15 years or until 2010, would not have had the chance to be in the possession of the second owner for more than 5 years at the end of the data collection phase depending on ship type[108]. According to Figure 5.4 presented earlier, which shows the distribution of complete and censored observations according to ship type and owner number, 38% of the records on ship level belonging to bulk carriers, 40% of all tanker records and 47% of all container records corresponding to the second owner, are censored. In other words, 38% of all bulk carrier vessels included in the dataset on ship level were in the possession of their second owner at the end of the data collection phase. The median period of ownership corresponding to the second owner is 5 years for bulkers, 5.5 years for tankers and 5.7 years for container ships. Figure 5.29 shows the periods of ownership corresponding to the second owner by ship type and size.

[108] For more information on the end of the data collection phase, see Chapter 4, section 4.3, Table 4.4.



	Bulkers			Tankers					Containers			
	Handy	Pana	Cape	Handy	Pana	Afra	Suez	VLCC	Handy	SubPana	Pana	PostPana
Median	5.0	5.0	5.1	4.9	7.1	5.5	5.4	6.5	4.3	6.3	9.8	6.8
Mean	5.9	5.6	5.9	5.8	6.9	6.0	6.6	6.5	5.2	6.7	8.9	5.9

Figure 5.29. Period of Ownership by Ship Type and Ship Size – 2nd owner

Within the bulker category, there are barely any differences in the length of second ownership according to ship size. In the tanker and container segments of the fleet, Handy size vessels remain with the second owner for the shortest period amongst their respective ship type category, however Panamax ships have the longest period of ownership in contrast to bulk carriers (Figure 5.29). The estimated survival curves presented earlier for first owner period have not been included in the main text for subsequent owners in the interest of brevity as their primary function was to introduce typical methods used in survival analysis and to present the main types of ship characteristics included in the dataset. Instead of presenting both: (i) estimated survival curves based on the raw data and individual ship characteristics, and (ii) predicted survival curves as a result of the final Cox PH models; only predicted survival curves would be discussed in detail as they represent the effect of all ship characteristics, which were found to have an effect on periods of ownership.

b) Results by Ship Type – second owner

Cox PH models were chosen to estimate the average effect of ship level characteristics on periods of ownership in shipping. The analysis is stratified by ship type and owner number because (i) there is evidence that periods of ownership may vary by ship type and owner number; (ii) the stratification by owner number improves the validity of the results as it decreases the probability of the PH assumption being violated[109] and (iii) improves the interpretability of the results. Therefore, the analysis of second owner period is a replica of the methods used for analysing the effect of

[109] Stratification by owner number implies stratification by time, which is one of the main techniques used to control for the validity of the PH assumption. For more information, see Chapter 3, section 3.3.2.b).

ship characteristics on first owner period. The event of interest is the termination of ownership, regardless of whether it comes under the form of a sale to a third owner or to a scrap yard. However, an additional variable – ship's age at purchase, has been included in the analysis of subsequent owners, whose purpose is to control for the age of the ship, which is no longer consistent with the period of ownership as in the case of first owner[110]. For subsequent owner numbers, ship's age at purchase ($A_{P(n+1)}$) is the sum of the periods of ownership of all previous owners (Equation 5.1(1)), whereas the '*end age*', denoted as $A_{E(n+1)}$, is the sum of the age at purchase and the current period of ownership (Equation 5.1(2)), where *n* is the previous owner number.

$$A_{P(n+1)} = \sum_0^n P_n \qquad \text{(1) Age at Purchase}$$

$$A_{E(n+1)} = \sum_0^n P_n + P_{(n+1)} = \sum_0^{(n+1)} P_{(n+1)} \qquad \text{(2) End Age}$$

Equation 5.1. Ship's Age

As the analysis is stratified by owner number, each period of ownership is investigated independently. The term '*end age'* refers to the age at the end of the follow up for censored observations or alternatively, the age when the ship was sold (to another owner or to a scrap yard) by the respective owner for complete observations. Therefore, the end age corresponding to the second owner is also the age at purchase corresponding to the third owner for each vessel with three or more owners. Figure 5.30 shows the distribution of age at purchase and end age associated with the second owner period. The peak of the distribution of age at purchase for bulkers is in the region of the ages of 7 and 8 years, whereas for tankers it is closer to the age of 10. It should also be noted that higher proportions of tanker and container vessels are scrapped at the end of the second owner period in comparison to bulk carriers.

[110] For a more detailed discussion on time scales and the effect of age in survival analysis, refer to Chapter 3, section 3.3.2.b).

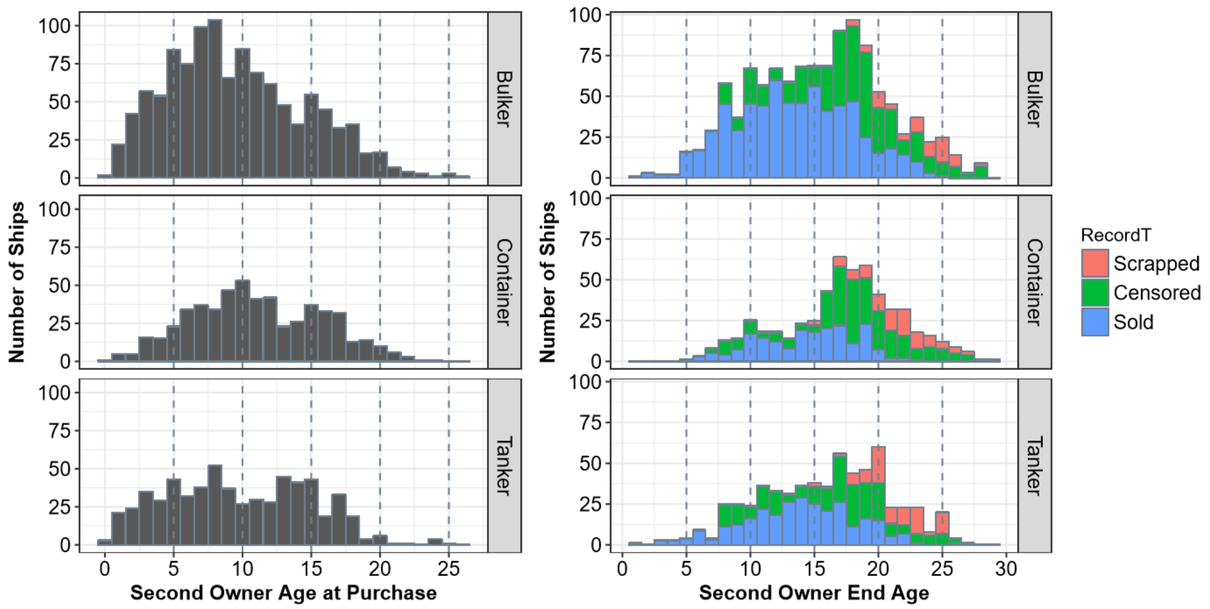


Figure 5.30. Distribution of Ships' Ages – 2nd owner

In order to investigate whether periods of ownership vary significantly between ship types and which of the variables on ship level may have a significant effect on survival, a main effects (additive) model is briefly discussed first.

The number of records and events as well as the output of all models regarding second owner data can be found in Data Annex Chapter 5, section 6. The main effects model regarding second owner periods in shipping is based on the following ship characteristics:

- Ship type,
- Ship size,
- Delivery year,
- Builder area,
- Ship's age at purchase[111].

According to the results from the main effects model corresponding to second owner period, all covariates apart from ship size have an effect on the probability of sale. The covariates, which show the strongest effect on survival are delivery year and age of the vessel. On average, vessels built at a later stage have a lower probability of being sold. As to be expected, the older a vessel at the time when it was bought by the second owner, the higher the probability of sale becomes.

[111] The pairwise correlation between ship's age and delivery year based on the dataset for 2nd owner is (-0.3). The coefficient is low enough for both predictors to be included in the model without serious multicollinearity issues arising as a result.

Bulkers – second owner

The covariates included in the final Bulkers Cox PH model for periods of ownership corresponding to the second owner (Bulkers-2nd owner model) are ship size, delivery year, builder area and ship's age at purchase. Figure 5.31 shows the minimal depth results regarding variable importance based on a random survival forests' (RSF) algorithm. According to the CART based technique, the most significant predictor is delivery year, followed by builder area, ship's age, and ship size, which appears to have a relatively small effect on survival in comparison with the rest of the covariates.

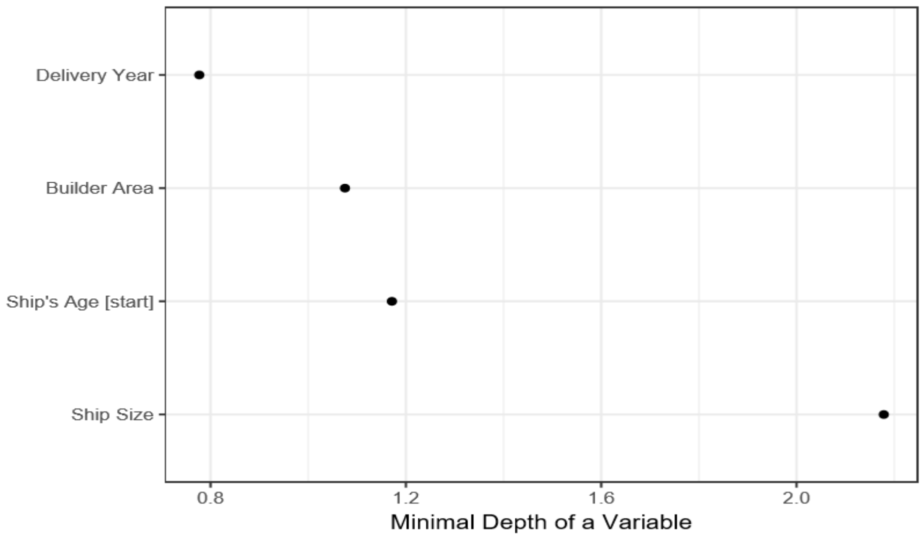


Figure 5.31. Minimal Depth - Bulkers - 2nd owner

According to the second owner Bulkers Cox PH model, the effect of delivery year changes based on builder area. The probability of survival of Japanese and Chinese-built bulk carriers increases with delivery year. Korean-built bulkers have very consistent survival probability, which is not affected by when the ships were built. The most dramatic change concerns bulkers built in Europe as European-built ships delivered at later stages of the delivery profile of the sample have much lower relative probability of survival. However, it should be noted that European yards' output in terms of bulk carriers decreased leading to a limited sample size for vessels built in the late 1990s.

In the Handy and Capesize bulker categories vessels built in Korea before the year 2000 have a higher probability of survival (Figure 5.32). However, for ships built after

2000 there is no significant difference between the predicted survival of ships built in Korea, China or Japan.

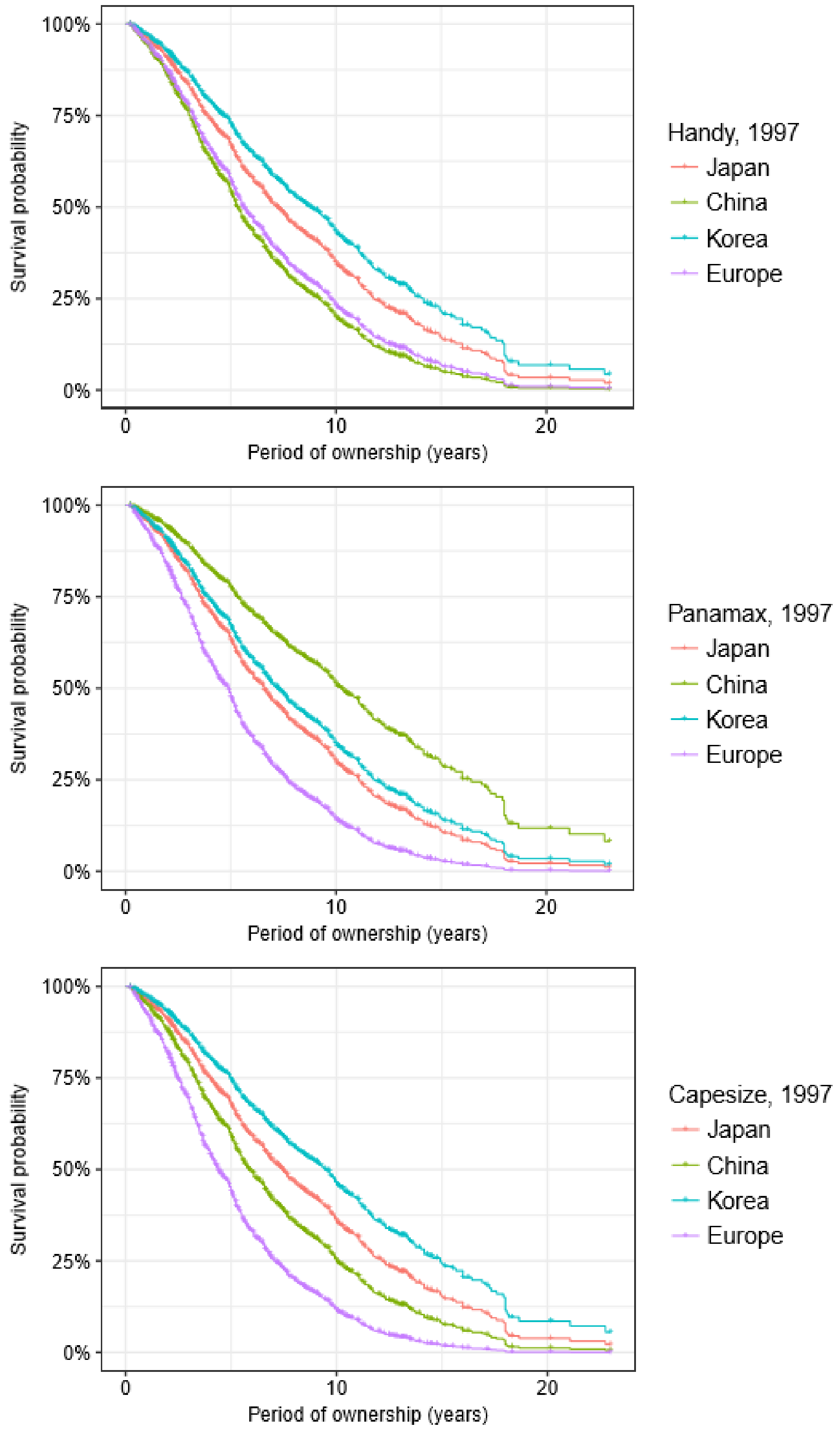


Figure 5.32. Predicted Survival Curves by Ship Size - Bulkers Cox PH model - 2nd owner

Ships built in Europe in the late 1990s are the most likely ones to be sold on average. Amongst the older Handy and Capesize bulkers, built between 1987 and 1997, however, Chinese-built vessels have the highest probability of being sold. On the contrary, within the Panamax size category Chinese-built ships, regardless of the delivery year, have the highest predicted survival not only of all Panamax bulkers but of all bulkers (Figure 5.32).

Tankers – second owner

The final set of covariates selected in the 2nd owner Tankers Cox PH model includes delivery year, ship's age at purchase, and ship size. Builder area does not seem to have a significant effect on the probability of survival with the second owner according to the Cox PH models. The choice of covariates is supported by the minimal depth results presented in Figure 5.33.

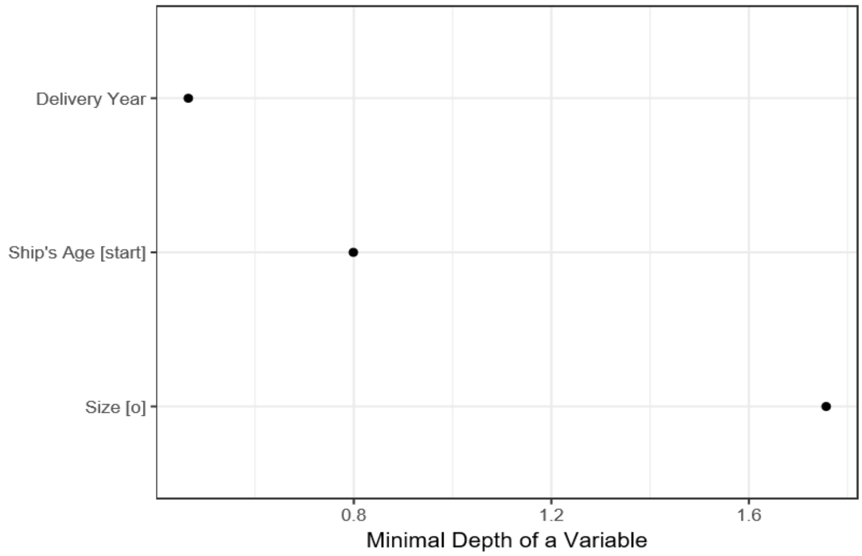


Figure 5.33. Minimal Depth - Tankers - 2nd owner

It should be noted that the effect of ship size is very weak and no clear distinctions between ship sizes can be made in terms of survival as shown in Figure 5.34. On average, the predicted survival probability of remaining with the second owner is higher for ships built at a later stage of the delivery profile of the sample.

The effect of age at purchase is shown in Figure 5.35, which consists of two separate plots, depicting the following: (i) the relative hazard of tankers to be sold at different ages (left); and (ii) the relative hazard of tankers related to termination of ownership in comparison to a 10-year old ship (right)[112]. The blue bands surrounding the relative hazard lines represent the 95% confidence intervals, whereas the vertical dashes along the x-axes[113], referred to as '*rug plot'*, represent the distribution of tankers by

[112] Gandrud (2015) defines relative hazards as 't*he expected change in the hazard*' for a specific value of the given covariate. The hazard function and hazards are discussed in Chapter 3, section 3.3.2.b).
[113] More information on simulating relative hazards and rug plots can be found in Gandrud (2015).

age at purchase in the sample corresponding to the second owner. The rug plots indicate that the number of tankers, which were purchased by the second owner after the age of 20 years is very limited.

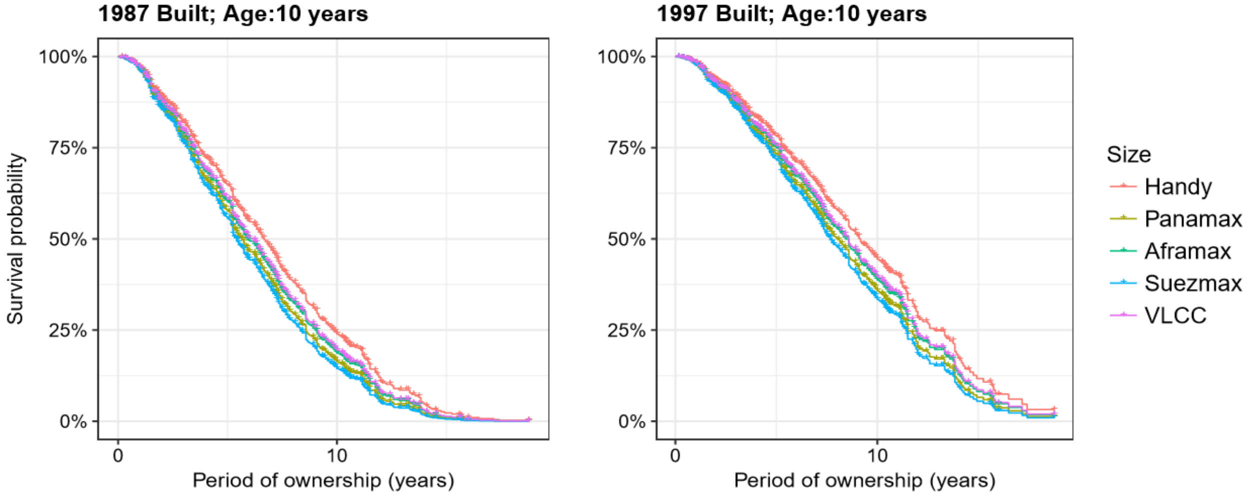


Figure 5.34. Predicted Survival Curves by Ship Size – Tankers Cox PH model – 2nd owner

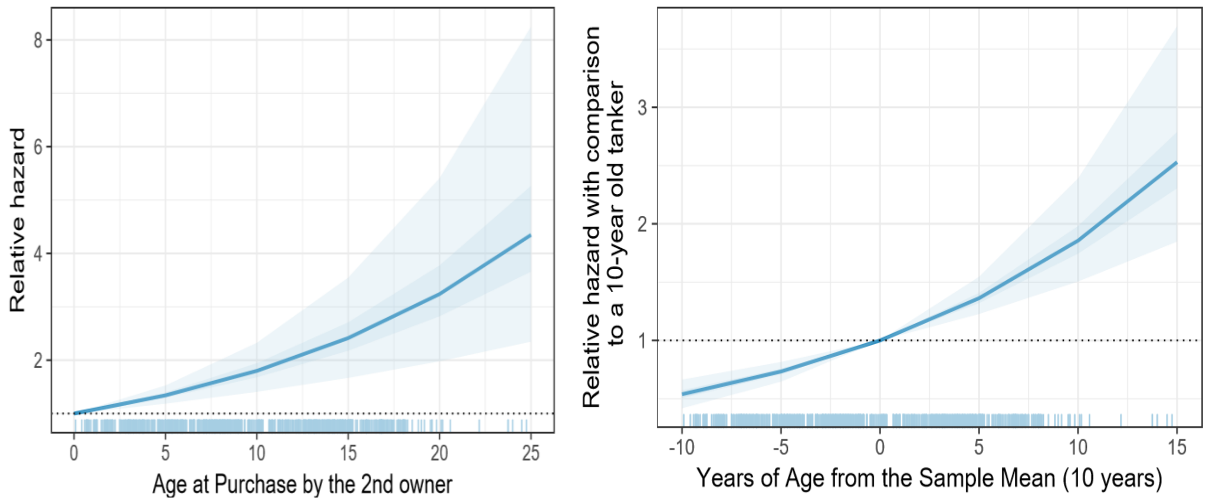


Figure 5.35. Simulated Relative Hazards of Age at Purchase - Tankers - 2nd owner

A tanker, which was 15-years-old at the time of purchase by the second owner is almost 2.5 times more likely to experience termination of ownership than a tanker, which was 1-year-old at purchase according to the relative hazards plot on the left of Figure 5.35. The right relative hazards plot uses a 10-year-old tanker as a reference (with a relative hazard of 1, horizontal axis = 0). It shows that a 20-year-old ship[114] is

[114] As the reference is a 10-year-old vessel (0 on the x-axis), the value '*-10'* refers to a new ship and the value '*10*' refers to a ship, which was 10 years older than the reference ship (20-year-old vessel).

almost twice more likely to experience termination of ownership than a tanker purchased at the age of 10.

Containers – second owner

Three covariates were kept in the final model Cox PH model corresponding to second owner period as builder area's effect was found to be insignificant, namely age at purchase, ship size, and delivery year (Figure 5.36).

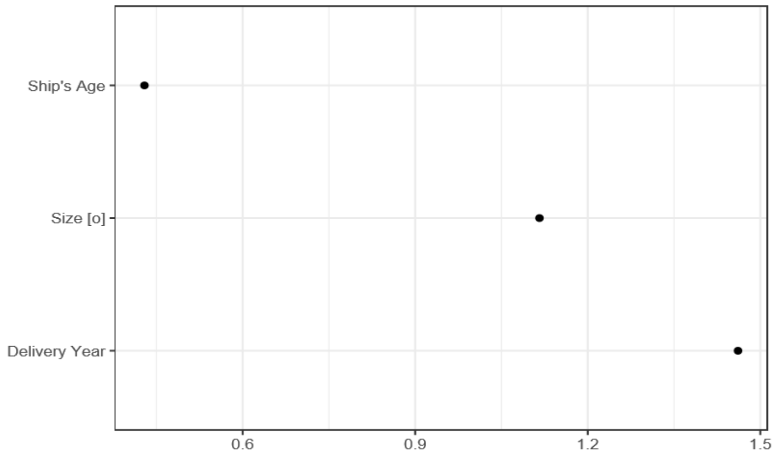


Figure 5.36. Minimal Depth - Containers - 2nd owner

The predicted survival of containers marginally increases for ships built at a later stage of the delivery profile of the sample (Figure 5.37). Smaller container ships are more likely to experience termination of ownership on average. Handy containers are the most likely ones to be sold by the second owner, whereas Panamax and Post-Panamax containers are the ones with the highest predicted survival (Figure 5.37).

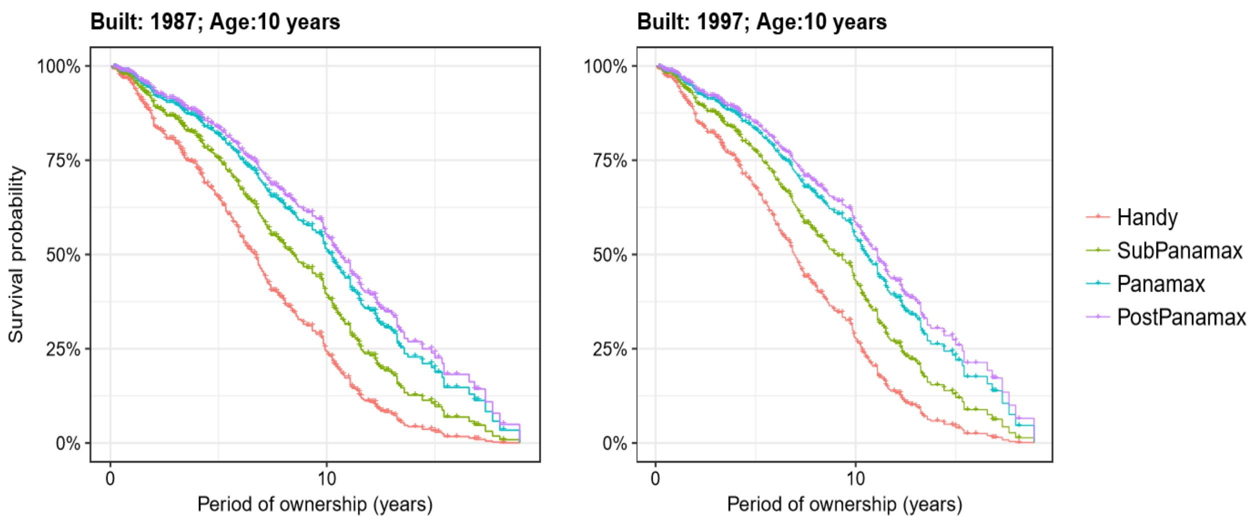


Figure 5.37. Predicted Survival Curves by Size – Containers Cox PH model - 2nd owner

In terms of ship's age, generally older vessels have lower probability of survival. According to the simulated relative hazard based on ship's age at purchase by the second owner shown in Figure 5.38, a 10-year-old container vessel is about 2.5 times more likely to experience termination of ownership than a vessel, which was about a year old when acquired by the second owner. According to the plot on the right of Figure 5.38, a container ship purchased at the age of 17 is twice more likely to experience termination of ownership in comparison to a ship, which was 10-year-old at the time of purchase.

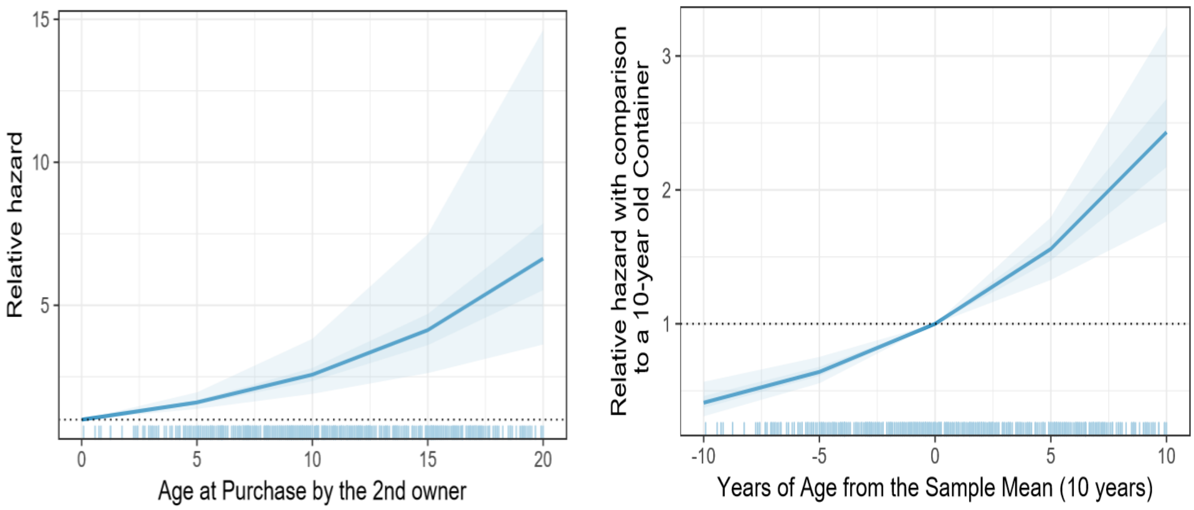


Figure 5.38. Simulated Relative Hazards of Age at Purchase - Containers - 2nd owner

5.3.3. Periods of ownership corresponding to third owner

a) Length of ownership – third owner

The following section is dedicated to investigating whether the duration of the period of ownership corresponding to the third owner, referred to as third owner period, is affected by the list of ship characteristics examined so far in the relation to first and second owners. When examining the period of ownership data corresponding to the third owner, censored observations represent the ships that were still in operation at the end of the follow up period and were in the possession of their third consecutive owner. The total number of records corresponding to third owner period is 1140 or 30% of the total sample on ship level. Table 5.12 summarises the number of records and censored observations used in the analysis of third owner period on ship level.

Type	Complete (Events)		Censored		Records Total	All Ships
Bulker	392	59.5%	267	40.5%	659	1140
Tanker	187	65.6%	98	34.4%	285	
Container	95	48.5%	101	51.5%	196	

Table 5.12. Third Owner Dataset

The average period of ownership corresponding to the third owner is 4.2 years for containers, 4.3 years for bulkers and 4.6 years for tankers. The period of ownership does not vary greatly between ship types at this point in the vessels' economic lives and it should be noted that container ships no longer outperform dry and liquid bulk ships in terms of length of ownership. Figure 5.39 shows that there are barely any differences between complete and censored observations.

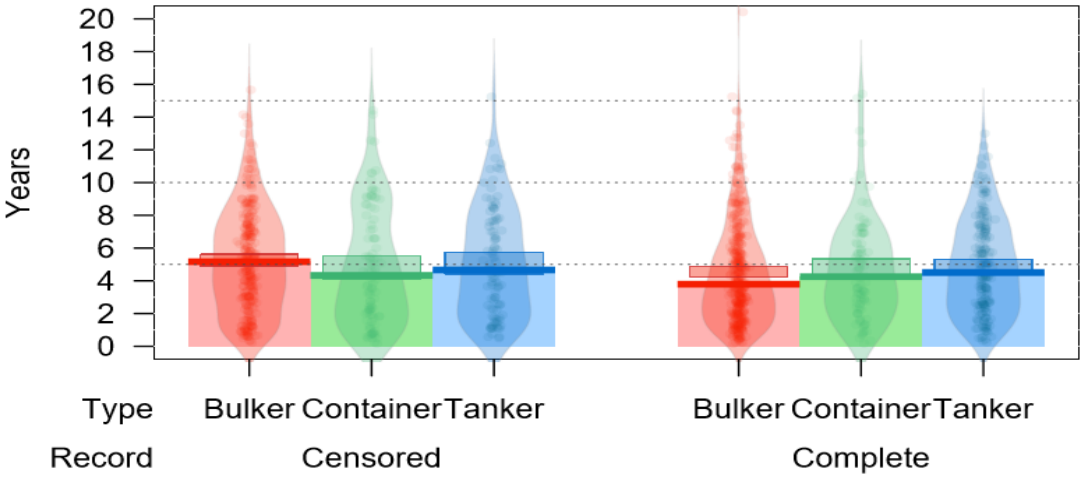
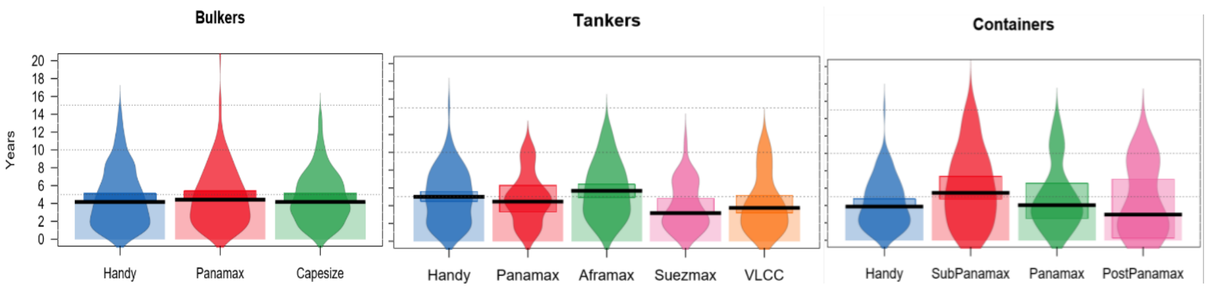


Figure 5.39. Period of Ownership by Ship Type – 3rd owner, complete and censored records

Figure 5.40 summarises the data on third owner periods by ship size. According to the median values for third owner period by ship size, Panamax bulkers, Aframax tankers and Sub-Panamax containers have the longest periods of ownership within their respective ship type category.



	Bulkers			Tankers					Containers			
	Handy	Pana	Cape	Handy	Pana	Afra	Suez	VLCC	Handy	SubPana	Pana	PostPana
Median	4.2	4.4	4.2	4.9	4.5	5.7	3.2	3.7	3.9	5.5	4.0	3.0
Mean	4.7	5.0	4.7	5.0	4.9	5.7	4.0	4.2	4.3	6.1	4.9	4.6

Figure 5.40. Period of Ownership by Ship Type and Size – 3rd owner

Suezmax tankers, VLCC tankers and Post-Panamax container ships have the lowest periods of ownership (Figure 5.40). Figure 5.41 presents the distribution of ships' age at the beginning and the end of the third owner period.

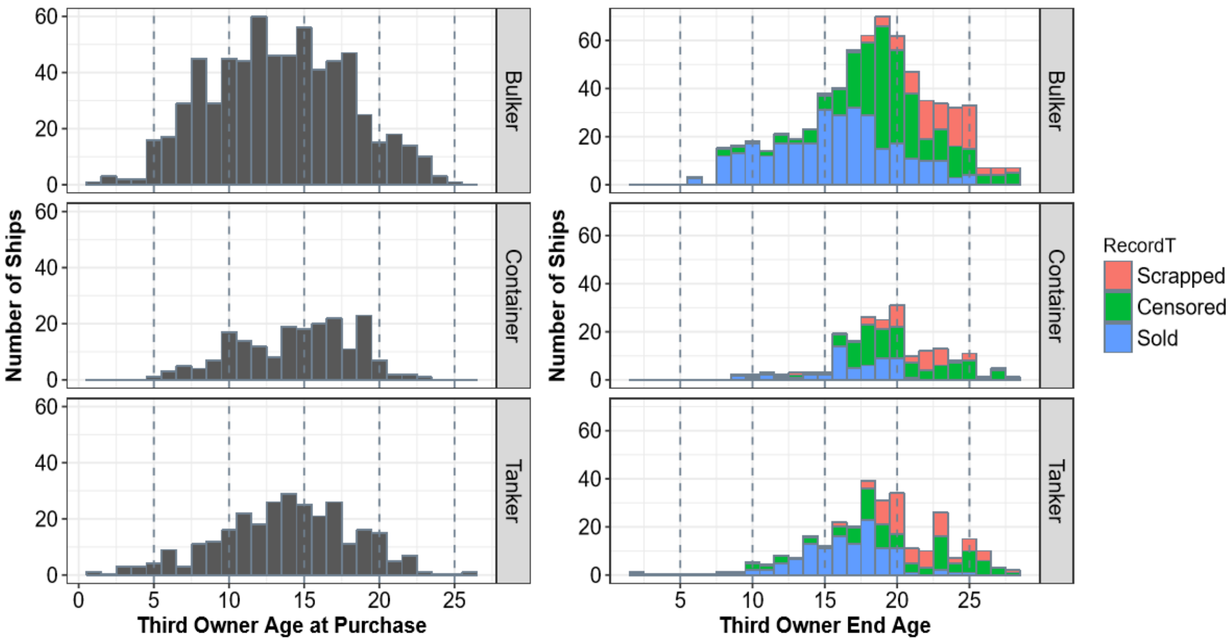


Figure 5.41. Distribution of Ships' Ages – 3rd owner

In the case of the third owner, ship's age at the time the ship was purchased by the third owner is the sum of the periods of ownership of the first and second owners. The average age at purchase by the third owner varies slightly across ship types. Bulk carriers are the youngest on average amongst the ship types at the time of purchase by the third owner (13.4 years), followed by tankers (13.8 years) and containers (14.5 years).

b) Results by Ship Type – third owner

In order to investigate whether the probability of survival varies significantly between ship types and which of the variables on ship level may have a significant effect on survival, a main effects model is briefly discussed first. The main effects model examining third owner periods in shipping is based on the following ship characteristics:

- Ship type,
- Ship size,
- Delivery year,

- Builder area,
- Ship's age at purchase.

According to the results from the main effects model corresponding to third owner period, the only covariates, which affect the probability of survival of vessels are delivery year and ship's age. Ships delivered at a later stage of the delivery profile of the sample are less likely to be sold by the third owner age for age. Models' output and diagnostics referring to third owner data on ship level are shown in Data Annex Chapter 5, section 7.

Bulkers – third owner

The final Bulkers Cox PH model for periods of ownership corresponding to the third owner (*Bulkers-3rd owner model)* is similar to the main effects model for third owner period as the two covariates which have an effect on the survival of bulkers are delivery year and age at purchase. Builder area was found to influence survival as well, however, the effect does not seem to be significant in practice as no distinctive groups of vessels could be identified in terms of survival probabilities based on builder area. Figure 5.42 shows the probability of a bulker to remain with the third owner based on the average age at purchase (13.4 years) and the delivery year of the vessel.

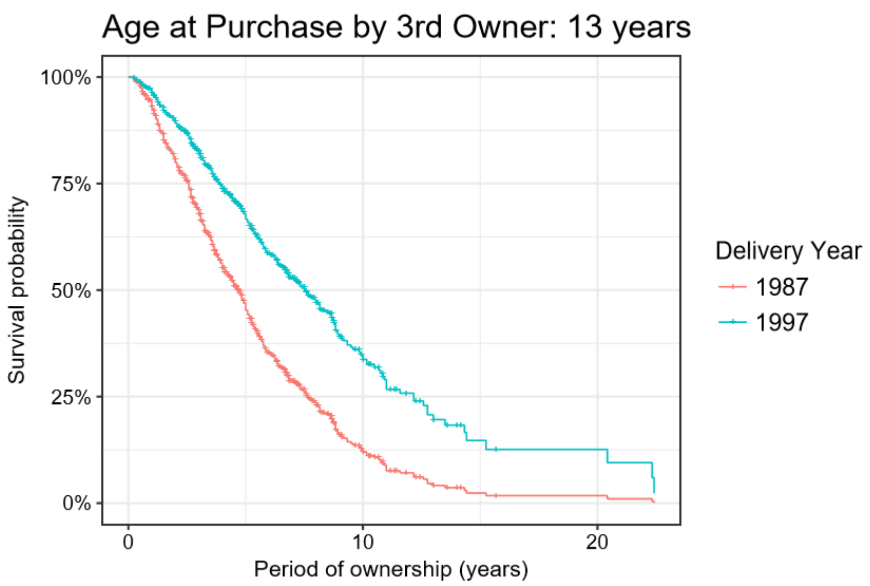


Figure 5.42. Predicted Survival Curves by Delivery Year and Age at Purchase - Bulkers Cox PH model - 3rd owner

On average, vessels built in the late 1980s are more likely to be sold than vessels built at a later stage, age for age. Figure 5.43 shows the relative hazard of a bulker purchased at the age of 10 by the third owner. In comparison, a bulker purchased at the age of 15 is 1.2 times more likely to experience termination of ownership.

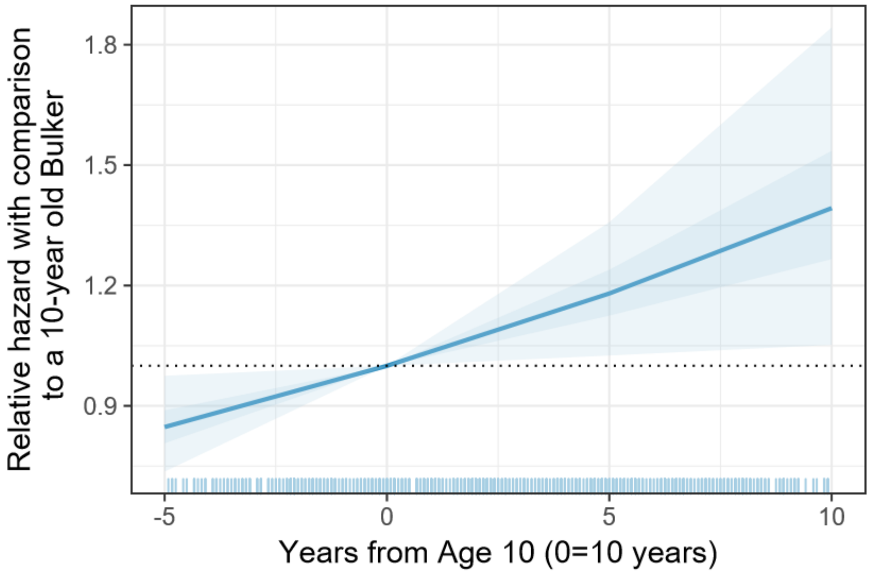


Figure 5.43. Simulated Relative Hazards of Age at Purchase - Bulkers - 3rd owner

Tankers – third owner

The list of covariates which have an effect on survival included in the final Tankers Cox PH model corresponding to the third owner (*Tankers-3rd owner model)* consists of ship's age at purchase, delivery year and ship size. It should be noted that the effect of size is relatively small in comparison to the other two covariates included in the model as shown in the minimal depth plot presented in Data Annex Chapter 5, section 7.3.

The predicted survival of tankers by size is shown in Figure 5.44. Handy vessels are the least likely ones to be sold on average, whereas Suezmax tankers have the highest probability to experience the event of interest – termination of ownership. The predicted survival probabilities of the remaining three size categories within the tanker segment – Panamax, Aframax and VLCC tankers; are very similar (the survival curves overlap).

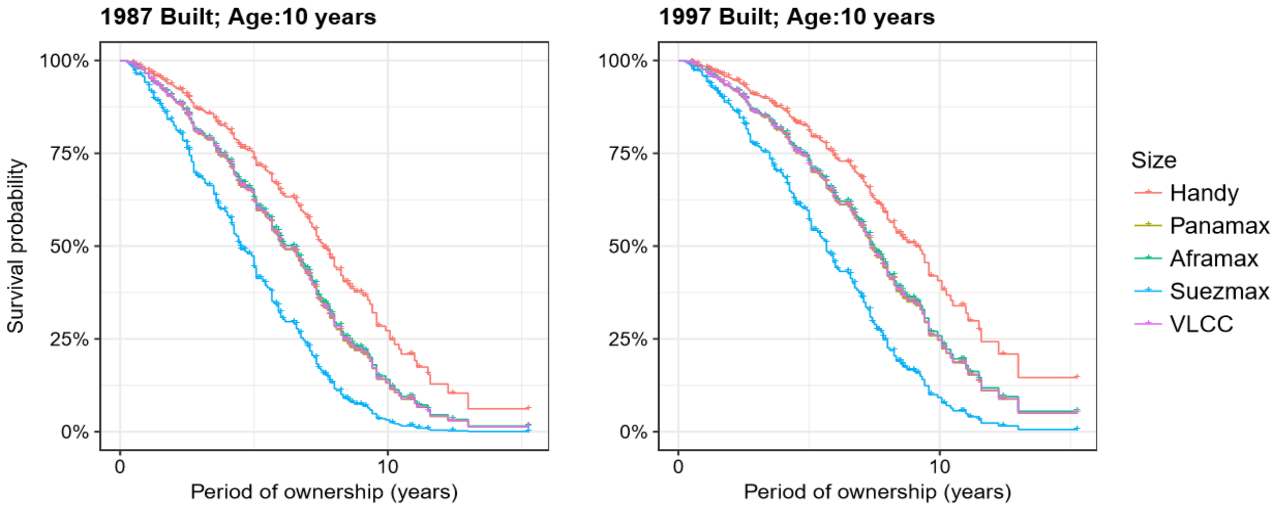


Figure 5.44. Predicted Survival Curves by Size - Tankers Cox PH model - 3rd owner

Figure 5.45 shows the relative hazard of a tanker purchased at the age of 10 years by the third owner.

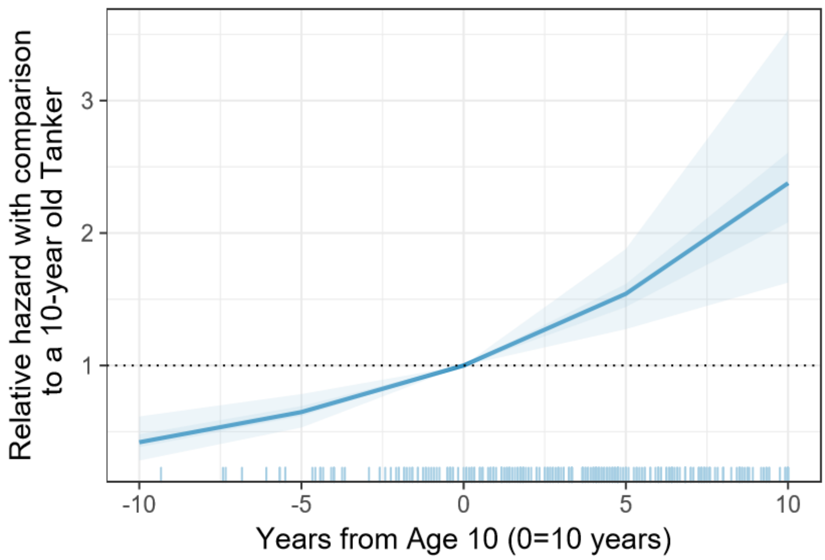


Figure 5.45. Simulated Relative Hazards of Age at Purchase - Tankers - 3rd owner

The effects of age and delivery year could partly be explained by the introduction of OPA'90, which triggered the phasing out of single-hull tankers built in the late 1980s and motivated the development of a stringent inspections' regime for tankers, which affected older vessels[115].

Containers – third owner

The final Containers Cox PH model corresponding to third owner (Containers-3rd owner model) includes ship's age at purchase, size and builder area as covariates.

[115] More detail on OPA'90 can be found in Appendix B-3.

Japanese and European-built vessels are the most likely to experience termination of ownership compared age for age, whereas containers built in China appear to have the highest survival probability[116].

In terms of size, Post-Panamax containers are the least likely ones to be sold by the third owner irrespective of age or builder area. The category with the second highest predicted survival is that of Sub-Panamax containers, followed by Panamax ships. Handy containers are the most likely ones to experience the event of all container vessels (Figure 5.46).

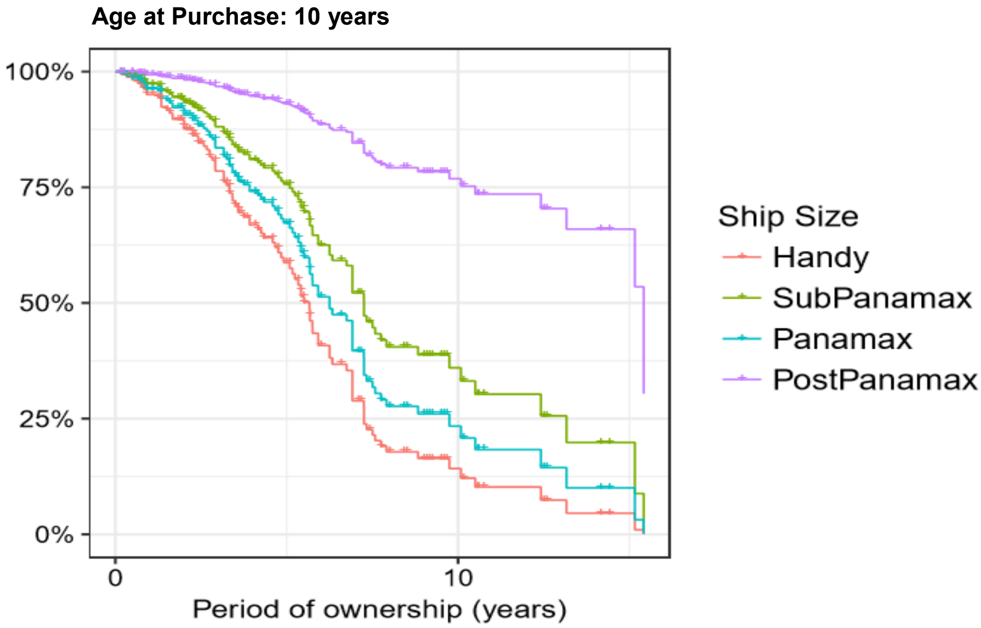


Figure 5.46. Predicted Survival Curves by Size and Age - Containers Cox PH model - 3rd owner

As with other ship types, vessels purchased by the third owner at a later stage in their economic life were found to be more likely to experience termination of ownership than younger ships. Figure 5.47 shows the simulated hazard of a container ship purchased at the age of 10 by the third owner. A vessel purchased at the age of 15 is found to be almost twice more likely to experience termination of ownership in comparison to a 10-year-old container ship.

[116] The predicted survival curves by builder area are presented in Data Annex Chapter 5, section 7.4.

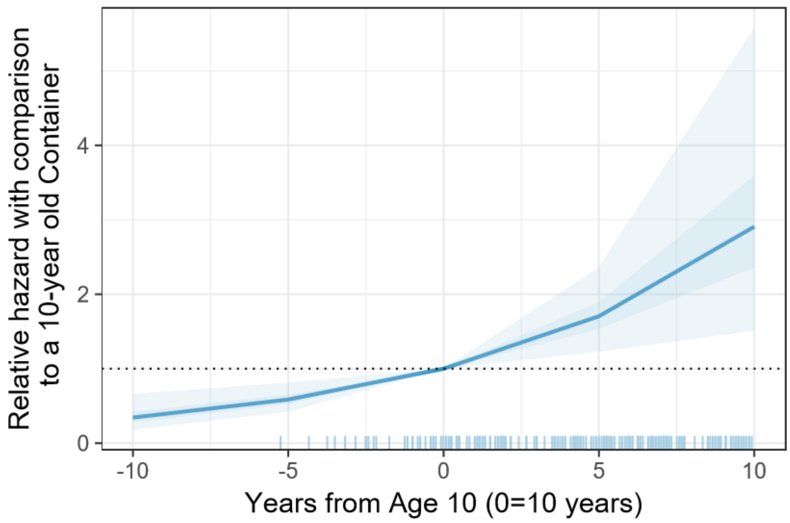


Figure 5.47. Simulated Relative Hazards of Age at Purchase - Containers - 3rd owner

5.3.4. Periods of ownership corresponding to later owner

a) Average periods of ownership – later owner

The following section focuses on ships with more than three owners and it examines ship records corresponding to owners four to eight, where applicable. Based on the data on ship level, the average number of owners per ship type is below three (Figure 4.8) with bulk carriers having the highest number of owners in general. Only 12% (474 ships) of all ships included in the sample have had more than three owners. Due to the limited number of records in the dataset representing the fourth and subsequent owners, the data on such records is pooled together under one category referred to as *'later owner'* hereinafter. A record is marked as '*complete'* if the vessel experiences the event of interest, which means that the number of events is equal to the number of complete records in the dataset. In the case of periods of ownership corresponding to later owners, censored observations correspond to vessels that were: (i) still in operation at the end of the follow up period and (ii) were in the possession of their fourth or subsequent owner at that moment in time. Table 5.13 presents the number of ships with more than three owners at the end of the data collection phase.

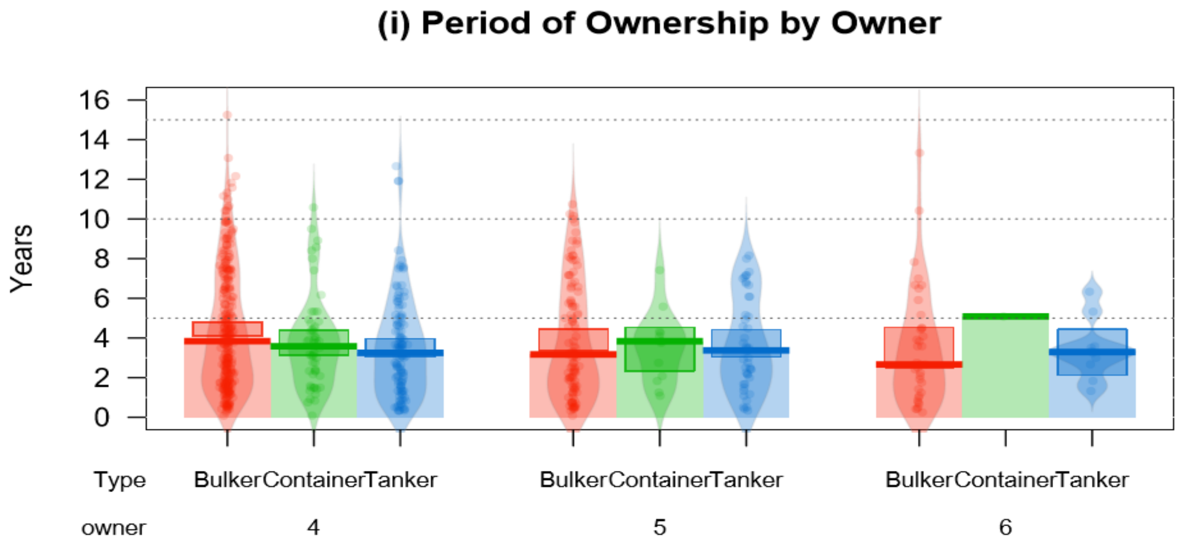
Ship Type	**Records**	**Events**	**Scrapped**	**No. of ships (owner>3)**	**No. of ships per owner number**				
					4	**5**	**6**	**7**	**8**
Bulker	455	237	80	299	188	74	29	7	1
Tanker	178	108	49	120	74	36	7	3	NA
Container	69	42	28	55	42	12	1	NA	NA
Total	702	387	157	474	304	122	37	10	1

Table 5.13. Later Owners Dataset

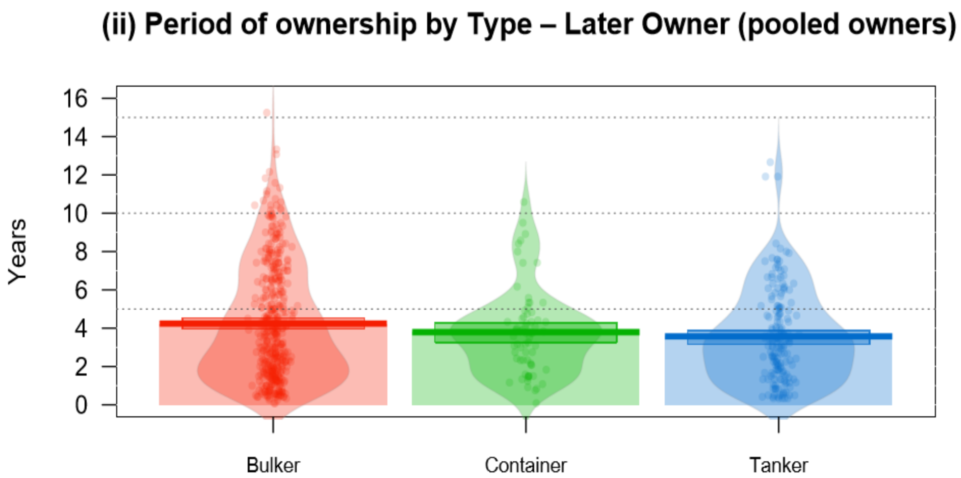
It should be noted that for all vessels with a total number of owners which exceeds four, there are two or more records that correspond to the same vessel. For example, a ship with six owners in total recorded at the end of the data collection will have three records included in the later owner dataset corresponding to the periods of ownership with the fourth, fifth and sixth owner respectively. However, these records are treated as independent observations. Figure 5.48 shows the following: (i) the period of ownership corresponding to the fourth and subsequent owners; (ii) the pooled periods of ownership by ship type; and (iii) the average periods of ownership corresponding to censored and complete records.

From Figure 5.48(i) it can be observed that there are small differences between average periods of ownership across ship types. However, the differences between ship types across owner numbers are in the magnitude of couple of months with the exception of periods of ownership corresponding to the fourth and fifth owner within the bulker segment of the fleet, where the means differ by approximately half a year – 4.4 and 3.9 years respectively. It should be noted that the sample sizes decrease with owner number and the confidence interval bands widen. In practice, especially when the effect of sample sizes is considered, such differences in the average period of ownership are negligible.

The median periods of ownership by ship type as a result of the pooled ship records corresponding to fourth and subsequent owners are presented in Figure 5.48(ii). According to the later owner dataset, the median period of ownership for bulkers is 4.2. years, followed by 3.7 years for containers and 3.6 years for tankers. Similar to third owner periods, container vessels are no longer held for considerably longer than bulkers and tankers as is the case with first and second owner, especially in the category of vessels that have experienced the event also referred to as '*complete records*' (Figure 5.48, (iii)). This phenomenon could be explained by the fact that on average container vessels are scrapped earlier than tankers and especially bulkers, which is reflected in the dataset on ship level as discussed earlier in this chapter. Bearing in mind that the median survival for bulkers is 23.1 years, followed by 20.2 for tankers and 20.0 years for containers and the fact that bulkers are kept for shorter periods by earlier owners, it is not surprising that bulkers are kept longer than any other ship type by later owners.



Note: Due to the limited sample size records corresponding to owner seven (11 records) and eight (1 record) are excluded. There is one record representing owner six in the container segment of the fleet, which is the reason for the lack of raw data points.



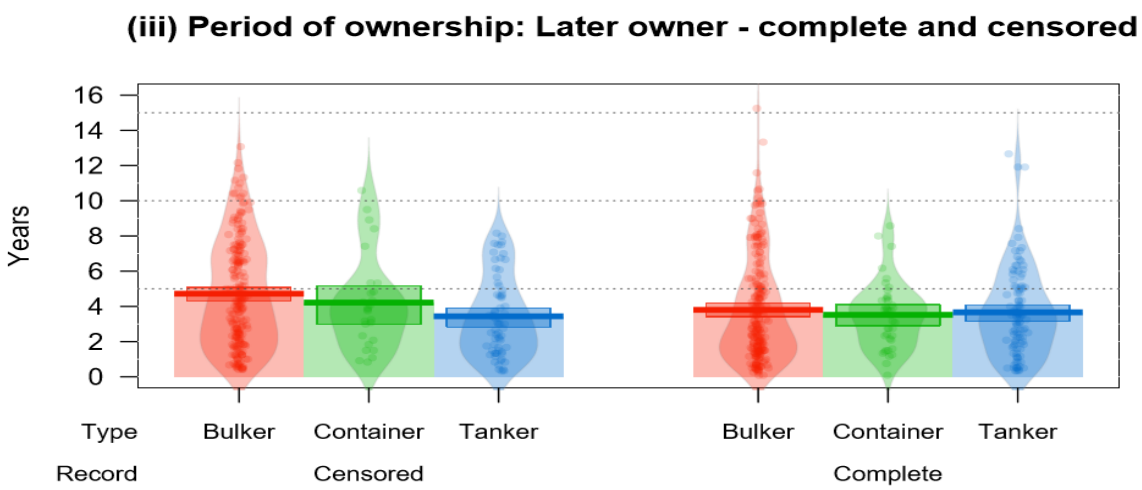


Figure 5.48. Period of Ownership – Later owner

However, there is anecdotal evidence amongst shipping professionals that small bulk carriers are likely to be operated long after their hypothetical economic life of 25-30 years, especially in parts of the world where the regulatory regime is not as stringent as Europe and the US, for example. This pattern is further supported by the data on ship level as the maximum age at purchase in the bulkers category for vessels that were still in operation at the end of the follow up is 27 years.

Figure 5.49 shows the distribution of ships' age at purchase and end age according to ship type.

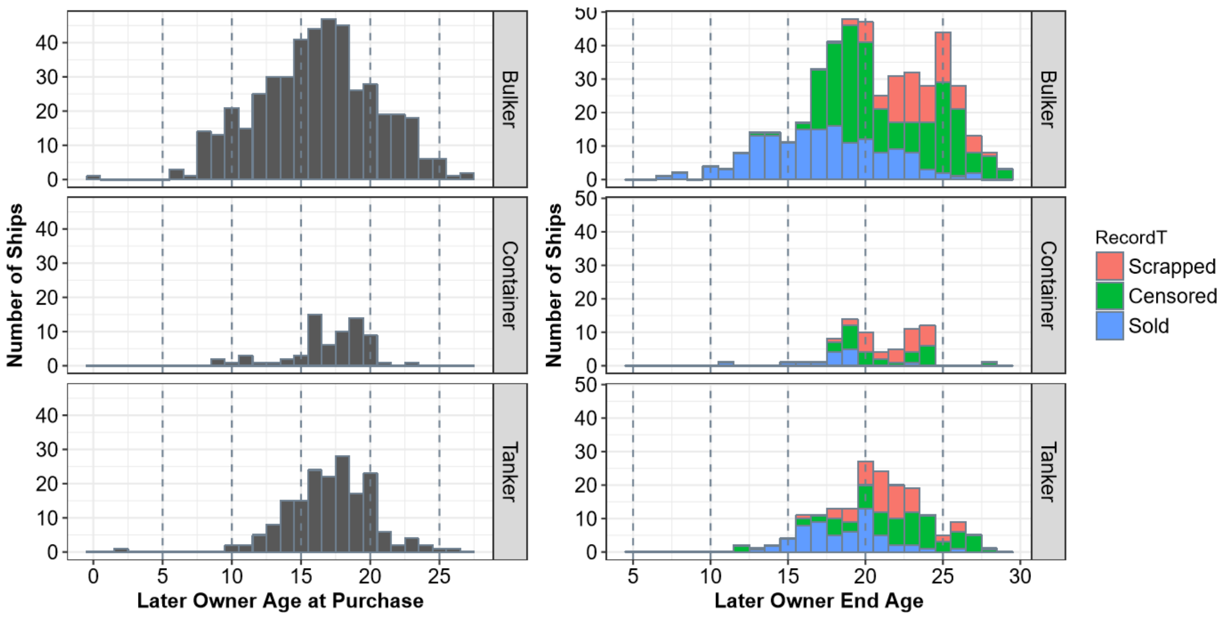


Figure 5.49. Distribution of Ships' Ages – later owner

In the case of later owners, ship's age at the time the ship was purchased is the sum of the periods of ownership of all previous owners. No average periods of ownership or average age at purchase according to ship size will be reported here as there is no statistical difference between size categories within each ship type. The only exception concerns age at purchase by ship size in the tanker segment of the fleet. However, the perceived statistical difference in age across the tanker size categories could be a product of the limited sample size, for example there are only 5 Panamax tankers and 14 VLCC ships included in the later owner dataset.

b) Results by Ship Type – later owner

The ship characteristics that have been considered for inclusion in the models investigating later owner periods of ownership include:

- Ship type,

- Ship size,
- Delivery year,
- Builder area,
- Ship's age at purchase.

The data on fourth, fifth and subsequent owners was analysed via separate main effects models as part of the preliminary data screening[117]. These models did not allow for stratification by vessel type due to limited sample sizes. Furthermore, only the main effects model based on fourth owner period showed statistically significant effects on survival. This development reinforced the decision to pool the records corresponding to fourth and subsequent owners together. According to the results from the main effects model corresponding to later owner period, the covariates, which affect the probability of survival of vessels are ship's age at purchase, size, and builder area.

Larger ships were found to be more likely to experience the event of interest regardless of ship type. Japanese built vessels are less likely to experience termination of ownership on average, whereas European built ships are the most likely ones to experience the event. The effect of age, as expected, puts vessels acquired at a later age at more risk of being sold or scrapped.

Bulkers – later owner

The covariates included in the optimal model are delivery year, ship's age at purchase, builder area and ship size. However, it should be noted that the effects of delivery year and age at purchase are very weak.

The results indicate that Japanese-built bulk carriers are significantly less likely to experience the event. Chinese vessels have the lowest predicted survival, however, there is no significant difference between Chinese-built bulkers and ships built in Korea or Europe. Ship size and predicted survival are negatively associated as with the increase of size, the predicted survival of the associated size category decreases. Capesize vessels are significantly more likely to experience termination of ownership in comparison to Handy and Panamax bulkers, which have very similar predicted survival[118] (Figure 5.50). Vessels delivered in the late 1980s have a lower predicted survival than ships delivered in the 2000s (Figure 5.50).

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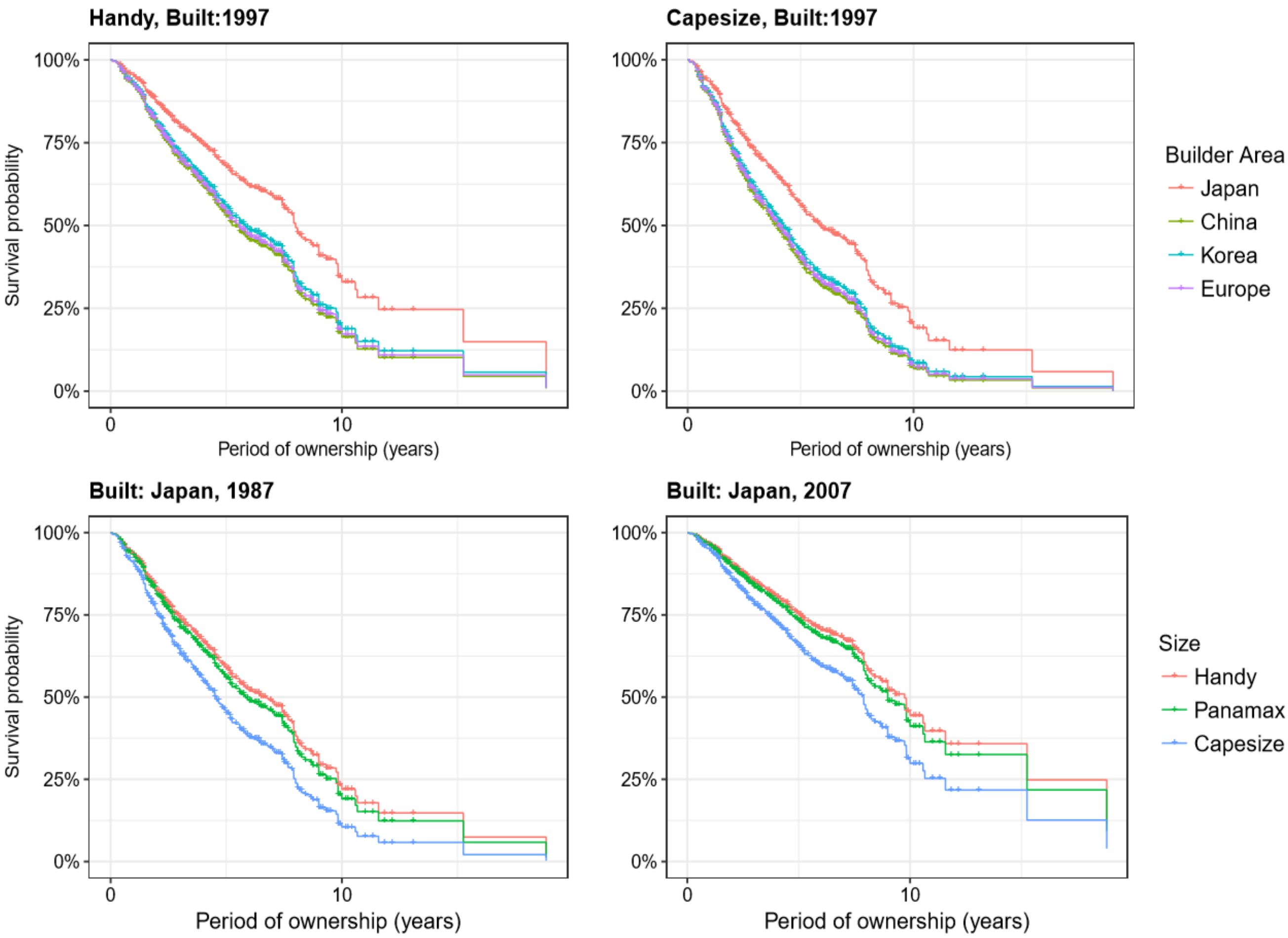
[117] The output of models concerning later owner data can be found in Data Annex Chapter 5, section 8.
[118] As there is no statistical difference between the survival probabilities of Handy and Panamax bulkers, the predicted survival curves of Handy bulkers only are shown in Figure 5.50.



Note: The predicted survival curves corresponding to China, Korea and Europe overlap.

Figure 5.50. Predicted Survival Curves (selection) – Bulkers Cox PH model - later owner

Vessels acquired at a later stage of their economic lives are more likely to experience termination of ownership as is to be expected. Simulated relative hazards are shown in Data Annex Chapter 5, section 8.2.

Tankers – later owner

As none of the characteristics on ship level seem to have a significant effect on the probability of a tanker to experience the event of interest when in the possession of a later owner, no results are presented here. There are two likely explanations: (i) the effect of OPA'90 and the continuous acceleration of the phasing out of single hull tankers, which had an impact on the scrapping date of the tankers delivered before the mid-1990s[119] and (ii) small sample size.

[119] See Appendix B-3 for more information on the phasing out of single hull tankers.

In the later owner category, there are 21 ships, whose age at the end of the follow up period is above 25 years. Figure 5.51 shows the age and status of all ship records included in the later owner dataset as of the end of the follow up period. The dashed horizontal lines in Figure 5.51 mark the age of 23 years and 28 years respectively. The censored ship records belong to ships that were still in operation at the end of the data collection according to Sea-web (2017).

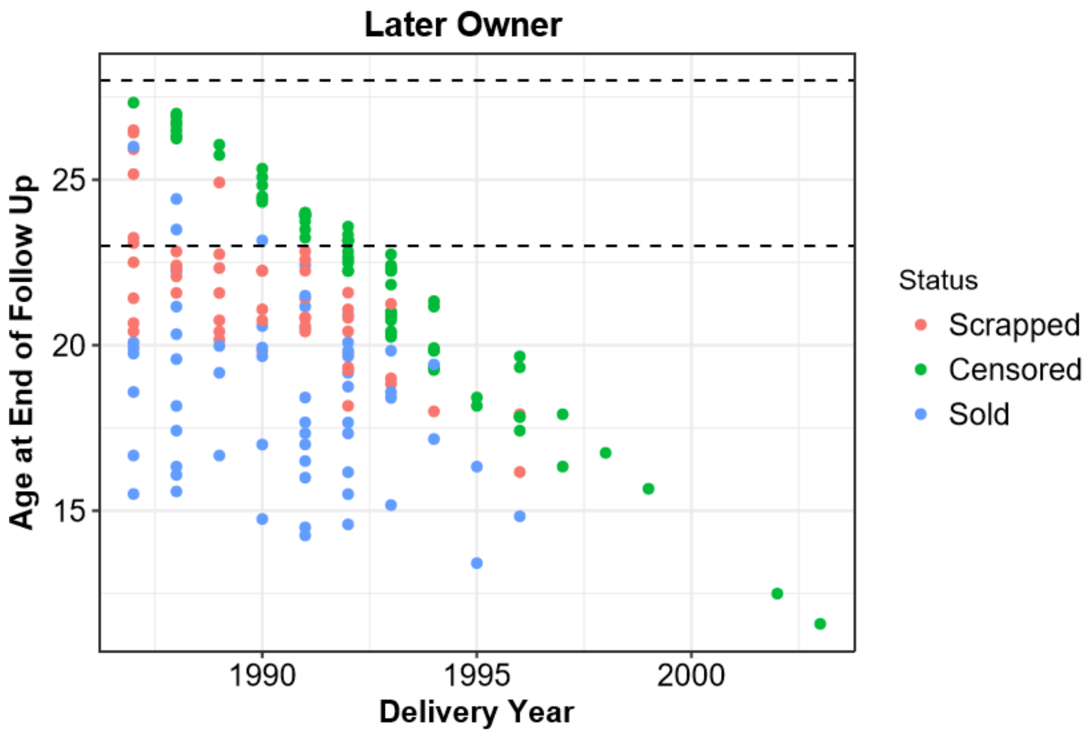


Figure 5.51. End Age and Delivery Year – Tankers – later owner

Based on the phasing out schedule of single hull tankers and its acceleration, it is concluded that the tankers that were presumably in operation at the end of the follow up period and older than 25 years are vessels that (i) stopped existing virtually due to potential late or missing status update on behalf of the data provider or due to the reluctance of the owner to disclose any changes in the status of the vessel; (ii) are laid up waiting to be scrapped; (iii) are not single hull tankers; (iv) are single hull tankers that were converted into FPSOs or ore carriers[120]; or (v) are traded in areas of the world where the international regulatory regime is less stringent while flagged by Administrations that have not adopted MARPOL.

[120] According to SIW (2013).

Containers – later owner

Container ships do not have many owners on average, therefore even the pooled later owner dataset is of limited size. It is recognized that the limited sample size (68 records, 42 events) can cause bias and thus negatively affect the validity of the findings. The raw data on ships status and builder area is presented in Figure 5.52.

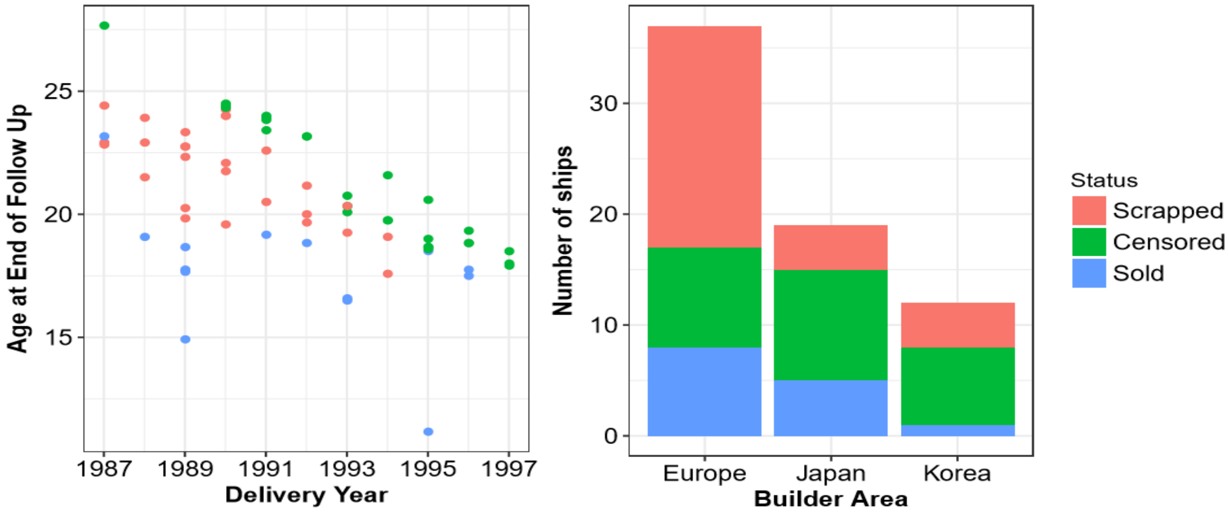


Figure 5.52. Containers Sample Profile – later owner

From all ship characteristics considered, the ones that have an effect on the survival of container vessels according to the data on later owner period of ownership, are ship's age at purchase and builder area.

The results are presented in Figure 5.53. According to the final Containers Cox PH model for later owner, ships built in Europe are a lot more likely to experience the event of interest than Japanese or Korean-built containers.

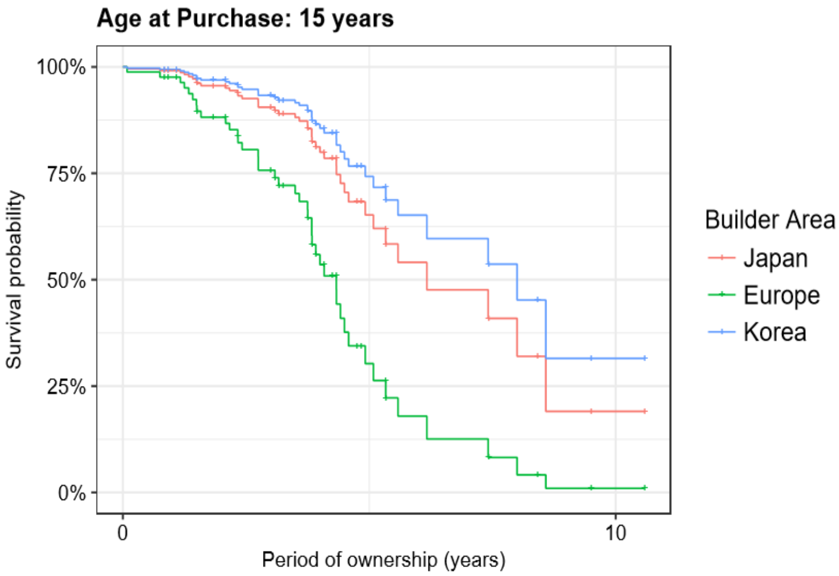


Figure 5.53. Predicted Survival Curves by Builder Area and Age at Purchase – Containers Cox PH model – later owner

According to the simulated relative hazard of age at purchase, shown in Data Annex Chapter 5, section 8.4, a vessel purchased at the age of 17 is twice more likely to experience termination of ownership than a vessel purchased at the age of 15. This is an indication of how strong the effect of ship's age is at this stage of the economic life of container vessels.

5.4. Periods of Ownership Results Overview

The following section provides a brief overview of the results addressing the research questions regarding: (i) likely length and patterns of ownership according to ship level characteristics; and (ii) whether certain ship characteristics, such as ship type, have an effect on the probability of a vessel to experience termination of ownership while in the possession of each respective owner.

5.4.1. Length of ownership

Earlier in this chapter it was established that the survival probabilities corresponding to different owners are significantly different (Figure 5.8; Table 5.4). The median and average period of ownership based on all ship records (censored and complete) corresponding to each owner number are presented in Table 5.14.

Owner No	1	2	3	4	5	6	7	8
Median Period (Years)	12.3	5.3	4.4	3.7	3.3	3.1	2.6	4.1
Mean Period (Years)	12.6	5.9	4.9	4.1	3.8	3.5	3.1	4.1

Table 5.14. Median and Mean Periods of Ownership by Owner Number – ship level

First owner period is considerably longer than subsequent periods of ownership, which is consistent with the results reported by Stott (2013). For subsequent owners, the average period of ownership gradually decreases from 5.9 years for second owner to about 3 years for the sixth owner.

As part of the exploratory analysis, average periods of ownership are also compared according to ship type. It appears that container ships are kept the longest by the first two owners, followed by tankers and bulkers. However, this trend disappears after the second owner as there is barely any difference between periods of ownership according to ship type in terms of the third owner period - 4.8 years for containers, 4.85 years for bulkers and 4.9 years for tankers. However, bulk carriers are found to be kept longer by later owners. This may seem counter-intuitive as bulk carriers were found to have a higher number of owners on average (2.4) and bearing in mind that vessels' economic life is finite, one would expect such ships to have shorter periods of ownership compared to container vessels, which have only 1.7 owners on average. This perceived paradox could be partially explained by the fact that bulkers have a higher median survival of 23.1 years, followed by 20.2 for tankers and 20.0 years for containers. Another likely explanation stems from a belief amongst shipping professionals that smaller bulk carriers are operated long after their 25th anniversary, especially if they service coastal trades in areas with less stringent regulatory regimes. This appears to be further supported by the data itself as the maximum age at purchase for Handy bulkers, which were still in operation at the end of the follow up period, is 27 years.

As the data on periods of ownership is censored no traditional statistical tests, such as t-tests or ANOVA, could be performed in order to check whether the average periods of ownership by ship type are statistically different. The average values for periods of ownership are reported but the information is treated as indicative of patterns rather than definitive. The following section investigates whether characteristics, such as ship type, have an effect on the probability of a vessel to remain in the possession of the respective owner.

5.4.2. Influences

Cox regression was used to examine periods of ownership on ship level as such models are capable of handling censored data. The analysis is stratified once by owner number in order to compare all ship characteristics postulated to have an effect on periods of ownership and subsequently by ship type.

a) Analysis by owner number

The analysis by owner number alone can be treated as complementary to the main analysis stratified by owner number and ship type because the effects of all characteristics are examined in more detail in the models stratified by ship type. The main purpose of the analysis by owner number is to establish whether there is a significant difference between ship types. As comparing any sub-categories across ship types, for example a Handy bulker, built in 1992 in China with a 2005 Korean-built Sub-Panamax container, are not of any particular interest due to the inherent differences between ship types, the analysis by owner number is achieved through fitting additive main effects models. A short summary of the findings is presented in Table 5.15. It should be noted that the ship characteristics (covariates) are not listed in any particular order as the purpose of the analysis is to establish whether a covariate has a significant effect on survival. The list of ship characteristics tested includes ship type, ship size[121], delivery year, builder area and age at purchase[122]. According to the summary of the main effects models by owner number, it can be concluded that ship type has a significant effect on the probability of vessels to remain with the first owner and second owners (Table 5.15). The effect of ship type weakens with owner number[123] - it is significant for second owner and then it becomes irrelevant for subsequent owners.

Owner	Covariates	Interpretation
First	Type Builder Area	Containers are the least likely ship type to be sold[124]. No significant difference between tankers and bulkers. Chinese-built ships are the least likely ones to be sold, followed by Korean-built vessels. On average, European and especially Japanese-built vessels are the most likely ones to be sold.
Second	Type Delivery Year Age at Purchase Builder Area	There is evidence that bulkers are more likely to experience the event. Vessels delivered in the late 1980s/early 1990s are more likely to be sold age for age than vessels built later. Ships that are older at purchase are more likely to experience the event. Ships built in China and Korea are less likely to be sold than ships built in Japan or Europe on average.
Third	Delivery Year Age at Purchase	Vessels delivered in the late 1980s/early 1990s are more likely to be sold age for age than vessels built later. Ships that are older at purchase are more likely to experience the event.
Later (>3)	Size Builder Area Age at Purchase	Larger ships are more likely to experience the event of interest regardless of ship type. Japanese built vessels are less likely to experience termination of ownership on average, whereas European built ships are the most likely ones to experience the event. The effect of age, as expected, puts vessels acquired at a later age at more risk of being sold or scrapped.

Table 5.15. Summary of Results by Owner Number – ship level

On average, Chinese and Korean-built ships are the least likely ones to experience the event of interest, whereas ships built in Japan and Europe are more likely to be sold by the first and second owners. However, in the later owner analysis Japanese-built ships were found to have the highest predicted survival in the bulker segment of the fleet.

Delivery year has a significant effect on the probability of sale for all owners apart from the first owner. For subsequent owners, however, vessels that are delivered in the

[121] Ship size is represented by deadweight capacity in the main additive models.
[122] Age at purchase is included in all models apart from first owner analyses. For more on age at purchase, see Section 5.2.2.b
[123] And with time as owner number represents a snapshot of the vessel's economic life.
[124] Equivalent to experiencing the event of interest – termination of ownership.

beginning of the delivery period (late 80s) are more likely to be sold than vessels delivered later on, age for age.

Age at purchase has a significant effect on the survival of vessels. As it can be expected, vessels that were older when acquired by the respective owner have a higher probability of being sold than vessels that were younger when acquired by the respective owner.

Size has a statistically significant effect on the probability of vessels to experience termination of ownership in the case of later owners only. As discussed earlier, termination of ownership could be a sale to another owner or to a scrap yard. The fact that size appears as a significant covariate in the later owner model can be explained by the combination of several factors: (i) the fact that most vessel records included in the later owner dataset belong to ships that are 20 years old on average; (ii) the likelihood of larger vessels to be scrapped earlier (Stopford, 2009); and (iii) the dependency of average scrapping age of the freight market (SIW, 2013). According to SIW (2013) the scraping age during the latest shipping boom up until 2009 was approximately 25 years, whereas during market slumps it decreases to about 20 years.

b) Analysis by owner number and ship type

The results from the analysis by owner number and ship type aimed to investigate which ship level characteristics affect the probability of termination of ownership within each individual segment of the fleet. The results describing how each covariate, found to have an effect on the probability of a vessel to experience termination of ownership, affects survival by owner number are presented in more detail in previous sections and all relevant model outputs can be found in Data Annex Chapter 5. In order to avoid repetition, only a brief summary of the average effects of each covariate is summarised below.

The list of covariates, which have a significant effect on the probability of termination of ownership by owner is presented in Table 5.16. First owner models for the three ship types identified the same covariates as significant – ship size, delivery year and builder area.

Owner Number	Significant covariates (Cox PH models)		
	Bulker	**Tanker**	**Container**
First	Size Delivery Year Builder Area	Size Delivery Year Builder Area	Size Delivery Year Builder Area
Second	Size Delivery Year Age at Purchase Builder Area	**Size*** Delivery Year Age at Purchase	Size **Delivery Year*** Age at Purchase
Third	Delivery Year Age at Purchase	**Size*** Delivery Year Age at Purchase	Size Age at Purchase **Builder Area***
Later	Size **Delivery Year*** **Age at Purchase*** Builder Area	NA	Age at Purchase **Builder Area***

Note: The covariates denoted with '' have a marginally significant (very weak) effect.*

Table 5.16. Summary of Results by Owner Number and Ship Type – ship level

Delivery year appears to be significant in the bulker and tanker segment of the fleet regardless of owner number. According to the findings there is evidence that tankers delivered in the late 1980s and early 1990s are more likely to experience termination of ownership (sale or scrap) in comparison with tankers of the same age built later. For example, a 10-year-old tanker built in 1987 is more likely to experience termination of ownership than a 10-year-old tanker built in 1997 (Figure 5.44).

It has been shown that OPA'90 affected the length of the economic lives of single hull tankers (OECD, 2017). Single hull tankers were found to be 50% more likely to be scrapped on average in comparison with double hull oil tankers (OECD, 2017). However, there is barely any difference between the scrap rates of single and double hull tankers until they reach 22-23 years of age (OECD, 2017, p 99), which according to the sample used in this research is the average scrap age for tankers. Therefore, the introduction of OPA'90 may have shortened the economic lives of single hull tankers but did not necessarily lead to a significant change in periods of ownership of ocean-going tankers overall, especially in the case of early owners. Research suggests that there was no quality differential in freight rates between single hull and double hull tankers (Tamvakis, 1995), which implies that there were no additional financial incentives for owners to sell or to scrap single hull tankers before they were due to be phased out[125].

The fact that no ship level characteristics were found significant in the case of later owners within the tanker segment of the fleet could partially be explained by the continuous acceleration of the phasing out of single hull tankers but it is also likely a product of insufficient sample size. For any formal tests to render statistically reliable results of whether OPA'90 affected termination of ownership, the sample size should be balanced. In the case of this research, single hull tankers comprise only about 20% of all tankers included in the sample. Therefore, any further statistical tests designed to investigate whether a significant difference between the likelihood of survival of different tanker categories exists may not be reliable at this stage.

The effect of delivery year is not observed only within the tanker segment of the fleet, which suggests that the effect is likely to be related to market cycles as it represents calendar time. The fact that vessels delivered at an earlier stage of the delivery profile of the sample are more likely to be sold on average than vessels built at a later stage of the delivery profile can be attributed to the market boom of 2003 to 2008. The shortage of tonnage supply led to a dramatic increase in second-hand prices, which tempted many to sell their assets. On the other hand, following the market collapse in 2008, a large number of ships were laid up for continuous periods of time.

Builder area has a strong effect on the probability of termination of ownership by the first owner. For subsequent owners, the effect decreases. It is likely that builder area serves as a proxy for company type and nationality of the beneficial owner. For example, many big Asian companies have significant fleets to serve their own domestic trades and their shipbuilding industries are backed up by state interests, which implies that a company such as COSCO, for example, is not likely to order ships from South Korea. The belief that Japanese and European-built vessels are superior to Chinese ships is another received wisdom amongst shipping professionals, therefore it is possible that certain maritime nations order ships based on their perceived quality.

Vessel size has a significant effect on survival when the size categories within each sector are being compared. On average in the bulk carrier category, smaller vessels

[125] For more information on OPA'90 and the phasing out of single hull tankers, see Appendix B-3.

have a higher probability of remaining with their respective owners. For tankers, there seems to be a shift associated with delivery year. For tankers built in the late 1980s and early 1990s it seems that, same as for bulkers, smaller ships have a higher probability of remaining with the respective owner. On the other hand, large tankers built during the early 2000s are less likely to be sold compared to smaller vessels built during the same period. For container ships, on average, large containers have a higher probability to remain with their respective owner. This is not surprising, bearing in mind that the liner industry is highly competitive and that capacity is key to market share.

Ship's age at purchase is relevant for subsequent owners, which is to be expected as the economic life of vessels is finite and operating older vessels is associated with higher maintenance costs.

5.5. Concluding Remarks

The chapter is aimed at investigating whether periods of ownership vary based on a predefined list of ship characteristics. In the light of the findings on typical periods of ownership of vessels built in the late 1980s and early 1990s reported by Stott (2013), it was postulated that periods of ownership differ based on owner number, ship type and size. As discussed in earlier chapters, an additional set of ship characteristics that might affect periods of ownership was added to the list suggested by Stott (2013) following a literature search and a number of interviews with industry professionals (see Chapter 7). The analyses were stratified by owner number because of (i) the evidence suggesting that periods of ownership differ by owner number based on the findings on periods of ownership by ship type and owner number reported by Stott (2013) and (ii) because it provided a convenient natural stratification by time. Creating separate models by ship type was decided based on the fact that the main shipping segments, represented by the three ship types, serve different trades and experience different market conditions in the short term[126].

An alternative approach would be to model the data as repeated events or recurrent event analysis, where the ship records are modelled as part of the economic life of each vessel. Such types of models are used when the focus of the research is on the event dependency within observations, common in reliability studies, for example, where often the aim is to predict equipment failure. However, the aim of the analysis

[126] See discussion in Chapter 4, section 4.3.3.

on periods of ownership is to examine the average effects of certain ship characteristics, therefore stratifying the analysis by owner number provides the ideal setting for the use of the Cox model.

The models described above, by owner number and by owner number and ship type, addressed the research questions of whether ship characteristics, such as ship type amongst others, have an effect on length of periods of ownership in shipping. Chapter 6 is dedicated to the investigation of the effect of company level characteristics on periods of ownership.

Chapter 6. Investigation on the Influence of Company Level Characteristics and Economic Indicators on Periods of Ownership

6.1. Introduction

This Chapter is dedicated to the investigation of periods of ownership based on both the company level characteristics and economic indicators considered as part of this research.

Section 6.2 provides an overview of length of ownership and patterns of ownership in terms of transition between owners (sales of vessels) based on company level characteristics. Furthermore, the influence of company level characteristics on the probability of termination of ownership is analysed with the help of Cox regression (section 6.3). That section builds on the results discussed in Chapter 5 regarding the influence of ship level characteristics on termination of ownership by adding company level characteristics to the analyses.

Next, the influence of economic indicators on the probability of termination of ownership is examined by using shipping earnings as a proxy for the state of the shipping markets (Section 6.4). This is achieved through extending the techniques used previously to accommodate covariates[127] which vary with time, such as shipping earnings.

Section 6.5 provides an overview of the results regarding the influence of the combined ship level characteristics, company level characteristics and economic indicators on the probability of termination of ownership across owner numbers.

Finally, section 6.6 provides some concluding remarks.

[127] The term '*covariates*' is used here instead of '*characteristics'* as it refers to variables (continuous or factor), which are to be fitted in a regression model. In the survival analysis literature the term '*covariate'* is preferred to *'control variable'*.

6.2. Periods of Ownership Overview in terms of Company Level Characteristics

A list of the available information on company level is discussed in section 4.3.2, accompanied by a brief overview of each characteristic. Based on the data limitations identified and discussed earlier, the characteristics considered likely to influence periods of ownership on company level and for which data is available are:

- Company Type – general type (financial, private, public or state);
- Company Size – owned fleet as per the end of the data collection phase;
- Nationality – registration and control.

In this section a selection of findings that illustrate and summarise the results on company level characteristics and their influence on periods of ownership, which is discussed later, are presented. Mean and median values for periods of ownership based on company level characteristics are discussed. Patterns of ownership are further examined in terms of the volume of ship sales based on different company level characteristics. Descriptive statistics regarding additional characteristics, such as the year that the company was founded, which were omitted from further analyses due to data limitations, can be found in Data Annex Chapter 6, section 1.

Furthermore, the Kaplan-Meier (KM) estimator was used to examine the individual effects of company level characteristics and to compare different groups comprising complete and censored observations. In the interest of brevity, only the KM results regarding first owner are presented here as this stage is a part of the preliminary screening of the characteristics to be included in the regression models which are used to identify the influence of different characteristics.

The main reason for dividing the analyses on '*ship*' and '*company*' level is the difference in sample sizes. Company level data is based on a reduced number of ship commercial history records and it represents a little over 50% of the original dataset on ship level[128]. The dataset on company level comprises 1,999 ships based on the examination of whose ownership history 3,674 changes of ownership were recorded. The number of companies which were involved in the ownership history of the 1,999 vessels examined is 1,125. It should be noted that the terms '*companies*' and '*records*' are not used interchangeably as the number of companies refers to the total number of companies that were identified as part of the analysis on changes of ownership

[128] The sampling framework is discussed in detail in Chapter 4, section 4.2.2.

(1,125), whereas '*records*' refers to the number of changes of ownership (3,674 in total). The numbers of companies and records according to the sample on company level is presented in Table 6.1.

Company Type	No. of Companies	No. of Company Records	Owner number* frequency based on No. of Records			
			1	**2**	**3**	**Later (≥4)**
Financial	26	111	64	34	10	3
Private	895	2316	1100	765	316	135
Public	159	1008	687	216	78	27
State	45	239	148	39	30	22
Total	**1125**	**3674**	**1999**	**1054**	**434**	**189**

** Refers to the owner number in the ownership sequence and not the total number of owners.*

Table 6.1. Number of Companies and Records – company level data

The number of financial and state companies is relatively limited, which led to the omission of these records from specific analyses where the sample size is too small rendering the categories irrelevant. For example, there are only 10 financial company records corresponding to the third owner (Table 6.1). Due to the very limited amount of data corresponding to later owners (≥4), the analyses by owner number include only the first three owners.

As the trends concerning lengths of ownership by owner number and ship type as identified earlier are in agreement across the ship and company samples, the results on length of ownership by ship type only are not included in the interest of avoiding repetition. However, a comparison between the results on length of ownership by owner number and ship type can be found in Data Annex Chapter 6, section 2.1.

6.2.1. Company type

Although 1,125 different companies are included in the sample, the number of records corresponding to each one of them differs based on the number of vessels each company was associated with. Figure 6.1 shows the top 10 companies with the highest total number of records in the dataset based on all three ship types.

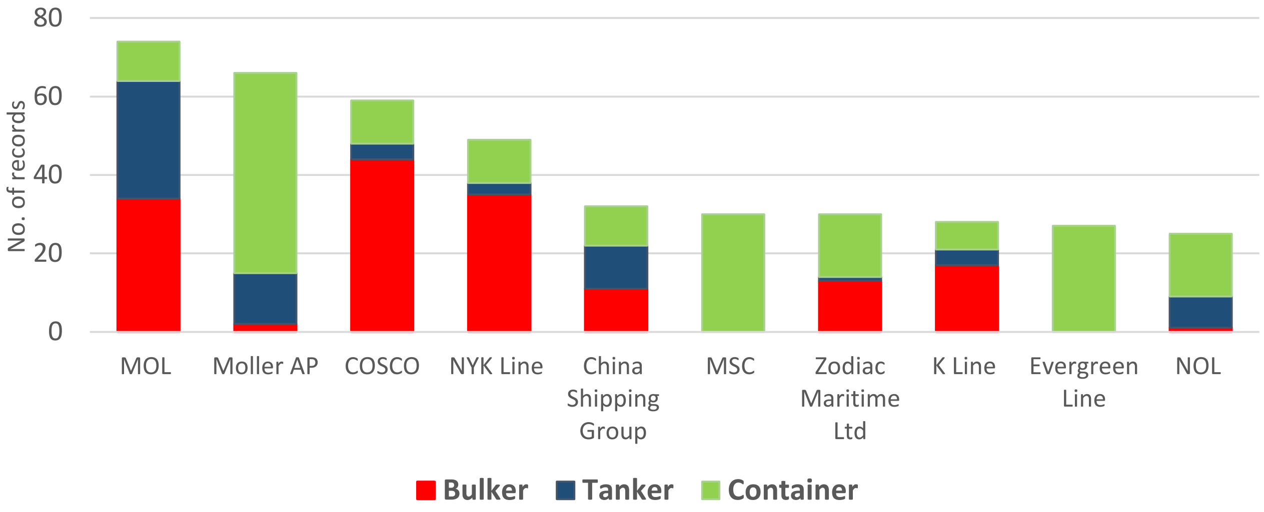


Figure 6.1. Top Ten Most Frequent Owners – company level data

As to be expected, some of the biggest shipping companies are the most frequent owners in the dataset, such as Mitsui Osaka Lines (MOL) and Moller AP. Figure 6.1 shows that some companies exhibit strong segment preferences. According to the company level data gathered as part of this research some of these companies operate in one main segment, such as Evergreen Line, whereas others have diversified fleets, such as China Shipping Group.

Figure 6.2 presents the proportion of records corresponding to each of the three main ship types that have been included within each company type according to owner number. According to Figure 6.2, proportionally bulk carriers comprise the largest single ship type category within every company type. The dominance of bulk carriers when it comes to later owners is attributed to the fact that tankers and container vessels tend to have smaller number of owners in total.

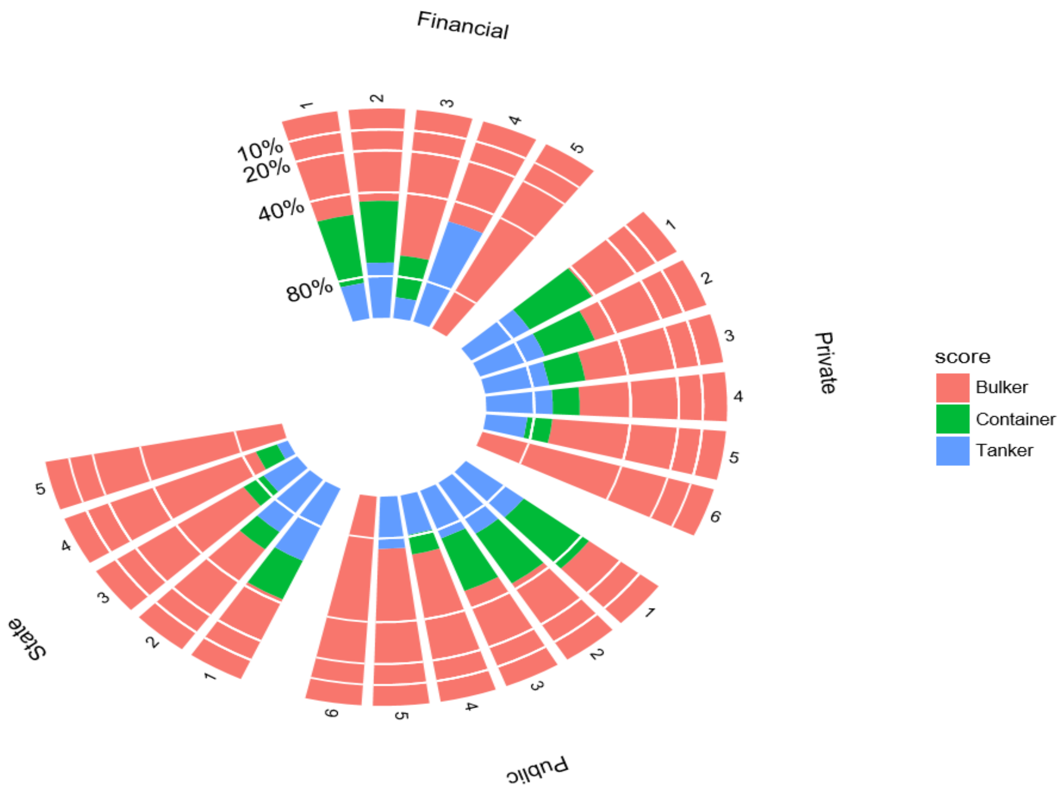
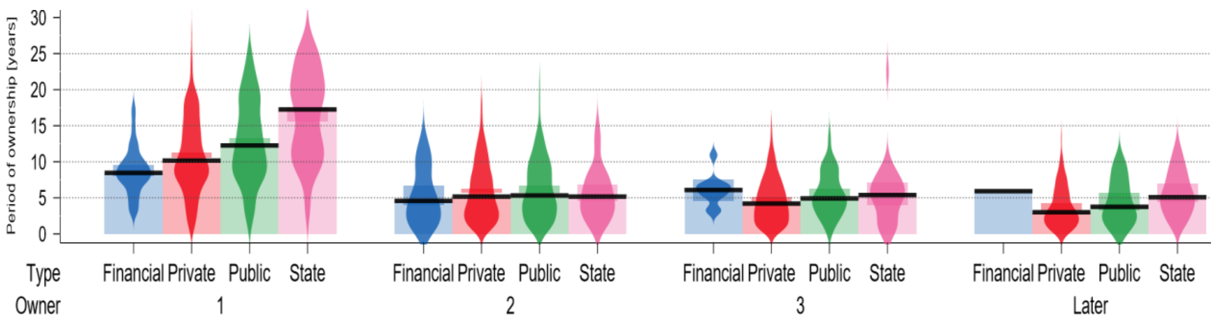


Figure 6.2. Fleet Distribution by Company Type and Owner Number

Figure 6.3 presents the median periods of ownership according to company type and owner number. In terms of first owner period, financial institutions such as investment funds, tend to keep vessels for less than 10 years, whereas state companies keep them for more than 15 years on average.



Company Type	1		2		3		Later	
	Median	Mean	Median	Mean	Median	Mean	Median	Mean
Financial	8.5	8.8	4.6	5.3	6.1	6.1	5.9	4.4
Private	10.2	10.9	5.2	5.9	4.2	4.7	3.8	3.0
Public	12.3	12.9	5.3	6.2	4.9	5.6	3.8	4.5
State	17.3	16.6	5.2	5.7	5.4	5.5	5.1	5.7

Figure 6.3. Periods of Ownership by Company Type and Owner Number

Interestingly, there is barely any difference between the behaviour of different company types in terms of periods of ownership corresponding to the second owner. For third and later owners the pattern established for first owner is repeated, although the difference in periods of ownership is less striking at this stage of the economic life of vessels. It should be noted that due to the very limited number of records belonging to financial institutions, the results regarding the behaviour of such companies are indicative for first and second owner period but no generalisations are possible in terms of results regarding periods of ownership corresponding to third and later owners.

The event of interest in the analysis is termination of ownership, which could take the form of a sale to a subsequent owner or to a scrap yard. Complete observations refer to records of vessels that experienced termination of ownership. By definition, censored observations correspond to vessels that were still in operation at the end of the follow up period. Figure 6.4 represents the proportions of complete and censored records in the dataset.

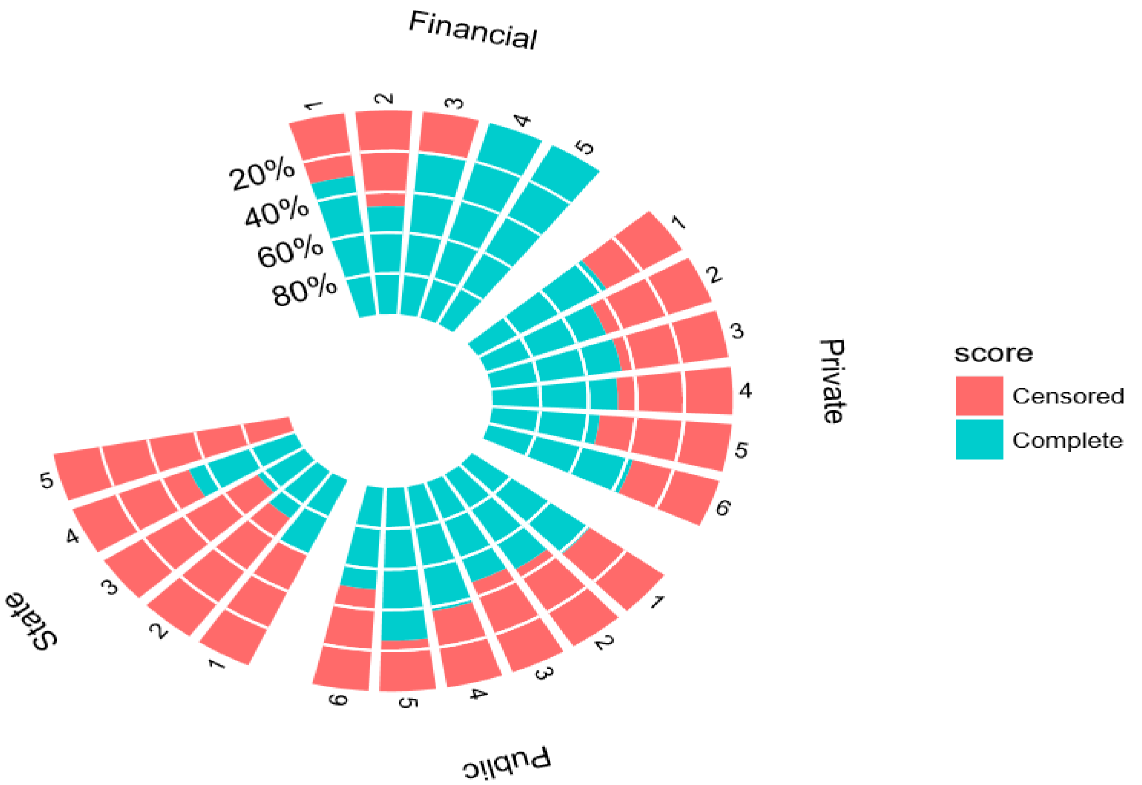
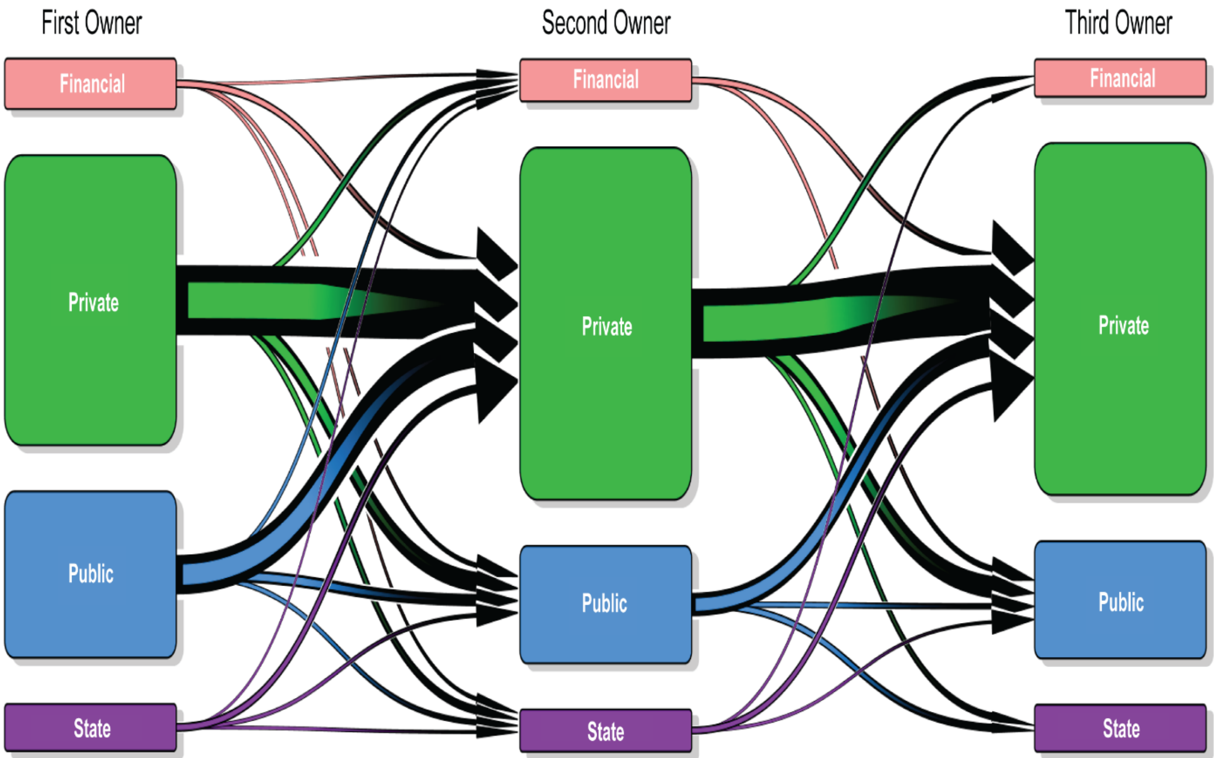


Figure 6.4. Distribution of Complete and Censored Observations by Company Type and Owner Number

It appears that for private and public companies, the proportions of complete and censored observations are very similar, whereas for state companies the number of complete observations is proportionately lower. In terms of financial organisations, the majority of the data records are complete.

As discussed earlier, the analysis is based on owner number, where the number assigned to each owner refers to the ownership sequence as recorded in the commercial history of each vessel. Figure 6.5 visualises the number of ships sold to subsequent owners. The size of the boxes assigned to each company type represents the proportion of each category within the sample per each owner number, whereas the width of the arrows represents the proportion of vessels sold within each category. For example, the proportion of ships owned by private companies out of the number of vessels that are sold by the first owner is smaller than the proportion of ships owned by private companies within the number of ships sold by the second owner.

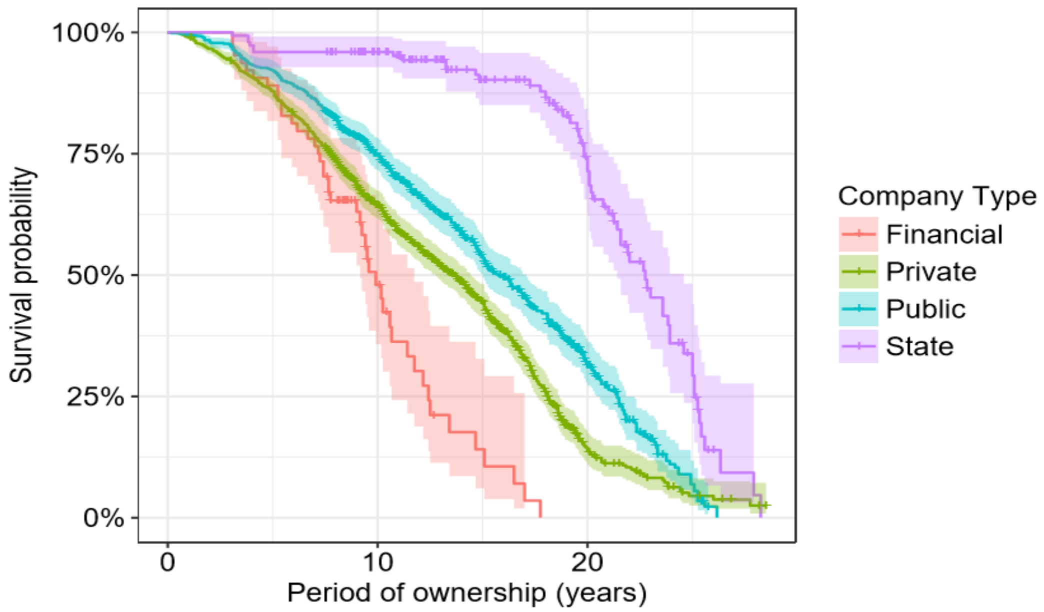


Number of vessels	Owner number		
	1st	2nd	3rd
Sold	**1,049**	**434**	**142**
Scrapped	165	120	87
Censored	785	495	205
Total	**1,999**	**1,049**	**434**

Figure 6.5. Ship Sales by Company Type and Owner Number

Although descriptive statistics provide an indication regarding certain data trends, no formal comparison can be achieved through standard procedures due to the nature of time-to-event data and censored observations. As an alternative to descriptive statistics, the *'survival'* of vessels is investigated where the survival probability refers to the probability of a vessel remaining with its owner for a time greater than a specified time t[129].

The survival curves corresponding to the four main company types considered as part of this research are presented in Figure 6.6. The KM plot on company type confirms that financial institutions are the most likely ones to sell a vessel, whereas the probability of a vessel to remain with a state company is considerably higher for first owner. The probability of survival of vessels owned by public companies appears to be very symmetrical in terms of the vessel's age as it drops by 25% in the first 10 years and then it continues to drop by 25% for every subsequent 5 years on average. For example, a 10-year old vessel has a 75% probability of remaining with the first owner, whereas for 15-year old ships the probability of remaining with the first owner is 50%.



Type	Records	Events	Median	CI	Survival Probability by Time (years)		
					10	15	20
Financial	64	44	9.9	9.2 - 11.8	0.5	0.1	-
Private	1100	691	13.7	12.8 - 14.4	0.6	0.4	0.1
Public	687	420	15.8	15.0 - 17.1	0.8	0.5	0.3
State	148	59	22.8	21.4 - 24.6	0.9	0.8	0.7

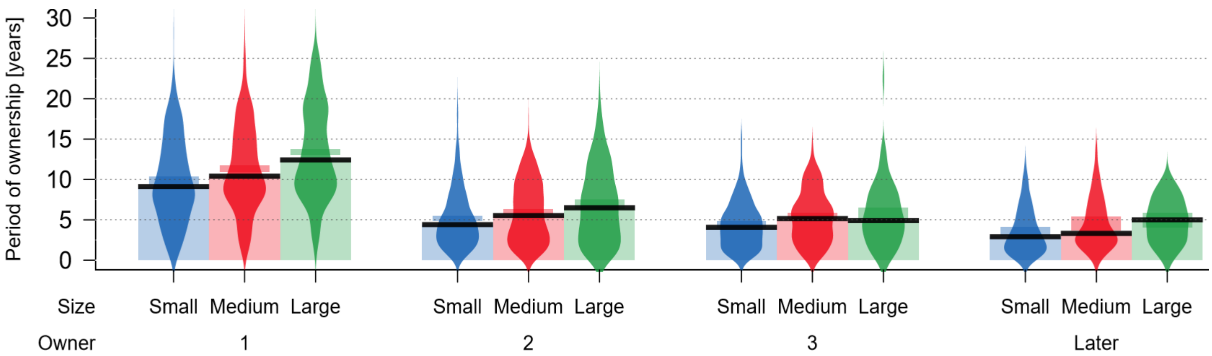
Figure 6.6. Survival Probability by Company Type, 1st owner period – Kaplan-Meier

[129] For a more detailed discussion on the choice of methods, see Chapter 3, Section 3.5.

6.2.2. Company size

The data on company size was originally grouped into six categories according to the custom size categories[130] used by CRSL, the data provider. However, exploratory analysis showed that there are no significant differences between neighbouring categories, such as for the very small (1-5 ships) and small (6-10 ships) companies for example[131]. In order to simplify the analyses, such categories were aggregated into 3 broader categories, namely: (i) small companies (1-10 ships); (ii) medium companies (11-50 ships) and large companies (more than 50 ships).

In terms of sector preferences, it appears that the large companies' category is the most balanced one, whereas smaller companies are found to be more engaged in the bulker and tanker segments of the fleet[132]. Figure 6.7 shows the mean and median periods of ownership based on company size and owner number.



Company Type	1		2		3		Later	
	Median	Mean	Median	Mean	Median	Mean	Median	Mean
Small	9.1	9.9	4.4	5.2	4.1	4.4	3.0	3.6
Medium	10.4	11.3	6.0	5.5	5.2	5.4	3.3	4.6
Large	12.4	13.4	6.5	6.9	5.0	5.7	5.0	5.0

Figure 6.7. Periods of Ownership by Company Size and Owner Number

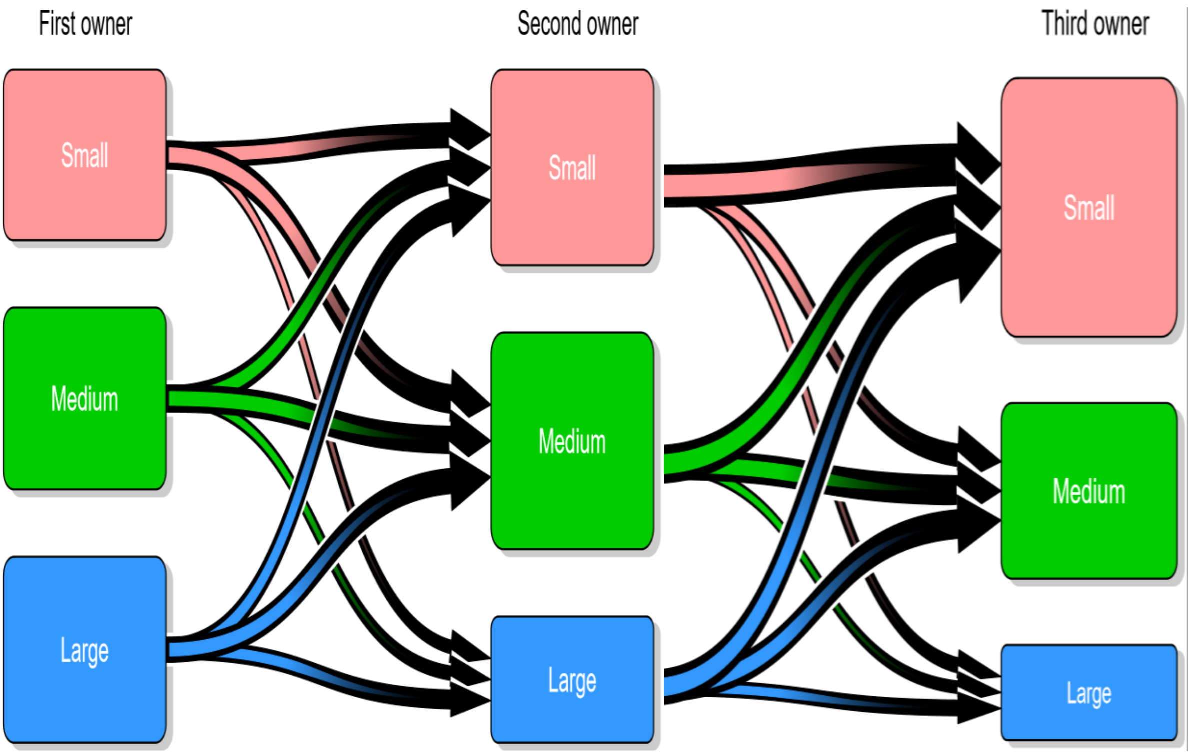
The mean and median length of ownership appear to be positively related to company size apart from the case of third owner, where there is barely any difference between the periods of ownership corresponding to medium and large companies.

It must be borne in mind, however, that the majority of companies classified as *'small'* are private companies, whereas most of the large companies are state, public or financial. Furthermore, the company size categories are based on fleet data as per the end of the data collection phase. The aggregated size categories are broad

[130] The size categories in question are discussed in Chapter 4, section 4.3.
[131] The exploratory work can be found in Data Annex Chapter 6, section 3.
[132] The fleet distribution by company size and owner number can be found in Data Annex Chapter 6, section 4.

enough that many companies would have remained within the fleet size margins assigned to each category, especially companies that had been established during the follow up period (42% of all companies).

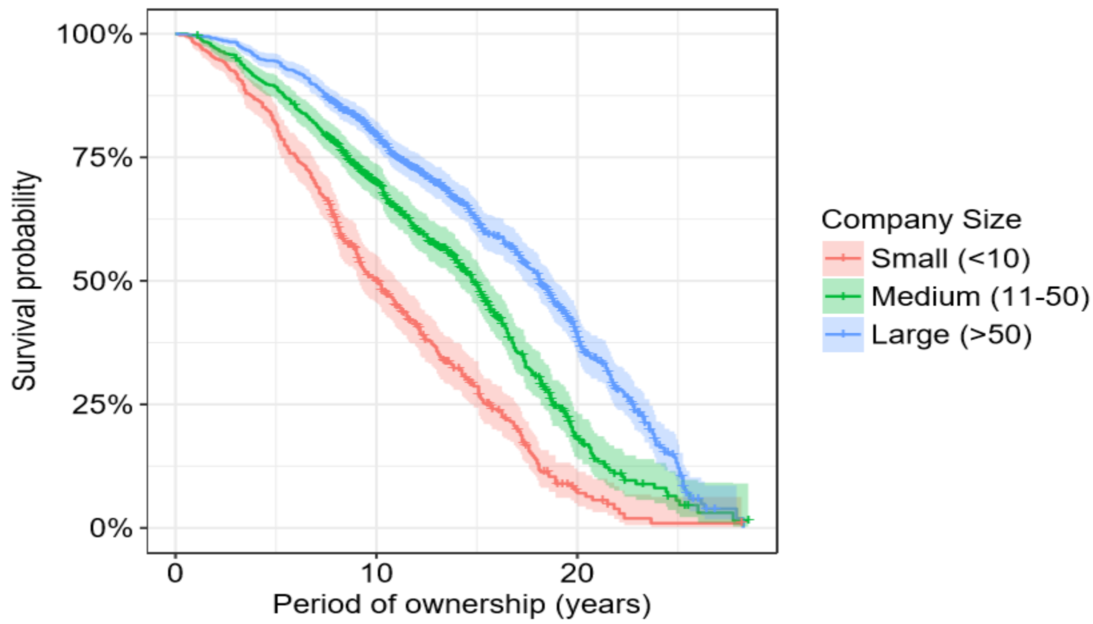
The transitions between owners suggests that although the distribution of companies by size is balanced within the records corresponding to first owner, the proportions of medium and large companies acting as second and third owners decreases substantially as shown in Figure 6.8. It should be noted that Figure 6.8 represents only data records belonging to vessels that were sold to subsequent owners.



*The number of vessels sold by owner number is shown in Figure 6.5.

Figure 6.8. Ship Sales by Company Size and Owner Number

The estimated survival probabilities of ships according to company size, shown in Figure 6.9, confirm the trends observed earlier regarding company size and length of ownership. Small companies were found to be more likely to sell ships on average, whereas ships owned by large companies are the least likely ones to experience termination of ownership age for age (Figure 6.9).



Type	Records	Events	Median	CI	Survival Probability by Time (years)		
					10	15	20
Small	430	344	10.1	9.1 - 11.1	0.5	0.3	0.1
Medium	665	392	14.8	13.9 - 15.6	0.7	0.5	0.2
Large	904	478	18.2	17.3 - 18.8	0.8	0.6	0.4

Figure 6.9. Survival Probability by Company Size, 1st owner period – Kaplan-Meier

6.2.3. Nationality

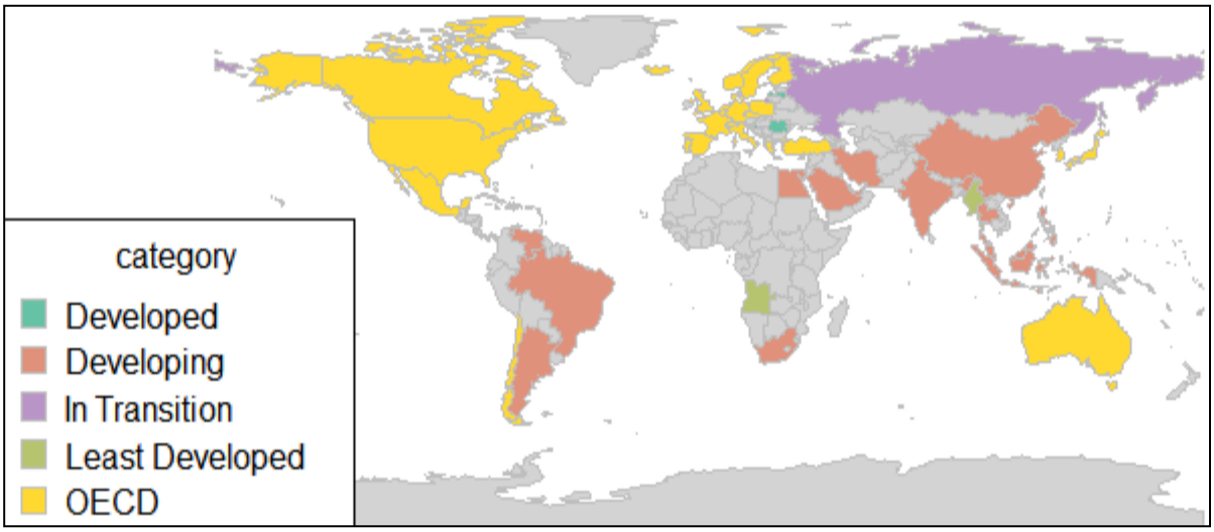
Nationality on company level is represented by nationality of control[133]. Several classification frameworks regarding nationality of control were considered, namely by: (i) geographical area; (ii) economic development status based on the United Nations' framework; and (iii) maritime traditions, a framework developed by Alderton and Winchester (1999). Figure 6.10 shows the different classifications according to geographical area. A comparison between the two maps reveals that the emerging maritime nations' category comprises almost exclusively of developing countries. Traditional maritime nations, on the other hand, comprise mostly of developed and OECD countries with some exceptions such as Brazil, Argentina and Russia.

As the number of records corresponding to the categories *'New Open Register'* (NOR) and '*Old Open Register'* (OOR) is limited, the records were added to the '*Emerging Maritime Nations*' (EMN) and the '*Traditional Maritime Nations'* (TMN) categories

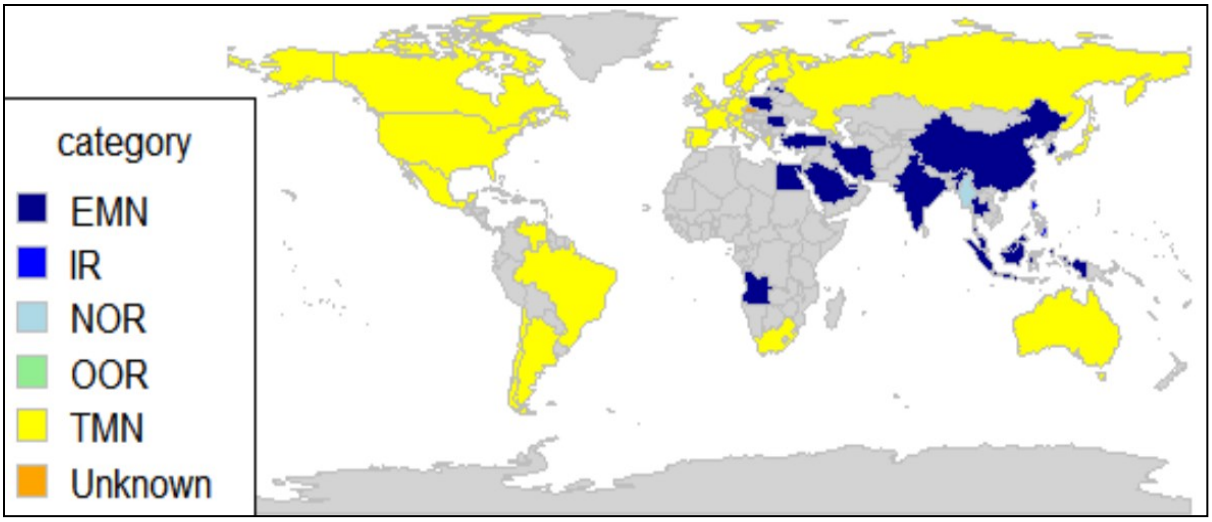
[133] Nationality of Control stands for the '*nationality behind the company regardless of location, and invariably where the primary economic contribution ultimately ends up*' (Sea-web, 2016a, p. 7). For basic descriptive statistics on nationality of control, see Chapter 4, section 4.3.2d.

respectively. Further aggregation was achieved through merging the *'International Register'* category with TMN as there is evidence that these categories have similar survival probabilities[134].

(i) Nationality of control by economic development status (UN framework)



(ii) Nationality of control by maritime traditions (Alderton and Winchester (1999))



Note: OECD stands for Organisation for Economic Cooperation and Development; EMN stands for Emerging Maritime Nations; IR stands for International Register; NOR and OOR stands for New and Old Open Register respectively; TMN stands for Traditional Maritime Nations.

Figure 6.10. Nationality of Control – classification framework

Figure 6.11 presents the survival probabilities by maritime traditions and by economic development status. The emerging maritime nations are found to be less likely to sell vessels on average according to the data on first owner period. In terms of economic

[134] The evidence is presented in Data Annex Chapter 6, section 3.2.

development status, on average owners from developing countries are the least likely to sell their vessels when acting as first owners, whereas owners from the OECD countries and the countries in transition are the most likely ones to sell their ships. The two economic development status plots at the bottom of Figure 6.11 show the survival of vessels associated with owners from traditional and emerging maritime nations by economic development status. Interestingly, the estimated survival of vessels does not vary significantly with economic development status within the traditional maritime nations. However, developing countries classified as '*emerging maritime nations*' according to Alderton and Winchester's (1999) framework appear to be causing the difference between traditional and emerging maritime nations' estimated survival as such countries: (i) comprise the majority of the records classified as '*emerging maritime nations*' and (ii) have a higher estimated survival on average.

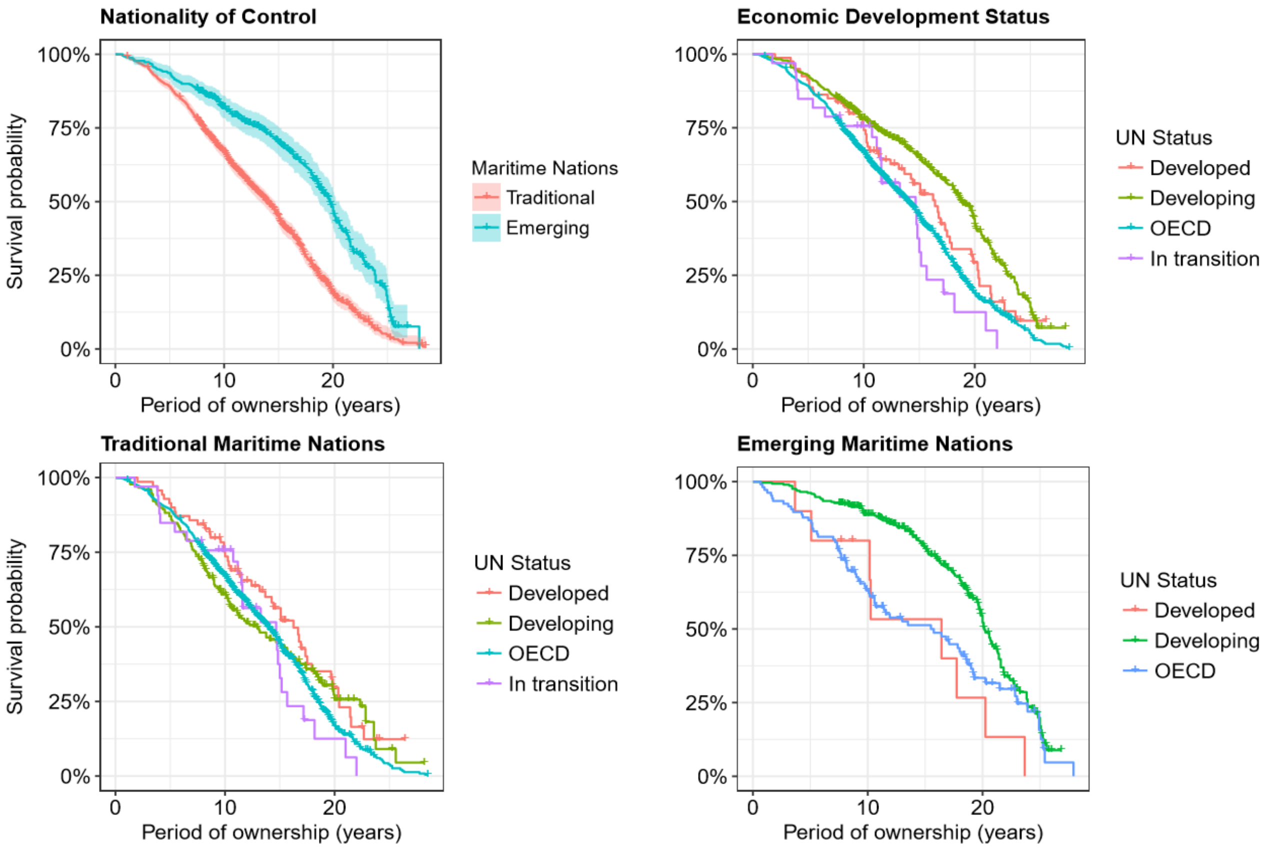
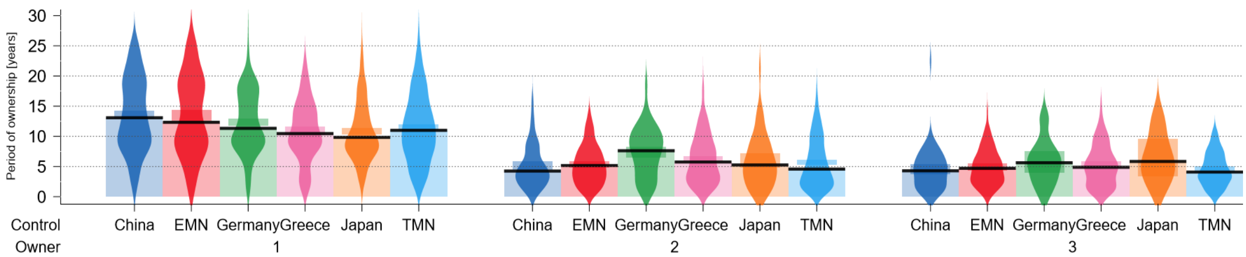


Figure 6.11. Survival Probability by Nationality of Control, 1st owner period - Kaplan-Meier

Based on the above, the classification by maritime traditions was deemed to provide a better representation of the behaviour associated with periods of ownership and it was chosen as the base for the analyses dedicated to investigating the influence of company level characteristics.

Further disaggregation of nationality of control can be achieved by considering the countries with the largest fleets. The largest number of data records on company level corresponds to the following countries: Japan, Greece, China, Germany, Singapore and Korea, which is consistent with the 2015 world fleet ownership statistics (Table 4.8). The only countries classified as EMN from the list above are China and Korea. It is recognized that certain countries might be less involved in some shipping segments, therefore the top three nationalities of control within each segment based on the number of records in the dataset are used in the analyses. Figure 6.12 provides a summary of the mean and median periods of ownership based on the top nationalities of control compared to the rest of the traditional and emerging maritime nations. Chinese owners appear to keep their vessels the longest in terms of first owner period, whereas German owners are found to keep vessels longer in their role as subsequent owners. However, it should be noted that German owners are predominantly involved in the container sector.



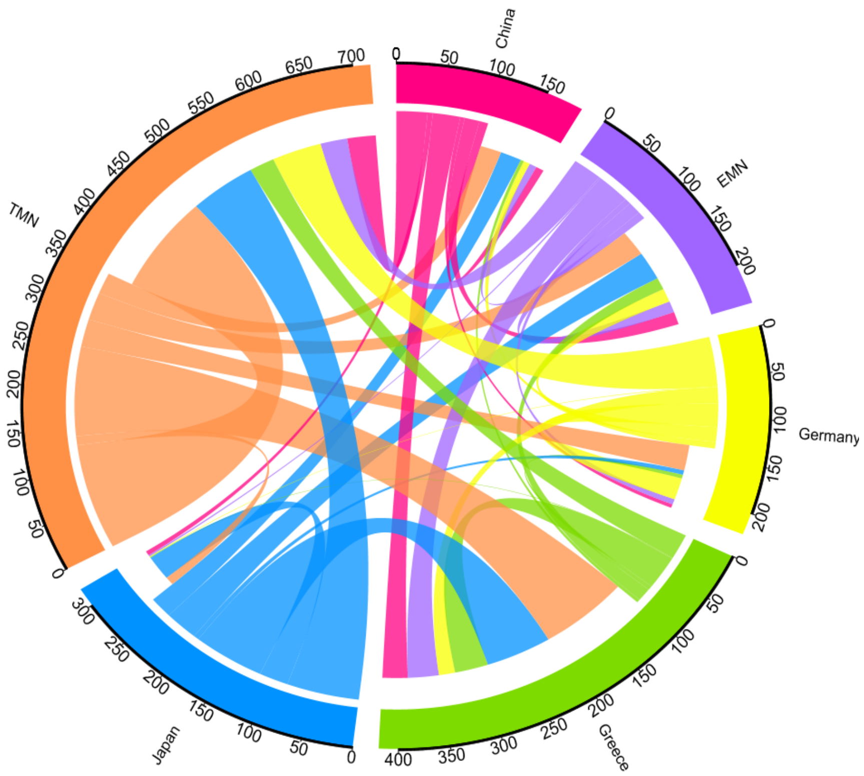
Company Type	1		2		3*	
	Median	**Mean**	**Median**	**Mean**	**Median**	**Mean**
China	13.1	13.6	4.3	5.1	4.3	4.6
EMN	12.3	13.5	5.2	5.4	4.7	5
Germany	11.3	12.3	7.6	7.4	5.6	5.8
Greece	10.5	10.9	5.8	6.3	4.9	5.3
Japan	9.8	10.9	5.2	6.0	5.8	6.5
TMN	11.0	11.5	4.6	5.7	4.1	4.6

**Later owner data is not included as the sample size is limited for most of the categories, such as Japan (1 ship).*

Figure 6.12. Periods of Ownership by Nationality of Control and Owner Number

Figure 6.13 represents the transitions of vessels between owners based on nationality of control. This is achieved through employing circular diagrams developed by Sander *et al.* (2014) in order to visualise the complex structure of migration flow data. The advantage of this approach is that it allows transitions between a large number of groups to be shown simultaneously (Sander *et al.*, 2014). The nationalities of control are represented by the segments of the circle diagram. These segments represent the number of ships sold and bought by owners associated with the same nationality of control.

(i) Sales between 1st and 2nd owner



(ii) Sales between 2nd and 3rd owner

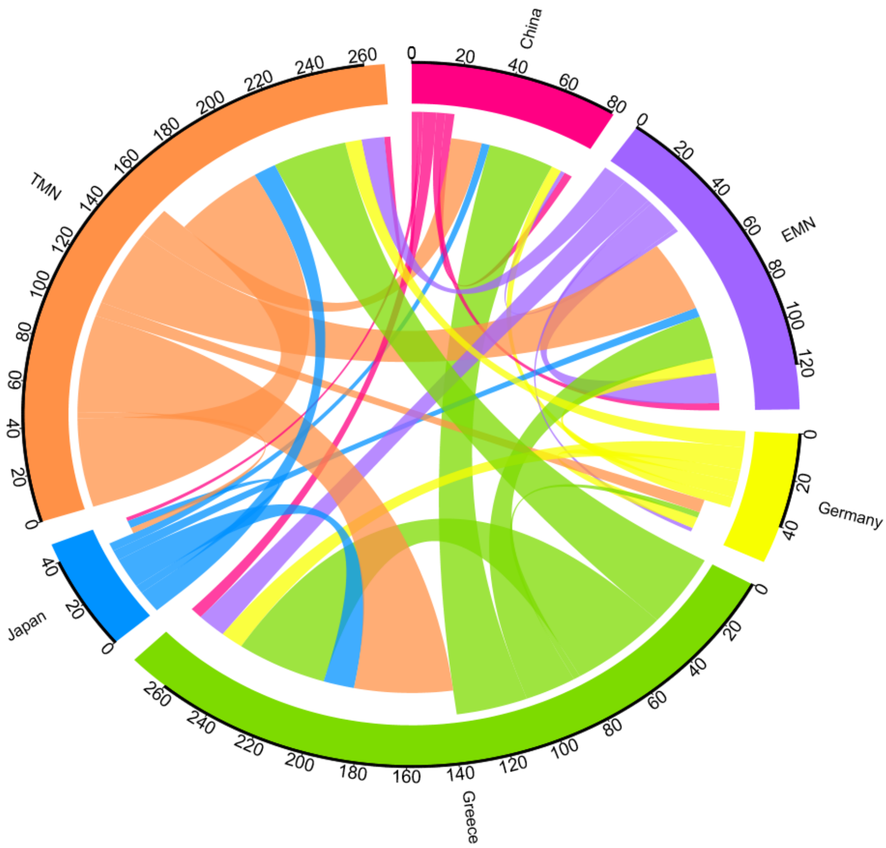
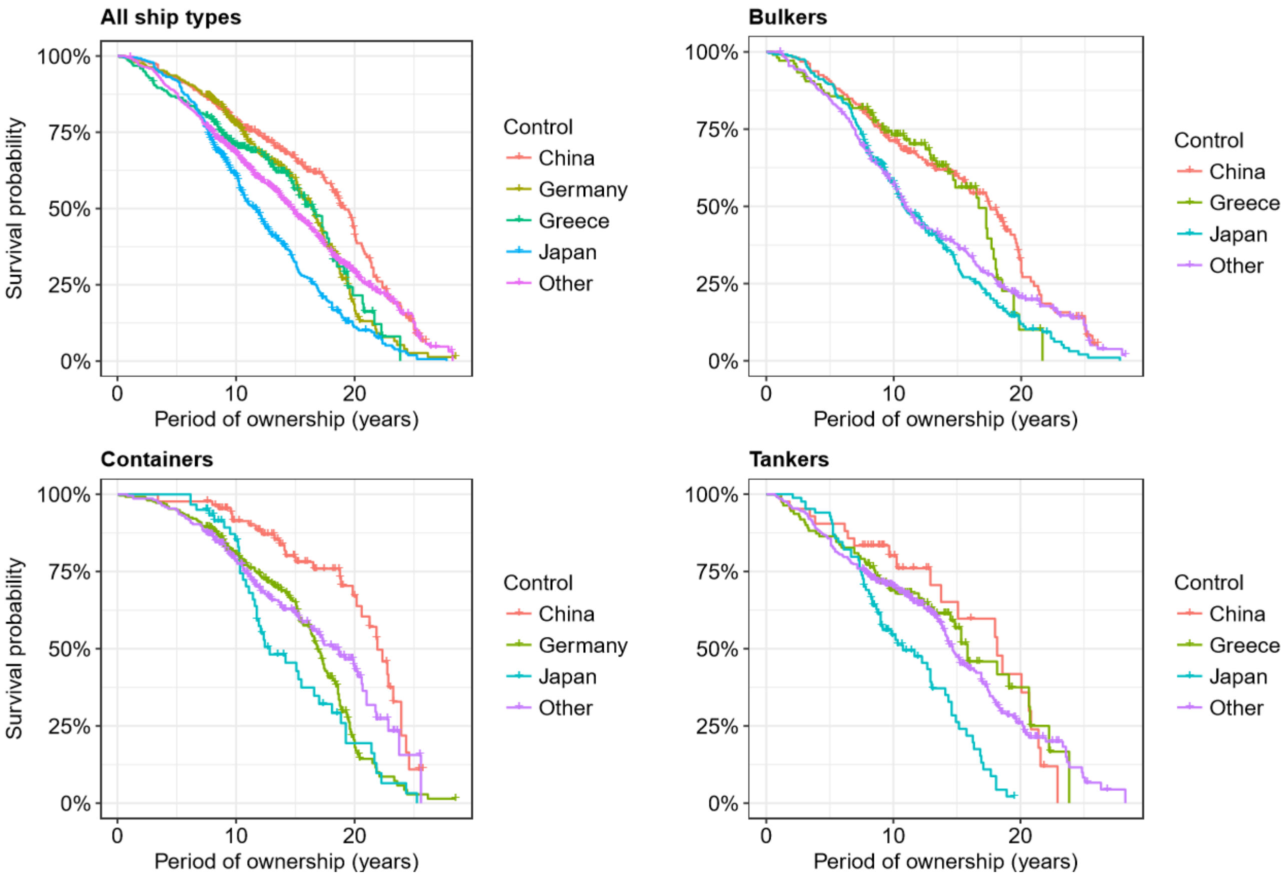


Figure 6.13. Ship Sales by Nationality of Control and Owner Number

The outgoing flows show the number of vessels sold and are shown: (i) in the same colour as the respective originating segment; (ii) and closer to the outer track of the respective segment. The incoming flows represent the number of vessels that were bought by owners associated with the respective nationality of control. The volume of sales is represented by the width of each flow. For example, Greek-owned vessels are depicted in green. In the case of ship sales between the first and second owner (Figure 6.13 (i)), the segment representing Greece comprises approximately 420 vessels. The outgoing flow (green) of approximately 100 ships represents vessels, whose first owner was associated with Greece and that were sold to subsequent owners. The incoming flows, which are further away from the outer track of the segment represented in green and other colours, represent the ships bought by Greek owners. This suggests that owners associated with Greece acted as first owners for only 100 vessels, whereas the number of Greek-owned ships in terms of second owner increased to more than 300 vessels. The majority of these vessels were previously owned by owners associated with Japan (blue flow), other traditional maritime countries (orange flow) and Greece (green flow). A noteworthy trend that becomes apparent from Figure 6.13 according to the sample is that Japanese and German owners tend to be more interested in new ships, whereas Greek owners are particularly active in the second-hand market. Furthermore, Japanese owners appear to purchase second-hand ships almost exclusively from other Japanese owners.

The estimated survival of ships based on the further disaggregation of nationality of control is presented in Figure 6.14. On average, Chinese-owned vessels are the least likely ones to experience termination of ownership, whereas Japanese-owned ships are the most likely ones to be sold in terms of first owner period regardless of ship type. In the case of bulkers, Greek-owned ships have a surprisingly high survival probability. For example, a 10-year old Greek-owned bulk carrier has a survival probability of 75%, whereas a Japanese-owned bulker of the same age has only a 50% probability of remaining with the original owner. However, this trend disappears with age as Greek-owned tonnage’s survival probability drastically decreases after the age of 17. In contrast to bulkers, Japanese-owned container vessels have a very high survival probability until the age of 10. The survival probability of 12 year-old Japanese-owned container is 25% lower than that of a 10-year old Japanese-owned container vessel.



* TMN and EMN are grouped under the category 'Other' in the interest of clarity.

Figure 6.14. Survival Probability by Nationality of Control and Ship Type (top 3 countries), 1st owner period – Kaplan-Meier

To sum up, all three main company level characteristics described in this section, namely company type, company size and nationality of control (in terms of maritime traditions and by top shipowning country) are included in the following analyses designed to estimate the simultaneous effect of multiple characteristics on periods of ownership in shipping.

The analyses are structured in a similar way to the investigation of effects on periods of ownership on ship level discussed in Chapter 5. The stratification by owner number and ship type is introduced because of the following reasons: (i) there is evidence that periods of ownership may vary by ship type and owner number; (ii) the stratification by owner number improves the validity of the results as it decreases the probability of the PH assumption being violated[135] and (iii) it improves the interpretability of the

[135] Stratification by owner number implies stratification by time, which is one of the main techniques used to control for the validity of the PH assumption. For more information, see Chapter 3, section 3.3.2.b).

results. The following sections provide a brief overview on length of ownership by owner number, followed by the results from the Cox regression models by owner number and ship type aiming to determine which covariates influence periods of ownership on ship and company level.

Due to the limited number of data records corresponding to later owners (≥4) as shown in Table 6.1, the following analyses do not include data corresponding to later owners for tankers and container ships. However, the number of records corresponding to later owners in relation to bulk carriers, which were found to have more owners and a higher scrapping age[136] on average, is larger, which allowed the analysis on the influence of company level characteristics to be performed.

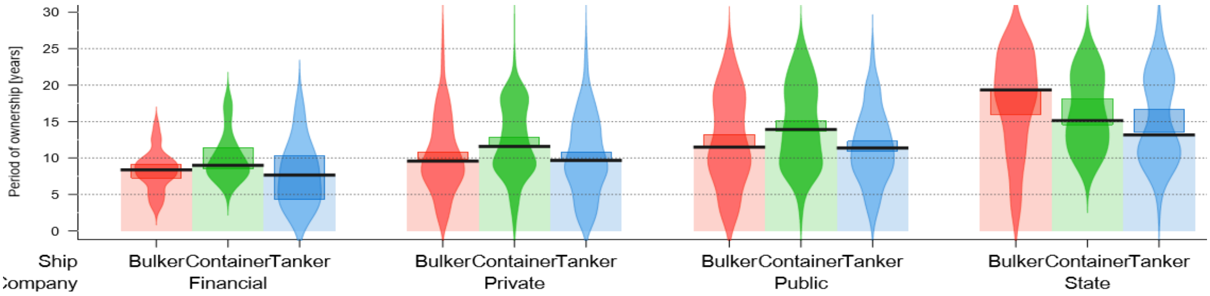
6.3. Periods of Ownership Analysis by Owner Number Including Company Level Characteristics

6.3.1. Periods of ownership corresponding to first owner – company level

a) Length of ownership – first owner

The periods of ownership data corresponding to first owner is based on the commercial history of 1,999 vessels on company level. The highest proportion of records belongs to bulk carriers (40%), followed by containers (31%) and tankers (29%). Figure 6.15 shows first owner median and mean periods of ownerhsip according to ship and company type. Figure 6.15 confirms the trend identified earlier according to which financial institutions keep the vessels for the shortest period of time, followed by private and public companies. State companies seem to keep vessels for substantially longer compared to other types of companies. In terms of ship type, state companies retain bulk carriers the longest, which is surprising given that bulk carriers are traded more frequently on average than the other two ship types. Container ships are found to be kept the longest by the first owner regardless of company type apart from state companies. There is barely any difference between periods of ownership corresponding to bulkers and tankers owned by private and public companies. It should be noted that on average, there is little difference between the length of ownership of tankers and bulkers in terms of first owner period according to the reduced company type dataset (Data Annex Chapter 6, section 2).

[136] See Chapter 4, section 4.3.1.c) and section 4.3.1.e) respectively.



Company Type	Financial		Private		Public		State	
	Med	Mean	Med	Mean	Med	Mean	Med	Mean
Bulker	8.4	8.3	9.6	10.4	11.5	12.5	19.3	17.8
Container	9.0	10.1	11.6	12.3	13.9	14.4	15.1	16.3
Tanker	7.7	7.7	9.7	10.2	11.4	11.7	13.2	15.4

Figure 6.15. Periods of Ownership According to Ship and Company Type - 1st owner

b) Results by ship type and owner number – first owner

The event of interest is termination of ownership. Censored observations correspond to vessels which were still in the possession of their first owner at the end of the follow up period. The model of choice for examining the effect of multiple fixed covariates on periods of ownership in shipping is the Cox PH model[137]. For each owner number a main effects model including all ship types is investigated aiming to provide an overall indication of the effect of covariates and to explore whether there is a difference between the three main ship types before the analysis is further stratified by ship type. The covariates included in the main effects Cox PH model corresponding to first owner on company level include: (i) the ship level covariates identified as influencing periods of ownership on ship level and (ii) the company level covariates selected as likely to have an effect on periods of ownership based on their individual effect as explored in the previous section. Builder area and nationality of registration have been excluded from further analytical work presented here as in most cases nationality of control coincides with nationality of registration and builder area, especially in the case of first owner period (Data Annex Chapter 6, section 1.3). A likely explanation is rooted in the design of the study as the company of interest is the group owner. More variation between nationality of control and nationality of registration is expected if the analysis focused on registered owners. Furthermore, based on preliminary work (Data Annex Chapter 6, section 5), it was established that builder area does not have a significant

[137] More detailed discussion on the choice of model can be found in Chapter 3, section 3.3.2.

effect on periods of ownership when company level characteristics are added to the model. The covariates included in the main effects Cox PH model on company are presented in Table 6.2.

Covariate Type	Covariate	Levels	Records	Events
Factor	Ship Type	Bulker (base)	797	565
		Container	617	314
		Tanker	585	335
	Company Type	Financial	64	44
		Private	1100	691
		Public	687	420
		State	148	59
	Company Size	Small (≤10)	430	344
		Medium (11-50)	665	392
		Large (>50)	904	478
	Nationality of Control	Emerging Maritime Nations	409	212
		Traditional Maritime Nations	1590	1002
Numeric	Ship Size (as DWT)	NA*	1999	1214
Integer	Delivery Year	NA*	1999	1214

* No levels as the covariates are not factors.

Table 6.2. List of Covariates – Main effects Cox model on company level – 1st owner

The main effects (ME) Cox PH model's output along with all relevant models' outputs and diagnostics referring to first owner data can be found in Data Annex Chapter 6, section 5. According to the main effects Cox PH model container ships are significantly less likely to experience termination of ownership while in the possession of the first owner than bulkers and tankers on average. Smaller vessels and vessels delivered at an earlier stage of the delivery profile of the sample were found to be less likely to experience the event of interest. Financial companies are the most likely ones to sell a vessel, whereas state companies are the least likely ones to do so. In terms of company size, small companies (≤10 ships) are the most likely ones to sell a vessel. Owners from traditional maritime countries are more likely to sell a vessel than owners from emerging maritime countries.

As all covariates included in the main effects Cox model on company level appear to have a significant effect on first owner period, all of them are tested for significance in following models that are stratified by owner number and ship type[138]. In the interest of brevity, only the results from the final models are reported. In the context of this

[138] It should be noted that as the following models are stratified by ship type, ship type is omitted from the default set of covariates.

chapter, a '*final*' model refers to a model, which provides the optimal model fit and satisfactory model diagnostics according to the chosen model building procedure[139].

Bulkers – first owner

The list of covariates in the final Bulkers Cox PH model corresponding to first owner on company level, referred to as 'Bulkers Cox PH-1st owner on company level' includes the following covariates:

- Ship size (Handy, Panamax, Capesize);
- Delivery year of the vessels;
- Company type;
- Company size;
- Nationality of control.

The covariates included in the final model were further tested for significance with the help of random survival forests (RSF) as in earlier chapters. In the interest of brevity, relevant results will be presented only if any discrepancies are detected. Otherwise, the RSF results can be found in Data Annex Chapter 6, section 5.2.

Delivery year was not found to have a significant effect on the probability of remaining in the possession of the first owner when company level covariates are added to the model. No significant difference between Handy and Panamax bulkers was detected in terms of their probability to experience termination of ownership by the first owner[140]. However, Capesize bulkers were found to be significantly less likely to experience a sale than smaller bulkers on average.

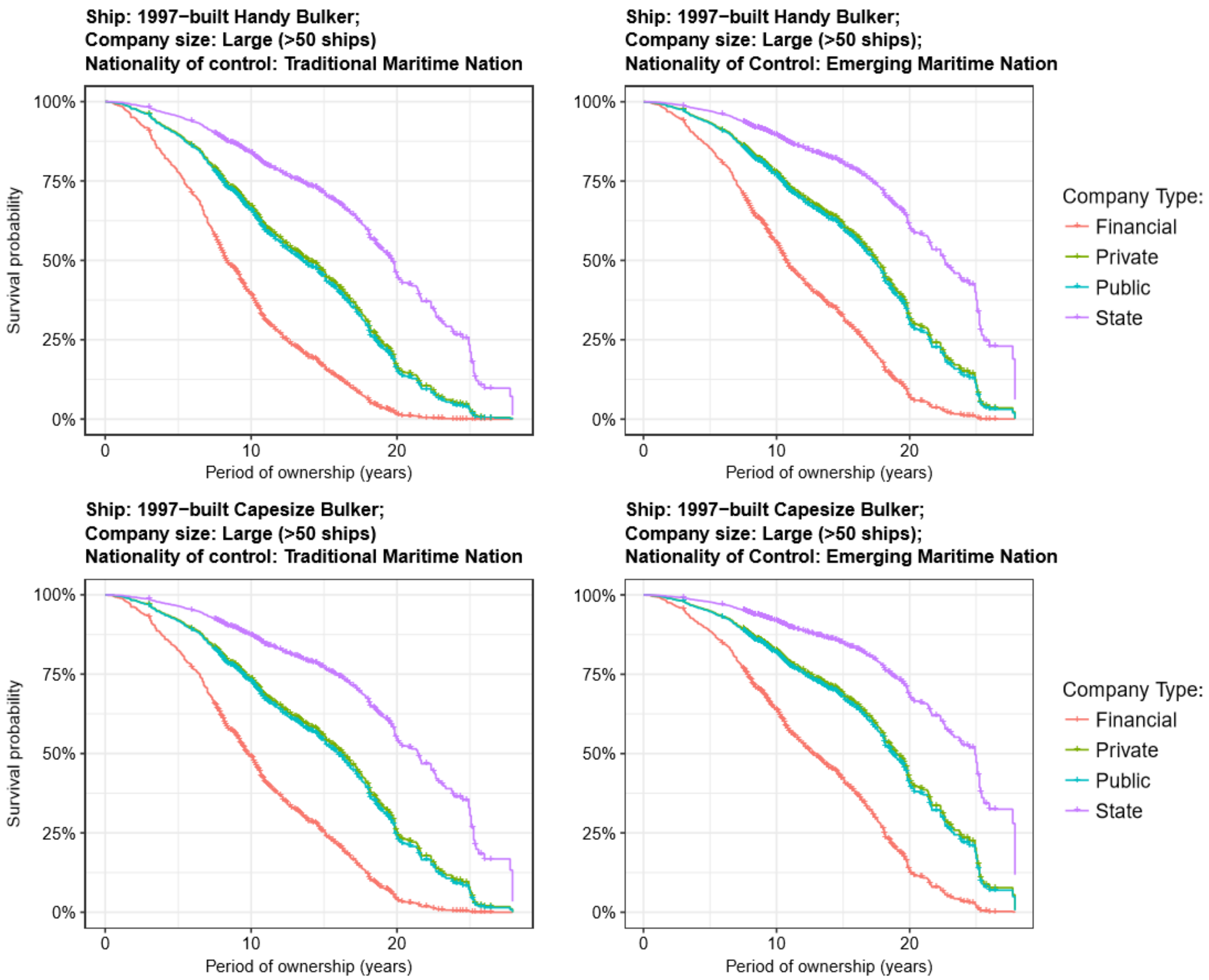
The results on company type and size corresponding to first owner period for bulk carriers are consistent with the overall trends identified earlier. The probability of survival of bulkers owned by financial companies is the lowest, whereas state companies' predicted survival is the highest. There is no significant difference between the survival probabilities of ships owned by private or public companies in the dry bulk sector. In terms of company size, however, all three categories comprising small, medium and large companies, are significantly different from each other. On average,

[139] As discussed in Chapter 3, section 3.3.2.b).

[140] The probability to remain with the respective owner is also referred to as the survival probability. Ships with higher survival probability have a lower probability to experience termination of ownership (the event of interest, which can be a sale to a subsequent owner or a scrap yard) respectively. Throughout this chapter, the results are reported using both – the survival probability and the probability of experiencing the event of interest (termination of ownership) in order to avoid repetition. This is discussed in Chapter 3, section 3.3.2.b) in theoretical terms.

small companies with a fleet of 10 ships or less are the most likely to sell a vessel, followed by medium and large companies age for age.

In terms of nationality of control, the probability of vessels to be sold by owners from traditional maritime nations is higher than that of owners from emerging maritime nations. Figure 6.16 shows the predicted survival probabilities of vessels based on the effect of company type and how they change within ship size and nationality of control.



Note: The predicted survival curves of Private and Public companies overlap.

Figure 6.16. Predicted Survival Curves by Company Type – Bulkers Cox PH model – company level, 1st owner

Further investigation[141] on nationality of control included the top three nationalities in terms of number of appearances in the sample for bulk carriers, namely Greece, Japan and China. The results, which are based only on private and public company records due to sample limitations, show that Greek-owned vessels have the highest probability of survival on average, whereas Japanese-owned bulkers and bulkers with owners from other traditional maritime nations have the lowest survival in terms of first owner period. It should be noted that the majority of state companies' records correspond to Chinese companies, such as COSCO and China Shipping Group. The relatively low predicted survival of Chinese-owned bulkers is caused by the omission of state companies' records from the further analysis on nationality of control.

Tankers – first owner

The final Tankers Cox PH model corresponding to first owner on company level, referred to as '*Tankers Cox PH-1st owner on company level'* includes the following covariates:

- Company type;
- Company size;
- Nationality of control.

Further tests, belonging to the random survival forests' family of techniques, confirmed that all the chosen covariates do have an effect on first owner period for tankers.

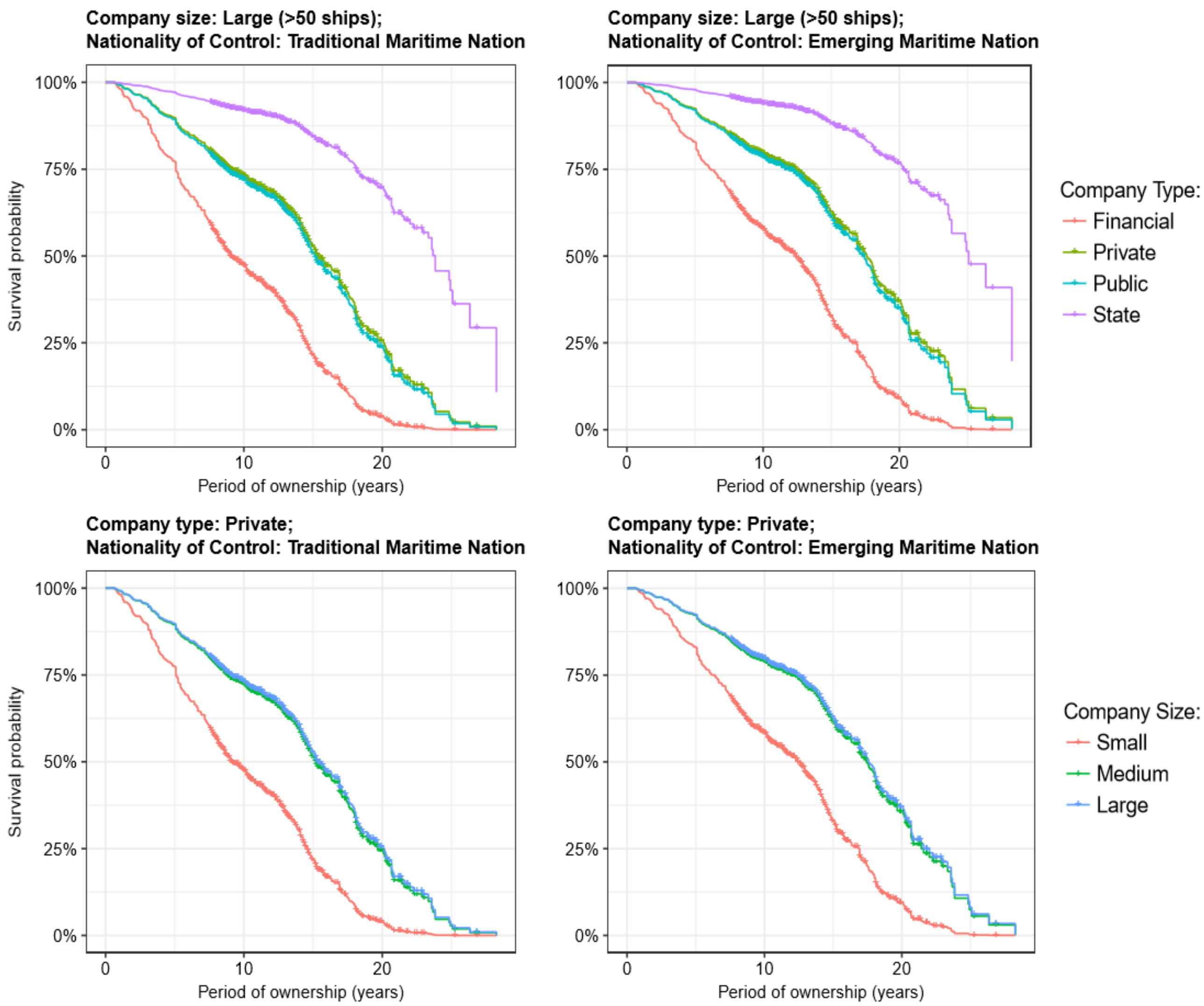
Ship level characteristics, such as ship size and delivery year, were not found to have a significant effect on the probability of termination of ownership in the tanker segment of the fleet. Fig 6.17 presents a selection of the results, in the form of predicted survival curves, which aims to illustrate the effects of the covariates included in the final model.

In terms of company type, the results are consistent with these for dry bulk carriers, namely: (i) financial companies are on average the most likely ones to sell ships; (ii) there is no significant difference between private and public companies in terms of the likelihood of termination of ownership to occur; and (iii) state companies are the least likely to sell ships. Another similarity between bulkers and tankers can be observed in

[141] This model uses a different classification regarding nationality of control and it can be found Data Annex Chapter 6, section 3.2. Instead of classifying the data by maritime traditions only, the sample is split into five categories – the three top nationalities of control for bulk carriers and the rest of the nationalities of control are organised in two broad categories representing traditional maritime nations and emerging maritime nations. Using additional factor levels, however, reduces the number of observations within each stratum, which led to omitting the data on state and financial companies due to reduced sample sizes. This is the reason why the main models presented here use the classification by maritime traditions as it allows the inclusion of state and financial companies in the analysis.

that owners from traditional maritime countries are more likely to sell vessels on average (Figure 6.17).

The results on company size indicate that tankers owned by small companies (≤10 ships) are significantly more likely to be sold in comparison to medium (11-50 ships) or large (>50 ships) companies, which have very similar behaviour in terms of termination of ownership. An example is presented in Figure 6.17, which represents the survival probabilities of tankers owned by small, medium and large private companies from traditional and emerging maritime nations.



Note: The predicted survival curves of Private and Public companies overlap. The predicted survival curves of Medium and Large companies overlap.

Figure 6.17. Predicted Survival Curves by Company Type – Tankers Cox PH model – company level, 1st owner

Further investigation on nationality of control includes the top three nationalities in terms of number of appearances in the sample for tankers, which happen to be the same as those for dry bulkers, namely Greece, Japan and China. There is evidence that Greek-owned tankers have a higher survival probability than that of ships in the possession of: (i) Chinese owners; (ii) Japanese owners or (iii) owners associated traditional and emerging maritime nations. Japanese-owned tankers are the most likely ones to experience a termination of ownership, which is consistent with the preliminary results on nationality of control reviewed earlier in section 6.2.3.

Containers – first owner

The model corresponding to first owner on company level[142] for fully cellular container ships, referred to as 'Containers Cox PH-1st owner on company level' includes the following covariates, whose effect was confirmed by the use of RSF techniques:

- Company type;
- Company size;
- Nationality of control.

As in the case of tankers, ship level covariates such as ship size and delivery year do not appear to have a significant effect on periods of ownership for container vessels in terms of first owner.

Figure 6.18 shows a selection of predicted survival curves corresponding to container ships, which illustrates the main patterns related to the covariates' effects.

In terms of company type, state and financial companies' records were omitted from the database due to the limited sample size. Private companies owning container vessels are more likely to sell than public companies. A difference between private and public companies seems to exist only in the container sector.

Container ships owned by small (≤10 ships), medium (11-50 ships) and large (>50 ships) companies have significantly different predicted survival. Vessels owned by small companies are most likely ones to be sold age for age, whereas vessels owned by large companies are the least likely ones to be sold. An example of the effect of company size for private companies is shown in Figure 6.18.

Figure 6.18 shows also that owners from traditional maritime nations are more likely to sell on average. However, the effect is very weak and barely significant.

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[142] The number of records and events by covariate as well as the model output can be found in section XX of the Data Annex.

Further investigation on nationality of control includes the top three nationalities in terms of number of appearances in the sample for containers, namely Germany, Japan and China. There is evidence that Chinese and German-owned vessels have higher probability of survival on average than ships associated with other traditional or emerging maritime nations. Japanese-owned container ships are the most likely ones to experience a sale on average and significantly more likely to be sold than Chinese and German-owned ships.

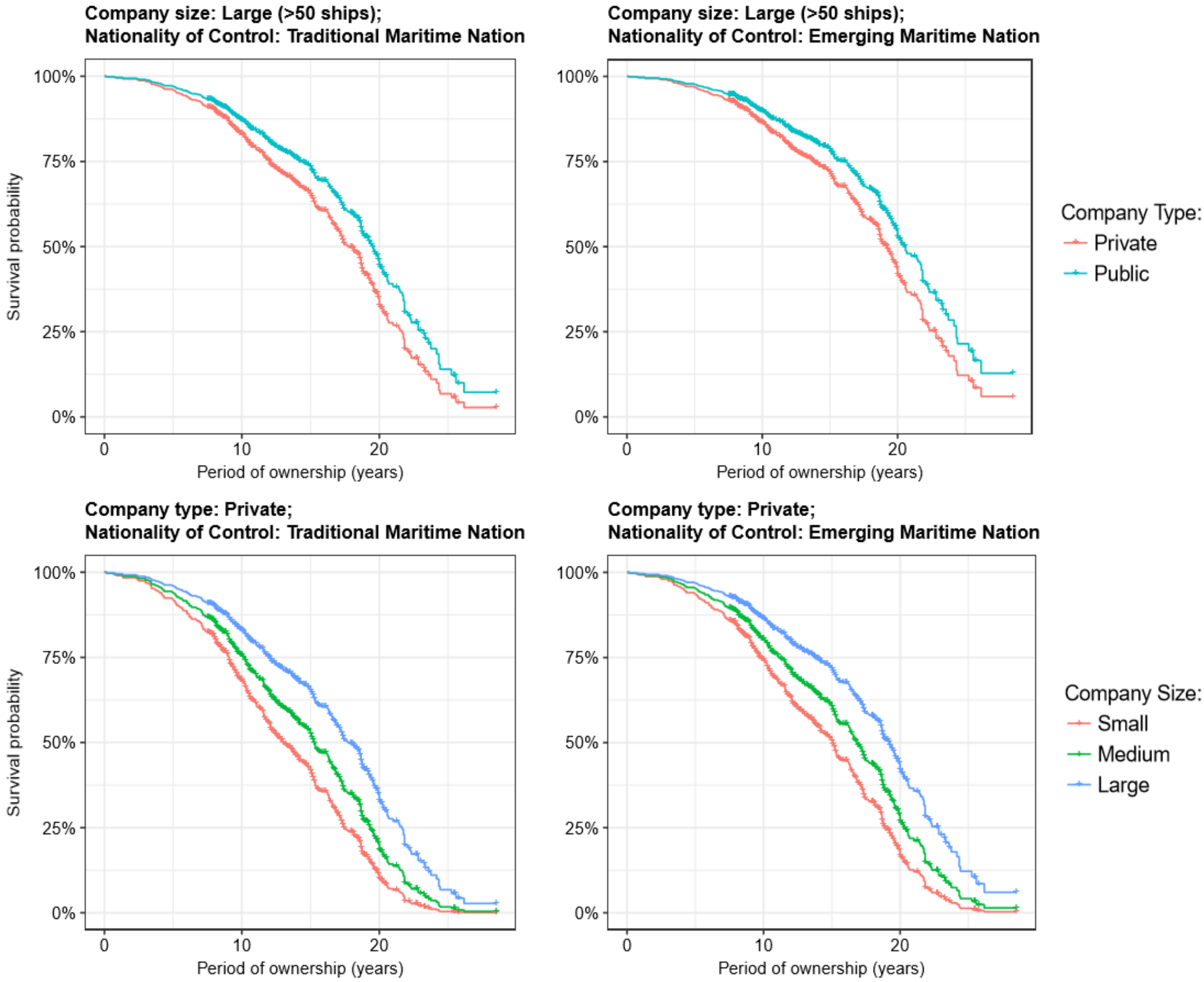


Figure 6.18. Predicted Survival Curves by Company Type – Containers Cox PH model – company level, 1st owner

Summary of first owner models by ship type

A summary of the characteristics that were found to have a significant effect on first owner period by ship type is presented in Table 6.3.

Ship level characteristics were found to have a limited effect on first owner period when company level characteristics are added. Ship size was found to influence periods of ownership corresponding to first owner in the case of bulk carriers only.

All three company level characteristics, whose effect is investigated in this chapter, namely company type, company size and nationality of control, were found to have a significant effect on the probability of termination of ownership by the first owner.

		Bulkers	**Tankers**	**Containers**
Ship level	**Size**	Capesize bulkers were found to have a higher predicted survival than Handy and Panamax bulk carriers.	NA	NA
Company level	**Type**	Ships owned by Financial companies are significantly more likely to be sold. No difference between Private and Public companies. State companies are significantly less likely to sell on average.	Ships owned by Financial companies are significantly more likely to be sold. No difference between Private and Public companies. State companies are significantly less likely to sell on average.	Ships owned by Private companies are more likely to be sold than ships owned by Public companies.
	Size	There is a significant difference between small, medium and large companies. Ships owned by small companies have the lowest predicted survival, whereas ships owned by large companies have the highest predicted survival.	Ships owned by small companies are significantly more likely to be sold than ships owned by medium or large companies. There is no difference between medium and large companies.	There is a significant difference between small, medium and large companies. Ships owned by small companies have the lowest predicted survival, whereas ships owned by large companies have the highest predicted survival.
	Control	Owners from TMNs are significantly more likely to sell than owners from EMNs. Based on private and public company records, Greek-owned ships have the highest predicted survival probability on average, whereas Japanese-owned vessels have the lowest predicted survival.	Owners from TMNs are significantly more likely to sell than owners from EMNs. Greek-owned ships have the highest predicted survival probability on average, whereas Japanese-owned vessels have the lowest predicted survival.	There is barely any difference in the predicted survival of ships belonging to owners from TMNs or EMNs. Chinese and German-owned vessels have higher predicted survival on average. Japanese-owned ships have the lowest predicted survival.

**TMN and EMN stand for traditional and emerging maritime nations respectively.*

Table 6.3. Summary of the Results on Characteristics that Influence First Owner Period by Ship Type – company level

Overall, the effects are consistent across ship types although differences in terms of statistical significance exist amongst levels of the covariates[143]. For example, in terms of the effect of company type, ships owned by financial companies were found to be the most likely ones to experience termination of ownership, followed by private, public and state companies, the latter being the least likely to experience the event. This trend is consistent across ship types. However, the difference in the probability of termination of ownership of ships owned by private and public companies is not statistically significant in the bulker and tanker segments of the fleet, however in the container segment private companies are significantly more likely to sell assets.

The effects of company size and nationality of control are also consistent regardless of ship type, however subtle differences are observed between covariate levels within different segments of the fleet. In terms of company size, on average ships owned by smaller companies are found to be more likely to be sold than larger companies. There is a statistical difference between small (≤10 ships), medium (11-50) and large (>50 ships) companies in the bulk and container segments of the fleet. In the case of tankers, however, ships owned by medium and large companies have a very similar probability of termination of ownership.

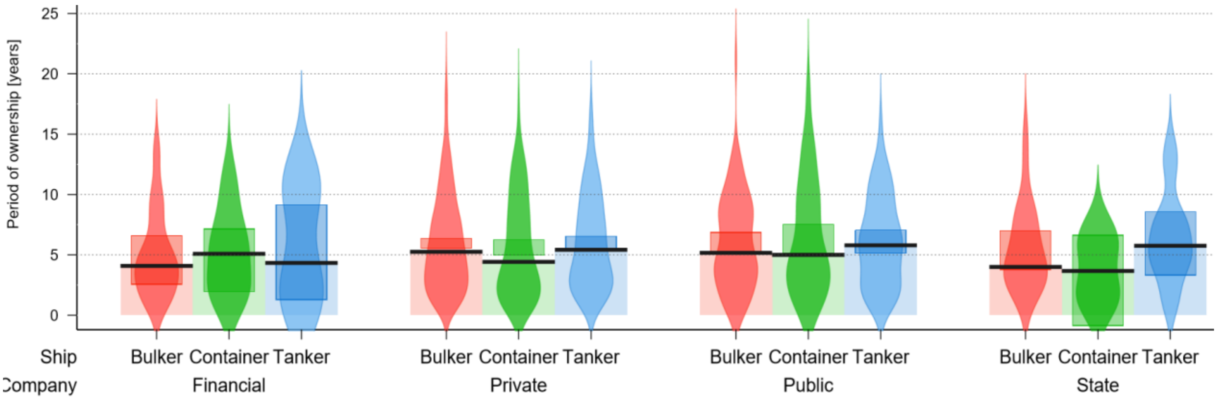
In terms of nationality of control, owners associated with traditional maritime nations are found to be more likely to terminate the period of ownership than owners associated with emerging maritime nations. Further investigation into nationality of control took into account the top three countries with the largest fleets according to the sample, namely: (i) Japan, China and Greece for bulkers and tankers; and (ii) Japan, China and Germany for container vessels. Japanese-owned vessels were found to have the highest probability to be sold regardless of ship type. Interestingly, Greek-owned tankers and bulk carriers are the least likely ones to be sold on average. However, this comparison is only based on private and public companies' records. In the container segment, Chinese and German-owned vessels are found to have a lower probability of experiencing termination of ownership than Japanese-owned ships; and ships owned by owners associated with other traditional maritime nations.

[143] A covariate level refers to the sub-categories or factor levels of certain characteristics (covariates). For example, the covariate levels of company type are the following: financial, private, public and state.

6.3.2. Periods of ownership corresponding to second owner – company level

a) Length of ownership – second owner

The results on length of ownership corresponding to second owner on company level are based on the commercial history of 1,054 ships. The number of bulk carriers represents 48% of the company level sample on periods of ownership corresponding to the second owner, tankers represent 29% and container ships represent approximately 23% of the whole sample. Figure 6.19 shows the median and mean values corresponding to second owner period in terms of ship and company type.



Company Type	Financial		Private		Public		State	
	Med	Mean	Med	Mean	Med	Mean	Med	Mean
Bulker	4.1	5.0	5.3	6.0	5.2	6.1	4.0	5.6
Container	5.1	5.2	4.4	5.6	5.0	6.5	3.7	3.9
Tanker	4.3	5.9	5.4	6.1	5.8	6.6	5.8	6.5

Figure 6.19. Periods of Ownership According to Ship and Company Type – 2nd owner

As the sample size decreases, the confidence intervals, shown as square boxes around the density beans, increase. The size of the confidence intervals in the financial and state company sections of Figure 6.19 suggest that the number of records is very limited, therefore the main analysis will be performed based on the data corresponding to private and public companies. Although results on length of ownership based on all company types are presented here, the values reported for financial and state companies should be treated as indicative only. Earlier in this chapter (see Figure 6.3) it was established that second owner period does not vary greatly by company type. As the variation by ship type is also not large[144] it is not

[144] The results are presented in Data Annex 6, section 6.1.

surprising that overall length of ownership corresponding to second owner appears to be relatively uniform across ship and company types (Figure 6.19).

b) Results by ship type and owner number – second owner

The following section investigates the effects of ship and company level characteristics based on periods of ownership corresponding to the second owner. In the case of second owner data, censored events correspond to ships which were still in operation and in the possession of their second owner at the end of the follow up period. First, a main effects Cox PH model including the three main ship types is fitted to the data on second owner as in the previous section. The number of records and events corresponding to each of the main covariates considered as part of the analysis on periods of ownership corresponding to second owner is presented in Table 6.4.

* No levels as the covariates are not factors.

Covariate Type	Covariate	Levels	Records	Events[145]
Factor	Ship Type	Bulker (base)	508	286
		Container	245	115
		Tanker	301	153
	Company Type	Financial	34	18
		Private	765	406
		Public	216	119
		State	39	11
	Company Size	Small (≤10)	383	222
		Medium (11-50)	424	222
		Large (>50)	247	110
	Nationality of Control	Emerging Maritime Nations	197	83
		Traditional Maritime Nations	857	471
Numeric	Ship Size (as DWT)	NA*	1054	554
	Age at Purchase	NA*	1054	554
Integer	Delivery Year	NA*	1054	554

Table 6.4. List of Covariates – Main effects Cox model on company level – 2nd owner

As with the analysis of subsequent owners on ship level, an additional covariate – ship's age at purchase, is added to the analyses on company level. The addition of this covariate aims to control for the age of the vessel, which is no longer consistent with the period of ownership as in the case of first owner[146]. Ship's age at purchase for a subsequent owner is the sum of the periods of ownership of all previous

[145] Events include sales to subsequent owners or scrap yards. The number of events that correspond to each are presented in Data Annex Chapter 6, section 6.1.c).

[146] For a more detailed discussion on time scales and the effect of age in survival analysis, refer to Chapter 3, section 3.3.2.b).

owners[147]. The average age at purchase for second owner data is 9.7 years[148]. According to the main effects Cox PH model using second owner data, ship type does not have a statistically significant effect on the probability of sale. In fact, of all the covariates listed in Table 6.4 only company size, nationality of control, delivery year and ship's age at purchase appear to have a significant effect on average. Even though the probability of sale does not vary across ship types according to the main effects Cox PH model, in the interest of consistency and interpretability of results, the following analyses on periods of ownership data corresponding to second owner are stratified by ship type.

The output of all models based on period of ownership data corresponding to the second owner, including also: (i) model diagnostics; (ii) random survival forests' (RSF) results, such as minimal depth plots; (iii) additional visualisations of the results that were not included in the main body of the thesis; and (iv) additional descriptive statistics can be found in Data Annex Chapter 6, section 6.

Bulkers – second owner

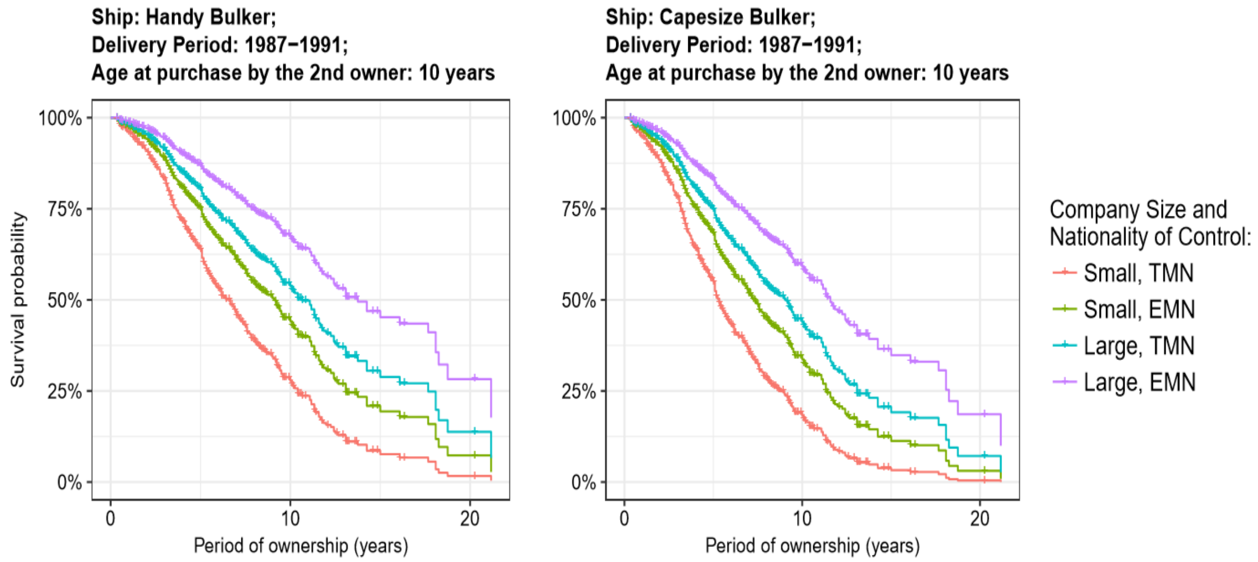
The list of covariates included in the final Bulkers Cox PH model corresponding to second owner on company level includes the following:

- Ship size (Handy, Panamax, Capesize);
- Delivery year of the vessels;
- Ship's age at purchase by the second owner;
- Company size;
- Nationality of control.

The effect of the covariates selected to be part of the final Bulkers Cox PH model is confirmed by the use of RSF techniques. In the interest of brevity, relevant results regarding RSF techniques will be presented only if any discrepancies are detected.

Figure 6.20 shows a selection of predicted survival curves corresponding to some of the covariates aiming to highlight the main effects identified by the final Bulkers Cox model corresponding to second owner on company level.

[147] This concept and the equation used for calculating ship's age at purchase are explained in more detail in Chapter 5, section 5.3.2.b (equation 5.1).
[148] Mean and median values are shown in Data Annex 6, section 6.1.b.



* TMN and EMN stand for traditional and emerging maritime nations respectively.

Figure 6.20. Predicted Survival Curves by Company Type – Bulkers Cox PH model – company level, 2nd owner

In terms of ship size, Handy bulkers are found to be less likely to experience the event of interest than Capesize and Panamax ships (Figure 6.20). A significant difference between the probability of sale of bulkers owned by small, medium and large companies is detected. Bulkers owned by small companies tend to be the most likely ones to be sold, whereas ships owned by large companies appear to be significantly less likely to experience a sale (Figure 6.20).

Nationality of control according to maritime traditions also affects the probability of sale. As seen in the results corresponding to first owner presented earlier, ships belonging to owners from traditional maritime nations are more likely to be sold than ships controlled by owners from emerging maritime nations (Figure 6.20). Further investigation on nationality of control suggests that Chinese owners and owners from other emerging maritime nations tend to keep vessels for longer on average. Bulk carriers owned by Japanese owners are the most likely ones to be sold[149].

Ships which were purchased when they were relatively older have a higher probability to be sold than younger vessels. This is not surprising given that the economic life of a vessel is finite. The effect of ship's age at purchase is presented in Figure 6.21, which depicts: (i) the relative hazards of bulkers of different ages to be sold on the left

[149] The model output considering different nationalities of control can be found in Data Annex Chapter 6, section 6.2.

and (ii) the relative hazard of bulkers to be sold in comparison to a 10-year old ship on the right. The blue bands surrounding the curves represent the 95% confidence intervals, whereas the dashes along the x-axes[150] represent the distribution of bulkers by age at purchase in the sample corresponding to second owner.

According to the relative hazards plot on the left of Figure 6.21, a bulk carrier, which was 15 years old when purchased by the second owner is almost twice more likely to be sold than a bulk carrier, which was 1 year old at time of purchase. The relative hazards plot on the right uses a bulk carrier, which was 10-years old at purchase as a reference (with a relative hazard of 1, denoted as 0 on the x-axis). This plot shows that a vessel, which is 10 years away from the sample mean, or in other words a 20-year old bulk carrier at the time of purchase by the second owner, is 1.5 times more likely to be sold than a 10-year-old ship (Figure 6.21). In the interest of brevity hereafter, only the values for simulated hazards are reported regarding age at purchase where applicable.

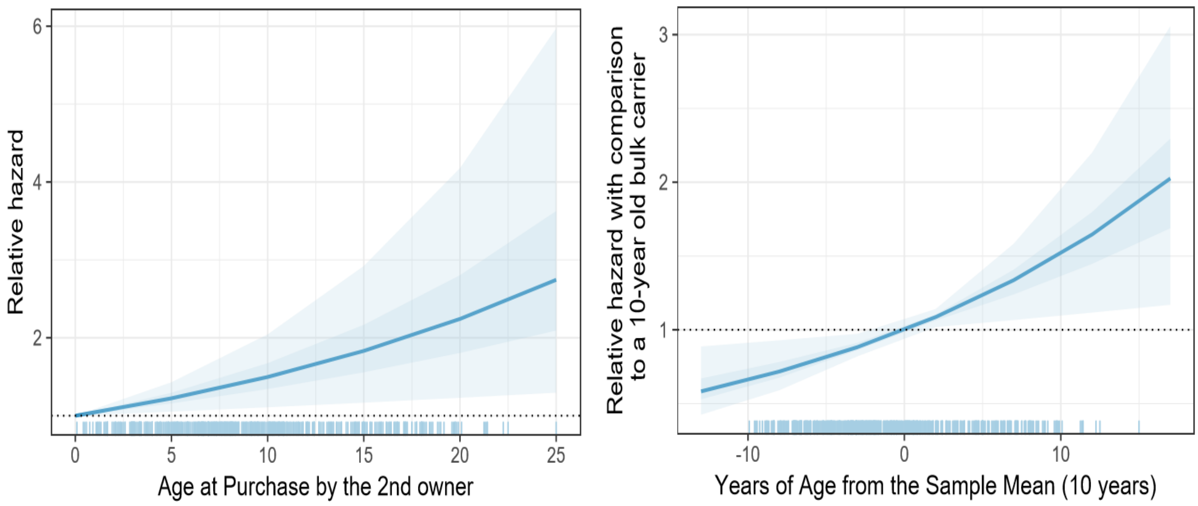


Figure 6.21. Simulated Relative Hazards of Age at Purchase – Bulkers Cox PH model - company level, 2nd owner

Bulk carriers delivered before the year 2000 are found to be more likely to be sold than bulkers of the same age delivered at a later stage of the delivery period. This finding can be explained by the state of the shipping markets. Vessels delivered after the year 2000 were very young when the global economy and seaborne trade entered a period of continuous growth, which explains why shipowners, especially dedicated service

150 This is referred to as '*rug plot*'. More information on simulating relative hazards can be found in Gandrud C (2015).

providers, would hold on to their ships. As the effect of delivery year is not particularly strong, no predicted survival curves or relative hazards are shown here.

Tankers – second owner

The list of covariates included in the final Tankers Cox PH model corresponding to second owner on company level includes the following:

- Ship's age at purchase by the second owner;
- Company size.

Figure 6.22 summarises the effects of age at purchase and company size.

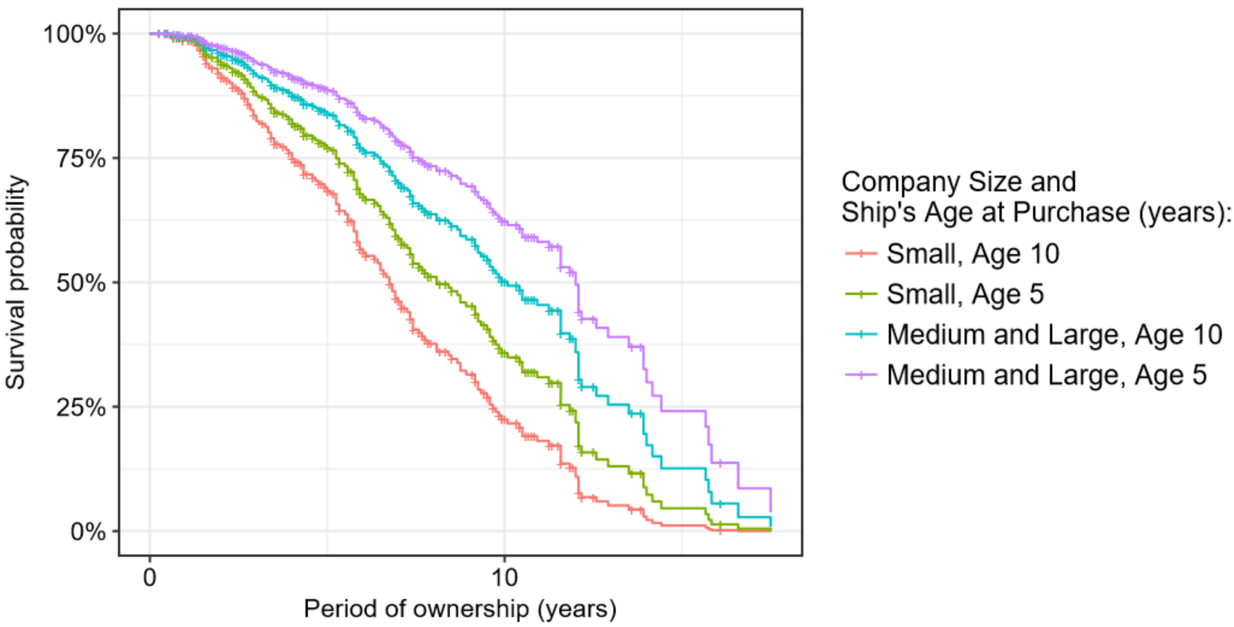


Figure 6.22. Predicted Survival Curves by Company Size and Age at Purchase – Tankers Cox PH model – company level, 2nd owner

In terms of company size, vessels owned by medium and large companies have similar probabilities of survival. Tankers owned by small companies with a fleet of up to 10 vessels, however, are significantly more likely to be sold than tankers owned by medium or large companies.

Vessels that were acquired by the second owner at a later stage of their lives have a lower probability of survival as shown by Figure 6.16. According to the simulated relative hazards for age at purchase, a tanker purchased at the age of 20 years is 2 times more likely to be sold than a 10-year-old ship.

Containers – second owner

The list of covariates included in the final Containers Cox PH model corresponding to second owner on company level is identical to the list of covariates that affect the probability of sale of tankers:

- Ship's age at purchase by the second owner;
- Company size.

Figure 6.23 summarises the effects of age at purchase and company size corresponding to second owner period for container ships.

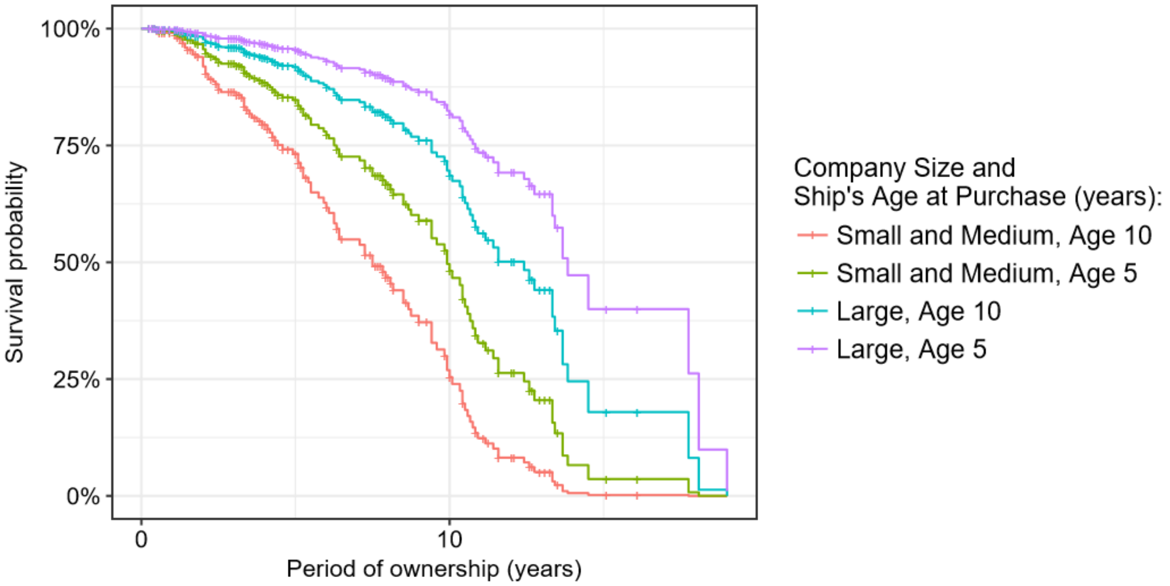


Figure 6.23. Predicted Survival Curves by Company Size and Age at Purchase – Containers Cox PH model – company level, 2nd owner

In the case of container ships, small and medium companies behave similarly. However, containers owned by large companies are significantly less likely to be sold on average.

Vessels acquired at an older age are more likely to be sold as shown in Figure 6.23. A 15-year-old container vessel is 2 times more likely to be sold than a 10-year old ship according to the simulated relative hazard shown in Data Annex Chapter 6, section 6.5.

Summary of second owner models by ship type

A summary of the characteristics that are found to have a significant effect on second owner period by ship type is presented in Table 6.5. Ship's age at purchase is the only ship level characteristic found to have a significant effect on the probability of termination of ownership within all three main segments of the fleet. The rest of the ship level covariates considered, namely ship size and delivery year, appear to have significant effects only in relation to bulk carriers.

Although included as part of the investigation of the influence of company level characteristics based on periods of ownership data corresponding to the second owner, company type was not found to have a statistically significant effect at this stage. Nationality of control was found to be significant only for bulker owners, however, company size affects the probability of termination of ownership regardless of ship type.

		Bulkers	**Tankers**	**Containers**
Ship level	**Size**	There is no difference between Capesize and Panamax bulkers. Handy bulkers are the least likely ones to be sold. The effect of ship size is barely significant.	NA	NA
	Delivery Year	Ships delivered before the year 2000 are more likely to be sold than bulkers delivered later.	NA	NA
	Age at Purchase	Vessels acquired later into their economic life are more likely to be sold.	Vessels acquired later into their economic life are more likely to be sold.	Vessels acquired later into their economic life are more likely to be sold.
Company level	**Size**	There is a significant difference between small, medium and large companies. Ships owned by small companies have the lowest predicted survival, whereas ships owned by large companies have the highest predicted survival.	There is no significant difference between medium and large companies. Tankers owned by small companies are significantly more likely to be sold on average.	There is no significant difference between small and medium companies. Containers owned by small or medium companies are significantly more likely to be sold on average.
	Control	Owners from TMNs are significantly more likely to sell than owners from EMNs. Chinese-owned ships have the highest predicted survival probability on average, whereas Japanese-owned vessels have the lowest predicted survival.	NA	NA

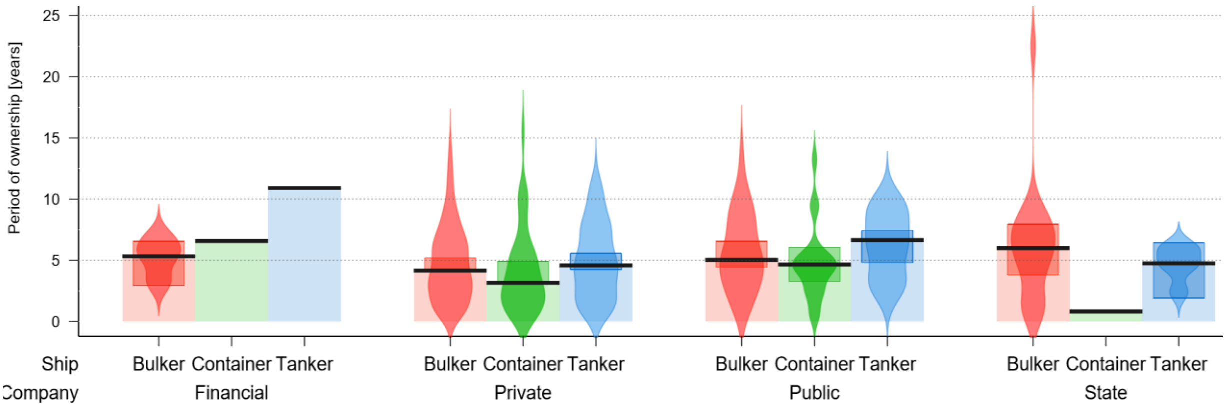
**TMN and EMN stand for traditional and emerging maritime nations respectively.*

Table 6.5. Summary of the Results on Characteristics That Influence Second Owner Period by Ship Type – company level

6.3.3. Periods of ownership corresponding to third owner – company level

a) Length of ownership – third owner

The sample size corresponding to third owner data on company level is relatively small compared to first and second owners. It comprises 434 records of which 58% correspond to bulk carriers, 25% to tankers and 17% to container ships. Figure 6.24 shows the median and mean values for third owner data. As the sample size is limited, the data for certain ship and company types is scarce, which is reflected in Figure 6.24. For example, as there are only several records corresponding to containers and tankers owned by financial companies, the bars representing these categories are missing two elements of the RDI plots: (i) the density beans, which show the density of raw data points; and (ii) the confidence intervals for the mean, which are depicted as square boxes around the density beans. The results per each category are reported for consistency reasons, however the results regarding tankers owned by financial companies and containers owned by financial or state companies presented in Figure 6.24 cannot be generalised due to limited number of records.



Company Type	Financial		Private		Public		State	
	Med	Mean	Med	Mean	Med	Mean	Med	Mean
Bulker	5.3	5.2	4.2	4.8	5.0	5.7	6.0	6.1
Container	6.6	6.6	3.2	4.1	4.7	4.8	0.9	2.2
Tanker	11.0	11.0	4.6	5.0	6.7	6.3	4.8	4.8

Figure 6.24. Periods of Ownership According to Ship and Company Type – 3rd owner

Although third owner periods do not vary greatly across ship types[151], there is some evidence that container ships are kept for shorter periods, which can be observed in the data regarding periods of ownership corresponding to private and public companies in Figure 6.24. The phenomenon can be partially explained by the fact that

[151] Results on third owner period by ship type can be found in Data Annex Chapter 6, section 7.1.a).

the average age at purchase for container ships is almost 2 years higher than that of bulkers and tankers[152], which is about 14 years. This, coupled with the data on average scrap age by ship type[153], suggests that it is likely that the shorter period of ownership corresponding to container ships is a function of their age at purchase and the likelihood of them being scrapped earlier than other ship types.

b) Results by ship type and owner number – third owner

In the context of the analysis of third owner period of ownership, censored records represent ships that were still in service and in the possession of the third owner at the end of the follow up period. The first step of the analysis, as with previous owner numbers, is fitting a main effects Cox PH model including the three main ship types aiming to indicate whether the probability of termination of ownership differs by ship type. The list of the default covariates considered likely to have an influence on periods of ownership along with the number of records and events as part of the analysis on third owner period is shown in Table 6.6.

Covariate Type	Covariate	Levels	Records	Events[154]
Factor	Ship Type	Bulker (base)	250	132
		Container	74	35
		Tanker	110	62
	Company Type	Financial	10	8
		Private	316	173
		Public	78	41
		State	30	7
	Company Size	Small (≤10)	212	124
		Medium (11-50)	144	71
		Large (>50)	78	34
	Nationality of Control	Emerging Maritime Nations	150	57
		Traditional Maritime Nations	284	172
Numeric	Ship Size (as DWT)	NA*	434	229
	Age at Purchase	NA*	434	229
Integer	Delivery Year	NA*	434	229

Table 6.6. List of Covariates – Main effects Cox model on company level – 3rd owner

Model outputs along with relevant diagnostics and additional results referring to the analysis based on third owner periods of ownership can be found in Data Annex Chapter 6, section 7.

[152] Results on age at purchase by the third owner can be found in Data Annex Chapter 6, section 7.1.b).
[153] Discussed in Chapter 4, section 4.3.1.d) and Figure 4.7. Average scrap age by ship type.
[154] Events include sales to subsequent owners or scrap yards. The number of events that correspond to each are presented in Data Annex Chapter 6, section 7.1.c).

According to the results from the main effects Cox model on company level corresponding to third owner period, there is no significant difference between the probabilities of sale across ship types. However, in the interest of consistency of reporting and the interpretability of results, the following analyses are stratified by ship type. The covariates that are found to influence periods of ownership based on the main effects Cox PH model are: ship size, ship's age at purchase, company size and nationality of control.

Larger vessels are found to be more likely to experience the event of interest on average. As to be expected, ships acquired by the third owner at a later stage in their economic life are more likely to be sold than younger ships. A difference between small and large companies is detected with small companies being more likely to sell their ships on average. Vessels owned by traditional maritime nations were found to be more likely to be sold than vessels owned by emerging maritime nations, a trend which is consistent with the results corresponding to first and second owner data.

The results from the Cox models representing the three main ship types included in the analyses are discussed next.

Bulkers – third owner

The covariates included in the final Bulkers Cox PH model corresponding to third owner on company level are:

- Ship size;
- Delivery year;
- Ship's age at purchase by the third owner.

Figure 6.25 summarises the effects of ship size and delivery year corresponding to third owner period for bulk carriers.

Handy bulkers are found to have a significantly higher probability of survival than larger bulk carriers, such as Panamax and Capesize bulkers.

In terms of delivery year, bulk carriers delivered at an earlier stage of the delivery profile of the sample are more likely to be sold on average than ships delivered later, age for age.

There is some evidence that ships acquired at a later stage of their economic life have a higher probability to experience termination of ownership but the effect is only marginally significant.

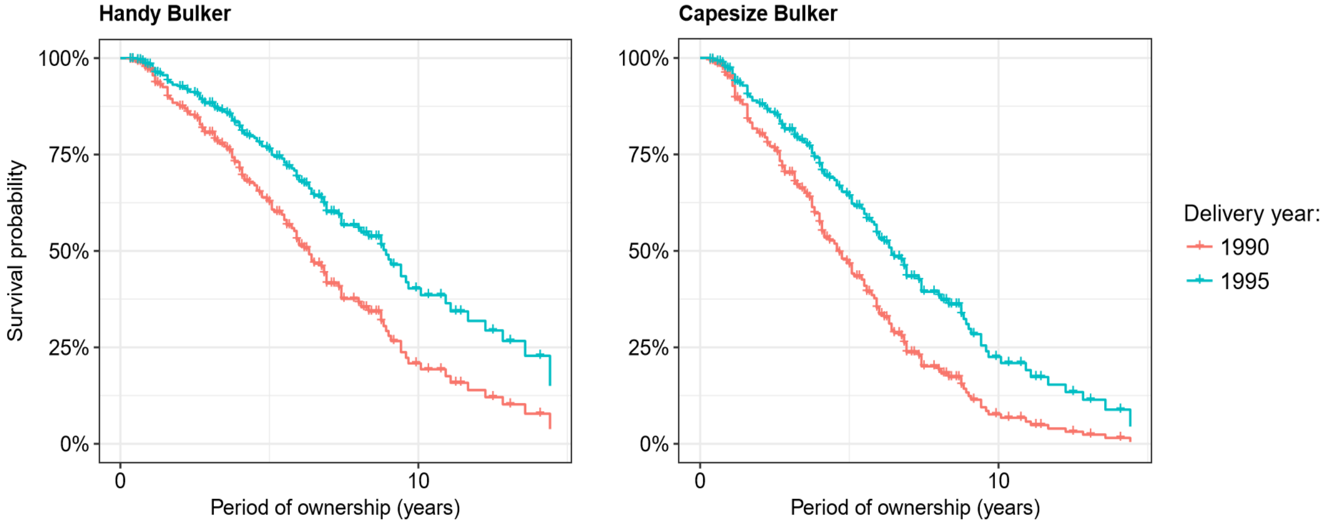


Figure 6.25. Predicted Survival Curves by Delivery Year – Bulkers Cox PH model – company *level, 3rd owner*

Tankers – third owner

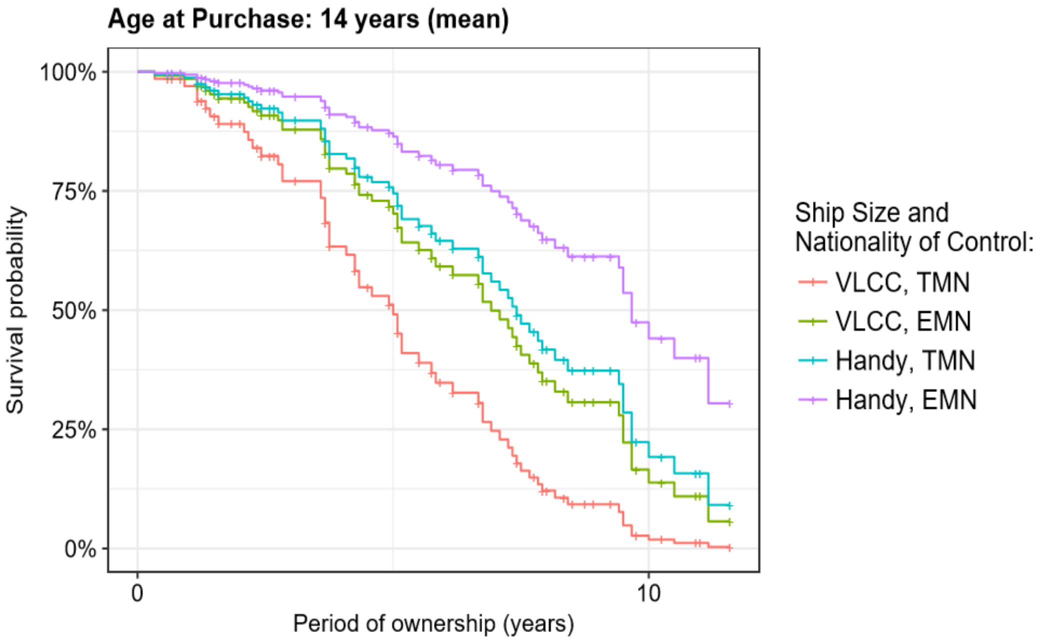
The covariates included in the final Tankers Cox PH model corresponding to third owner on company level are the following:

- Ship size;
- Ship's age at purchase by the third owner;
- Nationality of control.

A selection of the results summarising the main effects on the probability of sale corresponding to periods of ownership related to third owner in the tanker sector are presented in Figure 6.26. Handy tankers are significantly less likely to experience termination of ownership while in the possession of the third owner on average. Larger vessels, especially Aframax and VLCC tankers, are significantly more likely to be sold by the third owner. Figure 6.26 shows the predicted survival curves corresponding to Handy and VLCC tankers for comparison.

Nationality of control in terms of maritime traditions influences periods of ownership according to the Tankers Cox PH model corresponding to third owner. Ships associated with owners from traditional maritime nations are significantly more likely to be sold than ships with owners from emerging maritime nations (Figure 6.26).

The influence of age at purchase is very strong for tankers. A likely reason is the effect of the phasing out schedule for single-hull tankers, which controlled the length of the economic life of such vessels[155] irrespective of the owners' investment horizon. According to the simulated relative hazard, a 20-year-old tanker is twice more likely to experience the event of interest than a 15-year-old ship.



* TMN and EMN stand for traditional and emerging maritime nations respectively.

Figure 6.26. Predicted Survival Curves by Company Type – Tankers Cox PH model – company level, 3rd owner

Containers – third owner

The list of covariates included in the final Containers Cox PH model corresponding to third owner on company level is identical to the list of characteristics selected as influential for second owner and includes the following:

- Ship's age at purchase by the third owner;
- Company size.

A selection of predicted survival curves resulting from the final Containers Cox PH model corresponding to third owner are presented in Figure 6.27.

As in the case of second owner in the container segment of the fleet, there are no significant differences between small and medium size companies. Container ships owned by large companies are found to be significantly less likely to be sold to a subsequent owner or to a scrap yard.

[155] For more information on the phasing out of single hull tankers see Appendix B-3. The simulated relative hazard corresponding to age at purchase can be found in Data Annex Chapter 6, section 7.4.e).

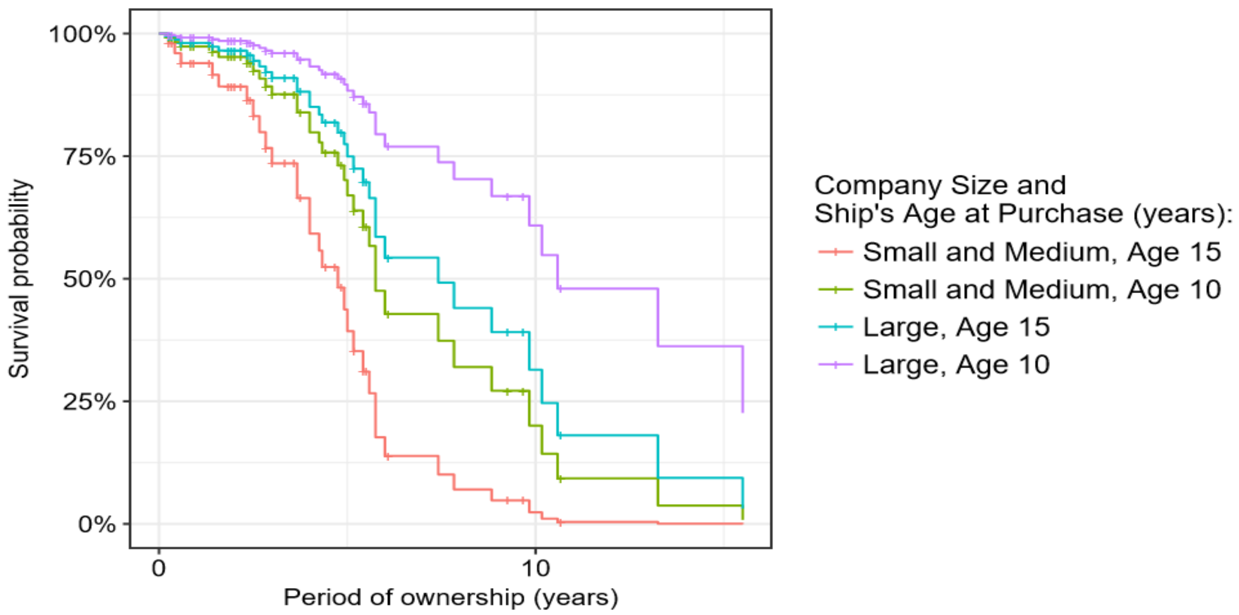


Figure 6.27. Predicted Survival Curves by Company Type – Containers Cox PH model – company level, 3rd owner

Age at purchase also has a significant effect on the probability of sale as shown in Figure 6.27. Furthermore, the simulation of the relative hazard of age at purchase shows that a 15-year-old ship is 2.5 times more likely to be sold than a 10-year-old vessel, whereas a 20-year-old ship is 5 times more likely to experience the event of interest[156] in comparison to a 10-year-old vessel.

Summary of third owner models by ship type

A summary of the characteristics that are found to have a significant effect on third owner period by ship type is presented in Table 6.7.

Ship level characteristics seem to be significant within the bulker and tanker segments of the fleet but not for container ships except for vessel's age at purchase. Furthermore, company level characteristics do not appear to affect the probability of termination of ownership in relation to bulk carriers. The effect of company level characteristics on tankers and container ships is also limited and confined to nationality of control and company size respectively.

[156] The simulated relative hazard of age at purchase can be found in Data Annex 6, section 7.5.e).

		Bulkers	Tankers	Containers
Ship level	Size	There is no difference between Capesize and Panamax bulkers. Handy bulkers are the least likely ones to be sold.	Handy tankers are the least likely ones to be sold. Larger tankers, especially Aframax and VLCC tankers, are more likely to be sold on average.	NA
	Delivery Year	Ships delivered before the year 2000 are more likely to be sold than bulkers delivered later.	NA	NA
	Age at Purchase	Vessels acquired later into their economic life are more likely to be sold. Very weak effect.	Vessels acquired later into their economic life are more likely to be sold.	Vessels acquired later into their economic life are more likely to be sold.
Company level	Size	NA	NA	There is no significant difference between small and medium companies. Containers owned by small or medium companies are significantly more likely to be sold on average.
	Control	NA	Owners from TMNs are significantly more likely to sell than owners from EMNs.	NA

**TMN and EMN stand for traditional and emerging maritime nations respectively.*

Table 6.7. Summary of the Results on Characteristics That Influence Third Owner Period by Ship Type – company level

The effect of ship size in the case of third owner is attributed to the fact that the number of ships, which were scrapped at the end of the third owner period is proportionally larger than in the case of first and second owner data. The higher proportion of scrapped vessels and the fact that smaller vessels were found to have a higher scrapping age on average explains the effect of ship size in relation to third owner.

6.3.4. Periods of ownership corresponding to later owner – company level

a) Length of ownership – later owner

Due to limited sample size regarding later owners, the analyses comprising company level characteristics were originally supposed to focus on the first three consecutive owners. However, as the in-depth interviews with industry representatives were conducted before the statistical analyses were finalised, the exploration of certain patterns of ownership perceived to exist in shipping by industry representatives was integrated in the statistical modelling. For example, it was suggested by one interviewee that at the later stage of the economic life of bulk carriers owned by Greek owners, the pattern of ownership reverts as the vessels cease to be traded speculatively and remain with their last owner for as long as they can be operated[157]. In order to investigate this suggested pattern of ownership the analyses investigating the characteristics that influence termination of ownership were extended to incorporate later owner data. Only bulk carriers are included in the later owner analysis due to sample size limitations. Table 6.8 provides information on the number of records and events included in the later owner dataset and it summarises the data on periods of ownership and age of the vessels.

Bulk carriers	Records	Events	Period of ownership		Age at Purchase		Age at End	
			Median	Mean	Median	Mean	Median	Mean
Owner 4	94	52	3.7	4.4	17.3	16.7	21.6	21.0
Owner 5	26	15	3.1	4.0	17.4	16.9	21.1	20.1
Owner 6	10	6	2.6	3.8	18.7	18.6	22.0	22.3
Later owner	130	73	3.2	4.3	17.4	16.9	21.1	21.5

Table 6.8. Bulk Carriers' Records Corresponding to Later Owner Periods of Ownership

Period of ownership corresponding to later owners in the bulk carriers segment appear to be shorter than periods of ownership corresponding to the third owner.

b) Results by ship type and owner number – later owner

The covariates included in the final Bulkers Cox PH model corresponding to later owner on company level are the following:

- Ship size;
- Ship's age at purchase;
- Nationality of control.

The results summarising the effect of the characteristics that affect the probability of termination of ownership are presented in Figure 6.28.

Handy and Panamax bulk carriers have similar survival probabilities[158] and are significantly less likely to experience termination of ownership while in the possession of a later owner in comparison to Capesize bulkers.

Nationality of control was also found to have a significant effect. As in previous analyses, owners from traditional maritime nations were found to be more likely to sell

[157] The pattern of ownership described by this interviewee as well as other relevant findings from the in-depth interviews can be found in Chapter 7, section 7.4.2.
[158] Which is why only predicted survival curves corresponding to Handy bulkers were included in the presentation of the results (Figure 6.28).

a vessel than owners associated with emerging maritime nations (Figure 6.28). Further investigation of nationality of control reveals that Greek and Chinese owners are less likely to sell their bulk carriers than owners from traditional maritime nations. It appears that at this stage of the vessels' economic lives Greek owned vessels are found to have the highest median and mean period of ownership[159]. The number of Japanese owned bulk carriers at this stage of the economic life of the vessels is very limited (1 bulk carrier), therefore Japan was excluded from the list of countries investigated.

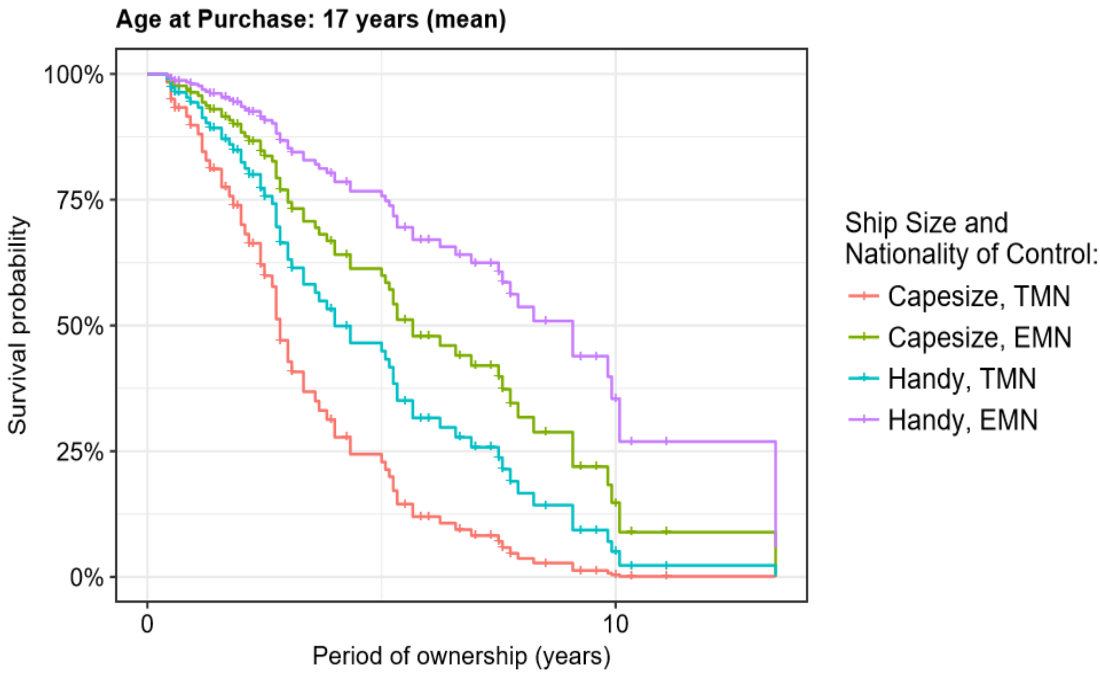


Figure 6.28. Predicted Survival Curves by Company Type – Bulkers Cox PH model – company *level, later owner*

The effect of age at purchase on termination of ownership increases substantially for vessels acquired by a later owner after the age of 20 years. According to the simulated relative hazard of age at purchase, a 25-year-old tanker is twice more likely to experience the event of interest than a 20-year-old ship.

Upon comparison with the results on third owner summarised in Table 6.7, it becomes apparent that the results on later owner in the bulk segment of the fleet are identical to the results on the characteristics affecting third owner period of ownership in the tanker segment of the fleet. A likely explanation is the fact that bulk carriers have a

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159 Results on mean and median period of ownership by nationality of control corresponding to later owners as well as additional results related to the effect of age at purchase can be found in Data Annex Chapter 6, section 8.

higher scrap age and a larger number of owners on average, which suggests that some bulkers purchased by the fourth and later owners are at an equivalent stage of their economic life, proportionally speaking, to tankers and containers purchased by their third owner.

6.4. Investigation of the Influence of Economic Indicators on Periods of Ownership

The last group of characteristics identified as likely to influence periods of ownership consists of economic indicators. Initially, a list comprising shipping market and global economic indicators (see Table 4.9) was considered. However, shipping earnings were chosen as the basis of the analysis concerning the influence of economic indicators for the following reasons: (i) according to the literature, earnings are regarded as the main reason behind strategic decisions in shipping such as the buying or selling of assets[160]; (ii) according to the interviews with shipping professionals conducted as part of this research, the indicator reflecting the profitability of the shipping market (freight rates[161]) is the single most important indicator influencing periods of ownership[162] and (iii) all of the economic indicators considered are found to be very highly correlated[163], which motivated the decision to limit the number of indicators from a practical point of view.

Monthly data on shipping earnings is provided by Clarksons Research Limited (CRSL). First, the Clarksea index[164] is modelled on owner number level in order to investigate the effect of shipping earnings based on owner number alone. Next, the analysis is stratified by ship type following the analysis structure applied in previous sections and chapters. In these models, monthly data on shipping earnings by ship type is used[165]. As international shipping is a volatile and capital intensive industry,

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[160] For a discussion on the importance of shipping earnings in terms of strategic decisions see Chapter 4, section 4.3.3.
[161] Shipping earnings were chosen over freight rates as they are estimated from overall voyage freight rates where some operational costs are deducted and therefore they represent a more accurate estimation of the profitability of the market as discussed in Chapter 4, section 4.3.3. Details of the calculations used by CRSL to determine earnings are available in Shipping Intelligence Weekly Sources and Methods (SIWa, 2016).
[162] For a discussion on the perceived effect of economic indicators according to the shipping professionals interviewed as part of this research, see Chapter 7, section 7.4.3.
[163] High correlation coefficients could lead to multicollinearity issues in the models but more importantly, this indicates that there is no great difference between the different indicators themselves.
[164] The Clarksea Index is a weighted average of the daily earnings of the main ship types where the weighting is based on the number of vessels in each fleet sector. See Figure 4.16.
[165] The monthly shipping earnings data, originally in dollars per day, was transformed into natural logarithms.

owners who are dedicated to providing a service are not expected to sell an asset due to minor downward fluctuations in the freight market. On the other hand, generating profit through asset trading when earnings are rising along with the demand for shipping capacity, is a well-known strategy. However, the success of asset trading is rooted in choosing the right time, which usually is a result of a cumulative improvement in earnings rather than random shocks as these are much more difficult to predict. Therefore, the effect of earnings on the decision to sell a vessel is not likely to be an instantaneous one. A potential exception is the case of a distress sale, which is usually a result of sudden cash liquidity problems experienced by an organisation. Overall, however, one would expect that decisions regarding buying or selling a vessel would be a product of careful consideration of the market and expectations of future profitability. In order to account for this, time-varying '*lagged*' effects are considered as well, where lagged effects are defined as '*effects of a covariate that precede an outcome in time*' (Shiyko *et al.*, 2014). Two time lags have been chosen to account for the different time horizons owners might have in order to make the decision to sell or buy in terms of availability of cashflow – 3 and 6 months. Although the transfer of ownership is usually instantaneous upon receipt of payment, the process of finalising a sale of a ship might be lengthy and complicated as a result of the negotiations stage. Therefore the shorter time lag investigated here (3 months), is based on the minimum period of ownership estimated as part of this research, which is 2.5 months. This suggests that the whole process of selling a vessel took place within 2.5 months, which motivated the choice of 3 months as a benchmark for short term time lag. The relatively longer time lag of 6 months was chosen arbitrarily to represent cases were the execution of the decision to sell an asset took longer than the minimum time required for a sale to be finalised.

Shipping earnings are fitted into the regression models as time-varying covariates[166]. In order for this to be achieved, the commercial history of all vessels included in the sample had to be split into monthly intervals. The number of these intervals depends on the follow up time of each individual ship. This process leads to multiplying the records corresponding to each ship in the dataset amounting to about 400,000 records in relation to company level data (1,998 ships). However, only the analyses based on

[166] The approach is described in Chapter 3, section 3.3.2.c).

the first three owners is presented here. The number of records by owner number and ship type is summarised in Table 6.9.

	Ship Type	Owner Number			
		First	**Second**	**Third**	**All owners**
Company level	Bulker	109,593	35,671	14,969	160,233
	Tanker	77,778	21,737	6,807	106,322
	Container	97,210	16,787	3,715	117,712
	Total	**284,581**	**74,195**	**25,491**	**384,267**

Note: The ship records corresponding to 4th and later owners are not included here as they were omitted from this analysis as the focus is on company level characteristics and the sample size for later owners is very limited in terms of records belonging to tankers and containers.

Table 6.9. Number of Records – Time-Varying Covariates

As the main focus of this chapter is the investigation of the influence of company level characteristics and economic indicators on periods of ownership, the models including shipping earnings are based on the same default list of covariates used in the analyses, which included company level characteristics in previous sections. These include the following:

- Ship type;
- Ship size;
- Delivery year of the vessels;
- Company type;
- Company size;
- Nationality of control according to maritime traditions.

Age at purchase is not included in the analyses as ships' age is modelled as a time varying covariate and it is the basis for splitting the data into monthly intervals. As there is no significant difference[167] in the estimated effect of the covariates included in the company level analyses and the analyses of shipping earnings for all covariates but ships' delivery year, only the effect of shipping earnings is reported in this section. Although delivery year was found to have a significant effect on the probability of termination of ownership according to the analyses on ship and company levels, the effect was found to be no longer significant in the models with time-varying covariates.

[167] Significant difference in this case refers to a change in the estimated effect of the covariate or in other words, no change greater than 15-20% in the estimated coefficient has been detected. All model outputs including shipping earnings can be found in Data Annex Chapter 6, section 8.

6.4.1. Influence of shipping earnings on periods of ownership according to owner number

The Clarksea index was used as a measure for shipping earnings when analysing the data based on owner number. The results, summarised in Table 6.10, show that on average, first and second owners are significantly more likely to sell a vessel when the earnings are higher. In the case of third owner, it appears that the effect of earnings is not significant. The calculated values from the Wald Z-tests[168] corresponding to each indicator and owner number are used as a means of comparing the estimated effects of the indicators. The Z-statistic is chosen because: (i) it is associated with the corresponding P-value and therefore it is indicative of whether the covariate is statistically significant and (ii) it is associated with the coefficient and therefore it is indicative of the effect of the covariate. A value close to or greater than '2' in absolute terms indicates statistical significance, whereas a positive Z-value suggests that the probability of the event occurring increases for a unit change in the covariate.

Economic Indicator	**Owner Number**		
	First	**Second**	**Third**
Clarksea index	3.24**	1.78*	0.54
Clarksea index 3 months lag	0.64	1.86*	-0.24
Clarksea index 6 months lag	-0.93	0.06	-1.12

Note: The reported values correspond to the Z-statistic calculated for each economic indicator. The '' symbol indicates significant (**) or marginally significant values (*).*

Table 6.10. Economic Indicators' Effect by Owner Number

Although not statistically significant, the difference in the effect of earnings for first and third owner between the Clarksea index and the lagged indicators is interesting. According to the results, if shipping earnings were high a few months previously (3 or 6 months), then owners are less likely to sell (Table 6.10).

6.4.2. Influence of shipping earnings on periods of ownership according to owner number and ship type

The results from the numerical models by owner number and ship type are summarised in Table 6.11. According to the Z-statistics, the effect of shipping earnings on the probability of a bulk carrier to be sold to a subsequent owner or a scrap yard by the first owner is not statistically significant. In contrast, tankers are significantly

[168] Wald Z-tests are discussed in Chapter 5, section 5.3.1.c). The Z-statistic is calculated by dividing the estimated coefficient by its standard error.

more likely to be sold when the earnings within the segment are high. This implies that most owners who are likely to invest in newbuild tankers would consider asset trading if the opportunity presented itself.

Ship Type	Economic Indicator	Owner Number			
		First	Second	Third	Later
Bulkers	Bulker Earnings	2.17**	2.57**	0.04	-2.72**
	Bulker Earnings 3 months lag	-0.05	2.28**	-0.40	-2.62**
	Bulker Earnings 6 months lag	-0.91	1.02	-0.13	-2.44**
Tankers	Tanker Earnings	3.37**	0.86	-0.85	NA
	Tanker Earnings 3 months lag	2.04*	0.90	-1.65	NA
	Tanker Earnings 6 months lag	1.77*	0.40	-3.92*	NA
Containers	Container Earnings	-0.62	-0.66	-1.47	NA
	Container Earnings 3 months lag	-1.79*	-2.05**	-2.10**	NA
	Container Earnings 6 months lag	-2.51**	-2.13**	-1.47	NA

Note: The reported values correspond to the Z-statistic calculated for each economic indicator. The '' symbol indicates significant (**) or marginally significant values (*).*

Table 6.11. Economic Indicators' Effect by Owner Number and Ship Type

In terms of second owner, bulk carriers are significantly more likely to be sold when the earnings are high. Tankers appear to be more likely to experience termination of ownership when the earnings are and have been high previously, however, the effect of earnings is not statistically significant. The intensity of the effect of earnings diminishes for lagged covariates, which suggests that the response of bulker and tanker owners to changes in shipping earnings, especially first and second owners, is much more pronounced in the short term.

Overall, the effect of earnings with regard to third owner seems to be negative, which suggests that most vessels are likely to experience termination of ownership when the average earnings by ship type are relatively lower. The results corresponding to later owner periods of ownership in relation to bulk carriers are consistent with this trend.

In the case of the owners of container vessels, it appears that the lagged earnings provide a more meaningful interpretation of the behaviour in relation to the likelihood of the vessels to experience termination of ownership. Past higher earnings encourage owners to keep their assets. The high significance of lagged covariates coupled with the intensity of the results is likely a product of the nature of the business at the core of which is providing a frequent and reliable service. There is no evidence that owners of container vessels are likely to take advantage of asset trading opportunities. This is to be expected as competition in the sector is linked to availability of capacity. Furthermore, the fact that the effect of lagged earnings appears to be stronger in the container sector indicates that the decision whether to sell an asset and its execution might take longer than in the dry bulk segment of the fleet. This phenomenon is also attributed to the nature of the container trade and it is likely linked to the fact that the time and capital it takes to enter or leave the dry-bulk carrier market is less than the resources required to enter or leave the container trade.

The results on the influence of economic indicators on periods of ownership and the probability of termination of ownership confirm that shipping earnings influence the probability of termination of ownership and therefore periods of ownership. According to the results presented here, the effect of shipping earnings varies across owner numbers and ship types. While no claims are made that the results provide a complete examination of the reasons behind any such behaviour, there is evidence that the first and second owner in the bulker and tanker segment of the fleet react to changes in shipping earnings fast and appear to be more prone to generating profit through asset trading. In the case of container vessels as well as third and later owners in the bulker and tanker segment of the fleet, higher past earnings encourage owners to hold on to their ships. This suggests that subsequent owners, who acquire vessels later on in their economic life in relation to bulk carriers and tankers are less prone to asset trading.

6.5. Results on the Influence of Company Level Characteristics and Economic Indicators on Periods of Ownership in Shipping Overview

As in previous analyses, Cox regression was used to examine the likelihood of vessels to experience termination of ownership based on a selection of ship and company level characteristics. The overall analysis in this chapter is stratified once by owner number in order to compare all ship types and subsequently more detailed analyses by ship type[169] are discussed. The chapter was divided into two parts: (i) the investigation of fixed covariates representing ship and company level characteristics[170]; (ii) and the investigation of time-varying covariates represented by monthly shipping earnings data. The main reason for presenting the results in this way is the fact that models with time-varying covariates do not allow for the generation of graphical representation of the results in the form of predicted survival curves. The default list of covariates used in both types of models (with fixed or time-varying

[169] See discussion on analysis stratification in Chapter 3, section 3.3.2.
[170] Often referred to as '*company level analyses'* in the interest of brevity. However, this section of the chapter refers to analyses where company level characteristics were added to a selection of ship level characteristics thus combining both ship and company level characteristics.

covariates) is identical with the exception of shipping earnings, which were the reason for the consideration of time-varying covariates. As there is no significant change in the effects of ship or company level covariates within the fixed and time-varying models, except for delivery year, as explained in section 6.4, the overview of the results provided here comprises a summary of all models discussed in this chapter regardless of the types of covariates used.

6.5.1. Summary of the results by owner number

A summary of the findings by owner number is presented in Table 6.12, which contains the list of the characteristics that were found to have a significant effect on termination of ownership according to owner number.

	Covariates with significant effect according to owner number models		
	1st owner	**2nd owner**	**3rd owner**
Ship level	Ship type Ship size Delivery year***	Age at purchase**	Ship size Age at purchase**
Company level	Company type Company size Nationality of control	Company size Nationality of control	Company size Nationality of control
Economic Indicators	Shipping earnings* (no lag)	Shipping earnings* (no lag and 3 months lag)	

* 'Shipping earnings' refers to the Clarksea index in the case of owner number models.
** 'Age at Purchase' is included only in the company level models as a fixed covariate.
*** 'Delivery year' is only significant in the models with fixed covariates (ship and company level)

Table 6.12. Summary of Results by Owner Number

The probability of remaining with the respective owner differs by ship type only in the case of first owner, where container ships are found to be significantly less likely to be sold. In the case of first owner, larger vessels are less likely to experience the event whereas according to the model corresponding to third owner period of ownership, larger vessels are more likely to experience termination of ownership. A likely explanation is the fact that proportionally more vessels are sold to scrap yards at the end of the ownership period with the third owner. As larger vessels have a lower scrap age on average, it is not surprising that the effect of ship size reverses for third owner leading to such ships being more likely to experience termination of ownership.

Delivery year of the vessel is only marginally significant in the case of first owner. Vessels built at a later stage of the delivery profile of the sample appear to be more likely to be sold. Although not statistically significant, the effect of delivery year reverses for subsequent owners, which indicates that vessels built in the 1990s were less likely to experience termination of ownership while in the possession of the second and the third owner.

Age at purchase has a significant effect and as is to be expected, the older the vessels are at the time of purchase by the respective owner, the more likely are they to experience termination of ownership.

Company type has a significant effect on the probability of termination of ownership in relation to first owner. Financial institutions were found to be significantly more likely to sell a vessel, followed by private and public companies, whereas ships owned by state companies have the highest survival probability. Although the effect is not significant for second and third owners, this trend is consistent. In terms of nationality of control according to maritime traditions, owners associated with traditional maritime nations are more prone to selling an asset than owners from emerging maritime nations. Company size in terms of number of ships owned by the group company, has a significant effect on the probability of termination of ownership regardless of owner number. Larger companies are a lot more likely to hold on to an asset than small companies.

In the case of first and second owners it appears that ships are more likely to be sold when shipping earnings are high. The probability of termination of ownership regarding to third owner is not affected by shipping earnings.

Overall, ship level characteristics appear to have an impact on the behaviour of early and later owners in terms of owner sequence. Company level covariates, especially company size and nationality of control, appear to be consistently significant across owner numbers. Economic indicators in the form of shipping earnings appear to have a more pronounced influence on the behaviour associated with buying and selling of ships in the case of first and second owners.

6.5.2. Summary of the analyses by owner number and ship type

This section summarises the results based on the stratification by owner number and ship type, which aimed to investigate the effect of company level characteristics and economic indicators on termination of ownership and therefore periods of ownership within each segment of the fleet. As discussion of the results based on each individual model by owner number and ship type have already been presented earlier in this chapter[171], in the interest of brevity only a brief summary of the effect of each characteristic is presented below. The characteristics found to have a significant effect on the probability of termination of ownership by the respective owner are listed in Table 6.13.

List of characteristics tested as part of the analyses			
Level	**Ship**	**Company**	**Economic Indicator(s)**
	Ship Size Delivery Year Age at Purchase	Company type Company Size Control	Earnings (Average shipping earnings according to ship type)

List of characteristics found to have a significant effect on the probability of termination of ownership				
Owner No	**Characteristics' level**	**Ship Type**		
		Bulker	**Tanker**	**Container**
First	Ship	Ship Size	-	-
	Company	Company Type Company Size Control	Company Type Company Size Control	Company Type Company Size Control
	Economic Indicator	Earnings	Earnings	Earnings
Second	Ship	Age at Purchase Ship Size Delivery Year^	Age at Purchase	Age at Purchase
	Company	Company Size Control	Company size	Company Size
	Economic indicator	Earnings	-	Earnings
Third	Ship	Age at Purchase* Ship Size Delivery Year*^	Age at Purchase Ship Size	Age at Purchase
	Company	-	Control	Company Size
	Economic	-	Earnings	Earnings
Later	Ship	Age at Purchase Ship Size	NA	NA
	Company	Control	NA	NA
	Economic indicator	Earnings	NA	NA

* Indicates marginal statistical significance at the 95% level.
^ 'Delivery year' is only significant in the models with fixed covariates (ship and company level)

Table 6.13. Summary of Results by Owner Number and Ship Type

Note: The characteristic 'Control' refers to Nationality of Control according to maritime traditions. 'Age at Purchase' is included only in the company level models as a fixed covariate.

All characteristics considered on company level as well as shipping earnings representing the economic indicators' group of characteristics are found to be significant for first owner regardless of ship type. Interestingly, ship level

[171] Results discussed in each respective sub-section of section 6.3 and 6.4. The findings of each individual model based on owner number have also been summarised at the end of each sub-section.

characteristics barely affect termination of ownership in the case of first owner. Although new vessels are built to exact specification, which is often a product of the trade and even specific routes that a vessel might be intended for, the size of the ship does not appear to be a significant factor in the decision to sell the asset[172] in the case of tanker and container ships. Ship size appears to have a significant effect on the probability of termination of ownership for third owner in the tanker segment of the fleet, however. This effect is likely a combination of the following reasons: (i) vessels' average scrap age differs by ship size especially amongst different sized tankers[173] and (ii) the proportion of vessels sold to scrap yards in comparison to vessels sold to subsequent owners is higher for third owner than any earlier owners. Handy tankers are found to be the least likely to experience the event of termination of ownership, whereas larger tankers and especially Aframaxes[174] are significantly more likely to be sold. Ship size is found to have an effect on termination of ownership in relation to bulk carriers regardless of owner number. In the case of first owner, larger vessels are less likely to experience termination of ownership. The effect reverses for subsequent owners, which is likely a result of the shorter average scrap age for Capesize bulkers.

The rest of the ship level characteristics considered as part of the analyses, namely delivery year and age at purchase, are only included as part of the models with fixed level covariates (ship and company characteristics). Their function in the models with fixed covariates was to account for calendar time (delivery year) and vessel's age (age at purchase). According to the results, bulk carriers delivered during the early stage of the delivery period of the sample (late 1980s and early 1990s) are more likely to be sold by the second and third owner age for age than ships delivered at a later date. The effect of age at purchase by the respective owner is consistent across owner numbers and ship types – the older the vessel at the time of purchase, the more likely it is to experience termination of ownership. In the time-varying models, however, age is used to create the individual records based on monthly time intervals, which renders

[172] The event of interest is the termination of ownership, which could be a sale to a subsequent owner or a scrap yard.
[173] The average scrap age by ship type and size according to the sample is presented in Chapter 4, section 4.3.1.e).
[174] A potential explanation for this is the fact that Aframax tankers, although one of the three main ship sizes involved in the transport of crude oil, are also the most flexible of the large tanker categories as they are not restrained by the same draught restrictions as Suezmax and VLCC tankers. A part of the Aframax fleet is also involved in the transportation of clean (oil) products (Kavussanos, 2003), which might be related to why this ship size is more likely to be sold. However, it should be borne in mind that such questions are out of the scope of this research and that any attempts to elaborate on such findings at this stage is based on speculation

the use of age at purchase unnecessary. In the case of delivery year, the effect of the covariate disappears when included in the time-varying model, which suggests that the effect of delivery year is associated with the state of the market.

Company level characteristics, especially company size and nationality of control, appear to be consistently significant across owner numbers and ship types. Company type has a significant effect in the case of first owner across all ship types. Financial organisations are found to be the most likely ones to sell an asset, followed by private and public companies, whereas state companies are the least likely ones to sell an asset. This trend is consistent regardless of owner number or ship type. In the case of bulk carriers and tankers, there is no significant difference between the probability of a vessel owned by a private or by a public company to experience a termination of ownership. In the container ship sector, however, private companies are significantly more likely to sell an asset than a public company. It should be noted that the number of financial and state companies included in the overall sample is relatively small, which led to a limited use of the original company type classification based on all four company types in the data samples corresponding to second and third owners.

In most cases company size influences the probability of vessels' ownership to be terminated. Company size affects the probability of termination of ownership in the case of container ships regardless of owner number and it is found to be significant in the models regarding the first two owners in the bulker and tanker segments. Generally, ships owned by smaller companies are more likely to experience termination of ownership age for age. The highest disaggregation between likelihood of termination of ownership based on company size exists in the bulker segment, where there are significant differences between small (≤10 ships), medium (11-50 ships) and large (>50 ships) companies. In the case of tankers, small companies (≤10 ships) are more likely to sell an asset but there is no difference between medium and large companies. In the container segment, it appears that large companies (>50 ships) are less likely to terminate their ownership of an asset on average, however, no real difference is observed between the probabilities of termination of ownership by small and medium companies.

Nationality of control is another characteristic, which was found to have an effect on the probability of termination of ownership by the first owner regardless of ship type. It appears that nationality of control influences the bulker segment of the fleet the most, whereas the probability of termination of ownership by subsequent owners of container ships does not vary significantly based on the country the owner is associated with. Overall, ships in the possession of owners associated with traditional maritime nations were found to be more likely to experience termination of ownership in comparison to ships owned by owners associated with emerging maritime nations. This is no surprise as emerging maritime nations are mostly developing countries whose economies have not yet matured or are in the process of maturing, such as China. More often than not, such countries' fleets are dedicated to servicing the national demand for goods and materials and associated with national interests, which explains the limited association with asset trading and short-term ownership. Further investigation on nationality of control was based on the inclusion of the top three countries in each segment rated by the number of records in the dataset, which led to the inclusion of Greece, China and Japan in terms of bulkers and tankers and Germany, China and Japan in the case of container ships. Greek-owned bulkers and tankers were found to be significantly less likely to be sold in the analyses corresponding to first owner. Japanese-owned vessels are the most likely ones to experience termination of ownership regardless of ship type. There are no significant differences between specific countries in the case of subsequent owners in the case of tankers. However, in the case of bulk carriers it appears that Japanese-owned vessels are the most likely ones to be sold by the second owner, whereas ships associated with owners from emerging maritime nations are the least likely ones to be sold. There is evidence that in the case of later owners (>3), Greek-owned vessels are less likely to be sold.

The results regarding the influence of economic indicators confirmed that shipping earnings influence the probability of termination of ownership, although the intensity and the effect of the findings differ by owner number and within segments. Overall, the results suggest that first and second owners of bulk carriers and tanker vessels might be more likely to consider asset trading opportunities as the timing of the sales of vessels corresponds to periods of rising shipping earnings. In the case of container ships and third and later owners in both, the dry and wet bulk segments, it appears that higher past earnings encourage owners to keep their assets.

6.6. Concluding Remarks

This chapter aimed to investigate the influence of company level characteristics and economic indicators, such as shipping earnings, on the probability of termination of ownership and therefore periods of ownership.

The first part of Chapter 6 is dedicated to providing an overview of the main company level characteristics chosen to be tested as part of the analyses, in relation to periods of ownership. The list of company characteristics are tested with the help of the Kaplan-Meier product estimator as part of the exploratory work on first owner period and the reasons for omitting certain variables from further analyses are discussed (6.2.1).

In the interest of clarity, the subsequent analyses investigating the influence of company level characteristics (fixed covariates) were then stratified by both owner number and ship type (Section 6.3). Sections 6.3.1 to 6.3.4 provide a brief summary of the data on periods of ownership by owner number and the results from the Cox Proportional Hazards models used to examine the effect of the selected company level characteristics on the probability of vessels to experience termination of ownership by the respective owner. A similar approach was applied to the investigation of the influence of shipping earnings on termination of ownership. However, as shipping earnings change with time, the Cox Proportional Hazards model used to estimate the effect of fixed covariates on ship and company level, was extended to accommodate time-varying covariates (Section 6.4).

The results regarding the effect of all characteristics including company level and economic indicators are then summarised and discussed (Section 6.5).

Chapter 7 will now provide an overview of the results obtained as a result of a number of in-depth interviews with shipping professionals regarding perceived patterns and influences associated with periods of ownership in shipping.

Chapter 7. Industry Response to Patterns and Influences Concerning Periods of Ownership in Shipping

7.1. Introduction

In order to explore the perception of periods of vessel ownership in shipping from a practical, industry point of view, several in-depth interviews with shipping professionals were conducted as part of this research. The aim of the interviews was three-fold, namely (i) to help identify potential characteristics that industry professionals believe have an effect on periods of ownership in shipping; (ii) to provide potential elicitation on patterns of ownership in shipping and (iii) to gauge industry professionals' opinions about the perceived importance of the types of characteristics considered as part of this research. It should be noted that the purpose of the in-depth interviews is not to validate the results from the statistical models but to complement the results on patterns and influences associated with periods of ownership in shipping.

7.2. In-depth Interviews: Results Overview

7.2.1. First phase – introduction

All names are treated as confidential information due to ethical and commercial-in-confidence considerations. The distribution of participants' years of experience in the shipping industry is presented in Figure 7.1.

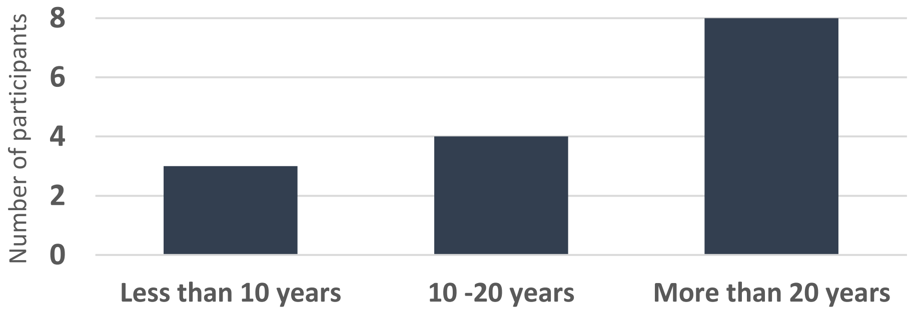


Figure 7.1. Distribution of participants' years of experience in the shipping industry

Figure 7.1 shows that the majority of the participants, 12 out of 15, have had more than 10 years of experience in the shipping industry, which would imply that they have gained knowledge and an insight into the nature of the industry and have observed and experienced market cycles, which according to Stopford (2009) tend to last about 7 years on average. The individual perspectives of shipping professionals who have spent less than or about 10 years in shipping are also very valuable as such participants will have started their careers about the time of the financial market collapse of 2008, which implies that they are familiar with current attitudes. It should be noted, however, that due to the limited sample size and the overall design of the interview process no comparisons between these two groups could be made. Furthermore, it should be borne in mind that despite limited exposure to shipping in terms of a professional career, two of the participants with less than 10 years of experience come from families with a history in shipping and therefore have a somewhat richer insight of the inner workings of the shipping industry. In terms of professional occupation, the sample is comprised of the following broad categories: marketing specialists (5 in total, 3 of which at executive level positions); representatives from three large ship registers[175] (3 in total, comprising of a marine surveyor, a designated person ashore (DPA) and a senior executive); technical managers (2); an executive editor from a leading shipping publication (1); an executive from a large shipping company (1); an IACS[176] representative (1); a shipping finance specialist with ties to academia (1) and a leading maritime economist (1).

7.2.2. Second phase – length and patterns of ownership

The second phase of the interview process focused on the perception of shipping professionals on length and patterns of ownership in shipping.

The analysis of the data gathered as part of the interview process reveals that the recurrent view of what constitutes '*short*' periods of ownership are periods between 3 and 5 years. In terms of what shipping professionals define as being a '*long*' period of ownership, all respondents indicated a range of above 10 years with the dominant view that '*long'* periods of ownership are periods of '*more than 20 years'* or realistically most of the economic life of the vessel. Three interviewees were not comfortable with assigning numerical values to '*short'* or '*long*' period of ownership.

There was a broad consensus amongst the interviewees that there are distinctive patterns of ownership in shipping. Although there were different characteristics discussed as being the reasons for the existence of patterns, the concept of first and subsequent owners was brought up by most interviewees. According to the data gathered, most interviewees perceive first owner to be normally associated with '*long*'

[175] The ship registers represented here are the following: Liberian register, Bermuda DMA, Bahamas Maritime Authority.
[176] IACS stands for the International Association of Class Societies.

term period of ownership, whereas subsequent owners are often seen as more '*speculative*'. For example, one of the interviewees said that:

> *'I think your average owner, when they order a ship, is committed to the life of this ship. […] I think all owners go in wanting to keep the ship for the whole life of the ship....'*

The differences in the length of ownership between first and subsequent owners is recognized in the literature (Einarsen, 1938; Stott, 2013)[177] and further supported by the findings on length of ownership presented in Chapter 5 and Chapter 6.

Another respondent provided a very insightful example of a typical pattern of ownership of a bulk carrier from a historical perspective:

> *'Well, from a historical perspective…for many years, respectable top tier British companies […] the better companies tended to keep the vessels for about 12 years and then traded them to the Greeks who traded them for the rest of their lives. In fact, often the Greeks would buy them and charter them more cheaply back to the liner companies. There was an institutionalised hybridity there in the sense that the first owners were not speculative, whereas the second and later owners were highly speculative. So look at old Captain Costas. He still has his first ship that was owned by a liner company for 12-14 years and then it was owned by 4 other Greeks and it eventually goes down to a price that Captain Costas can afford and he buys it at 25 years and interestingly, it stops being speculative then because Captain Costas wants some cash out of it, he runs it cheap so he reverts it at the ends of the ship's life.'*

This particular observation is consistent with the results on periods of ownership depending on the total number of owners a vessel has had, as discussed in Chapter 5[178]. According to the results from the ownership sequence analysis, the median periods of ownership for bulk carriers with more than 3 owners in total indicate that the last owner usually keeps the vessel for longer than intermediate owners. As the interviews were conducted prior to the completion of the statistical analyses this allowed for certain patterns identified by interviewees to be investigated further based on the ship records data gathered as part of this research. The analysis on periods of ownership data corresponding to later owners (>3) in the bulker segment of the

[177] For a more detailed discussion see Chapter 2, section 2.2.2.d).
[178] The discussion can be found in Chapter 5, section 5.2.1.

fleet[179], showed that Greek-owned bulk carriers have the highest mean and median periods of ownership in comparison to the rest of categories representing nationality of control.

Another interesting theme, which has not been investigated as part of this research but has been discussed by several participants and thus it was deemed it deserved to be mentioned here, is the perception that the quality of shipping is also linked to the idea of long term and short term periods of ownership. For example, a participant stated that:

> '*I think for us [Ship register representative], we have a lot of quality shipowners so they keep the vessels for 15 years and then they scrap them or they sell them on the second hand market. But there are shipowners who pick up ships at 15 years, when our shipowners sell them. So I'd say that there are couple of different kinds.'*

The same participant elaborated further that by '*quality shipowners'* they mean shipowners, who make sure that their ships meet '*all the inventory requirements, safety requirements, they take care of their crew and they also maintain their ship'*. Another participant, who had 3 years of experience in a company known for '*speculative asset trading'* in their own words, stated that:

> *'Well, short term players do zero maintenance, they defer dry-docking by changing the Class, changing Flag and probably the technical management. This way they can get 6-9 months of additional time. Then if they are interested in keeping the vessel, they will do the dry-docking. The Greeks dominate in this followed by the Chinese and the South-East Asian owners like from Vietnam, Thailand and oriental owners. I am talking about the new owners, who copy the Greek mentality or a modified version of the Greek mentality.'*

During the discussion on patterns of ownership, interviewees mentioned different characteristics that have an effect on ownership according to their personal view. The list of characteristics that were mentioned by the participants during the second phase as part of the discussion on patterns of ownership is summarised in a word cloud[180] (Figure 7.2). The weights visually attributed to each characteristic match the frequency in terms of the number of people who mentioned a characteristic as opposed to the

[179] Discussed in Chapter 6, section 6.3.4. Mean and median periods of ownership corresponding to Greek owned vessels are shown in Data Annex Chapter 6, section 8.1.a).
[180] The word cloud was generated using an online tool, which can be found at wordclouds.com.

number of times each characteristic was actually mentioned during the whole 2nd phase series of interviews.

Figure 7.2. Characteristics Affecting Patterns of Ownership as per the Second Phase of the Interview Process

A recurring theme during the discussions was how the nationality of the owner affects patterns of ownership. As to be expected often interviewees shared anecdotes involving '*astute*' and '*canny*' Greek shipowners, who managed to time the sale and purchase of vessels just right and in the process to generate a substantial profit. The prevalent perception of Greek shipowners amongst the interviewees is that they are mostly active in the second-hand market and prefer short term investment horizons as it transpires also from some of the quotes presented earlier in this section. Most other traditional maritime countries, such as Norway, Germany, the UK and Canada, were mentioned by interviewees as examples of '*quality*' or '*efficiency'*.

The perceived effect of owner number has already been mentioned with interviewees expecting first owners to keep the vessels for longer in general. However, interviewees with experience as Class surveyors, gave reference to Japanese owners as an example of an exception to this rule of thumb. According to their experience, Japanese owners would very often have a ship built and then sell it between the first and the second special survey. According to the results presented in Chapter 5 and Chapter 6, Japanese-owned vessels were found to be the most likely ones to experience termination of ownership in most cases. Special surveys take place approximately every 5 years, which suggests that Japanese owners are perceived to sell their vessels between the age of 5 and 10 years. The periods of ownership histogram corresponding to Japanese-owned ships[181] reveals that the majority of the Japanese-owned vessels in the sample were indeed sold between the ages of 5 and 10 years.

[181] Based on first owner data only. The histogram can be found in Data Annex Chapter 7, section 1.1.

Preference towards a particular shipping segment, or in the context of this research – main ship type, was mentioned by several participants as a characteristic that determines ownership patterns. The explanation offered as to why the choice of shipping segment influences periods of ownership is based on the nature of the segments themselves. One participant elaborated that periods of ownership will vary depending on whether the main activity of the owner is related to the commoditised bulk trades or to non-bulk trades, which include liner operators, other service providers as well as specialised trades. The reason behind this specific classification is that liquid commodity orientated markets, such as the bulk carrier and tanker markets, offer more opportunities for speculation in terms of asset trading. In the words of another interviewee: *'…you can only speculate if you are in a market where you can speculate*'.

Other characteristics on company level, which were frequently discussed by interviewees concern company type and size. Several of the interviewees distinguished between publicly listed companies, companies owned or controlled by investment funds and '*average*' or '*traditional*' shipowners. One participant described such owners as:

> '*I mean, your average shipowner probably has 8-9 ships and those seem to be family owned concerns where, you know, they raise money from banks and in more traditional ways, they haven't got access to the capital markets and they tend to be quite conservative.'*

The idea of '*traditional*' shipowners revolves around the concept of commitment to the industry and the fact that such owners are in the industry for the long run, regardless of their preferred investment strategy. One interviewee remarked that:

> '…*private equity struggles with this [commitment] because they don't get it, they don't get shipping. '*

In terms of company size, the dominant view is that larger companies tend to prefer building new vessels, obviously to their detailed specification, and keeping them for much longer periods of time.

The influence of the market itself was fconsistently mentioned during the interviews. Although all acknowledged that the state of the market can be the deciding factor for purchasing or selling a vessel, it transpired that the perception of the role of the market changes. For example, some discussed the role of the market only as a motivation behind distress sales. Others described the market as the ultimate driver of every decision and shipowners are perceived to '*play*' the market.

As part of the second phase of the interview process, participants were also asked whether they had noticed a shift over the years in the attitude of owners, which has had or could have had an impact on periods of ownership.

One respondent, who had previously acknowledged that many Greek owners seem to employ short-term, asset trading strategy, claimed that there has been a significant shift in the behaviour of the larger Greek shipowning companies over the past decade as they switched to ordering new tonnage instead of acquiring second-hand vessels. This perceived shift in behaviour was explained by the low newbuilding prices offered by Chinese yards in the last decade. The data included in the sample on company level supports this claim as the majority of new ships purchased by Greek owners were delivered after 1995[182]. However, the respondent did not think that this trend would last.

Another recurrent view is that shipowners '*like their ways'*, '*stick to what they know*' and they only change when they '*are forced to change their ways'*. Most interviewees reported that they have not observed any changes in behaviour but acknowledged that since the recent influx of private equity firms in shipping they have always been '*different*'. The shipping industry has always had a reputation for reluctance to change and several interviewees commented on the observation that only severe shocks to the system under the form of stringent new regulations can lead to change. In terms of periods of ownership, one interviewee shared their expectation that the Ballast Water Management Convention will have a serious impact on periods of ownership as vessels over 15 years of age will most likely be scrapped rather than retrofitted with an onboard ballast water treatment system. The same interviewee quoted a Class NK industry survey as the basis for this speculation. Unfortunately, this survey could not be found in published form.

7.2.3. Third phase – influences on periods of ownership

The aim of the third phase of the interview process was to examine the perception of the participants regarding which of the characteristics identified during the literature

[182] This is shown in Data Annex Chapter 7, section 1.2.

search have an effect on periods of ownership and to rank this perceived effect where applicable.

The first group of characteristics that the participants were asked to evaluate concerned ship level characteristics. The following characteristics were included in the questionnaire: ship type, ship size, age, fuel consumption, speed, builder (yard) and builder area.

a) Ship Level Characteristics

The frequency of responses in regards with whether certain ship level characteristics are perceived to have an effect on periods of ownership for first owner (Figure 7.3) and subsequent owners (Figure 7.4.) are presented as follows.

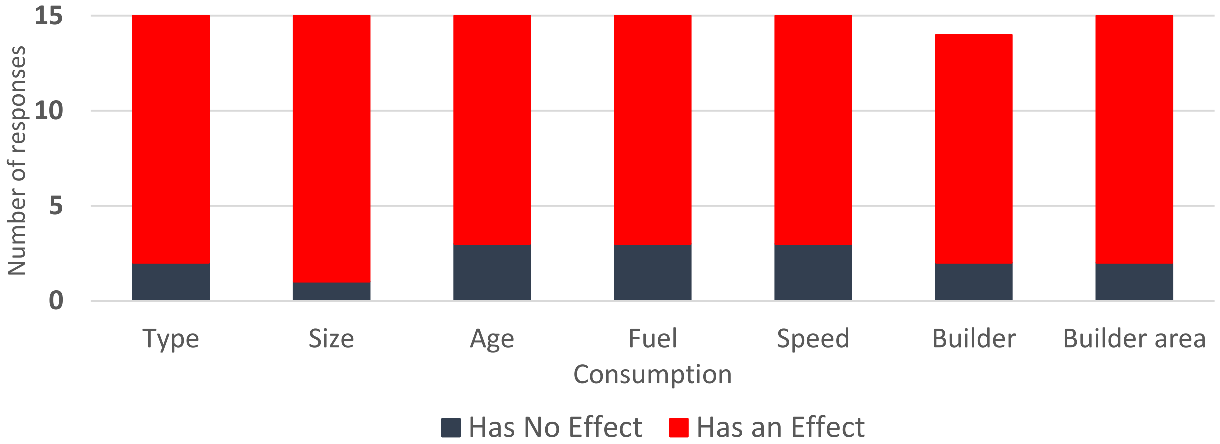
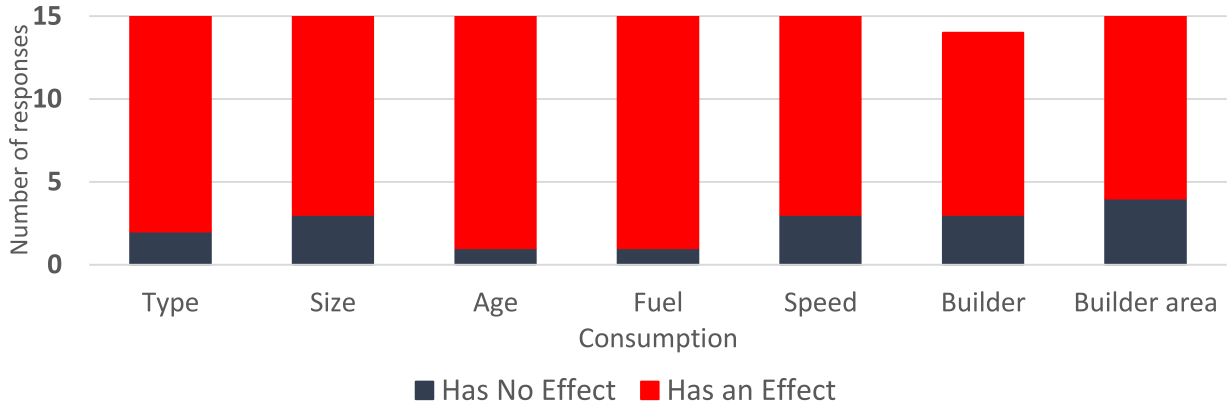


Figure 7.3. Ship Level Characteristics – effect on periods of ownership for first owner



Note: 1 participant chose the 'Not sure' questionnaire option in terms of builder effect.

Figure 7.4. Ship Level Characteristics – effect on periods of ownership for subsequent owners

All of the initially selected ship characteristics are perceived as having an effect on periods of ownership by the majority of the participants. For first owner, it appears that ship type, ship size, builder and builder area have been selected as having an effect by most participants. It appears that in terms of subsequent owners, participants perceive age and fuel consumption to be very important factors, followed by ship type, whereas ship size, speed, builder and builder area are perceived as likely to have an effect by less participants. It is natural that the effect of age is perceived to grow for subsequent owners as ships' economic life is finite and the age of the vessel has a direct impact on the amount of time it can be used for.

Figures 7.5 and 7.6 show how participants measured the size of the perceived effect on periods of ownership for first and subsequent owners respectively.

The three characteristics, which received the highest number of responses indicating that they have no effect on periods of ownership corresponding to first owner are: fuel consumption, speed and builder. This is further supported by the results on the perceived effect size as speed and builder received a high number of responses ranking their effect as '*weak*' in comparison to the rest of the characteristics. The case of builder area is interesting as only two people regarded it as having no effect, however most participants indicated that builder area has either weak or medium effect on periods of ownership. The characteristics, which are deemed to have a strong effect on periods of ownership are: ship type, ship size, age of the vessel and fuel consumption.

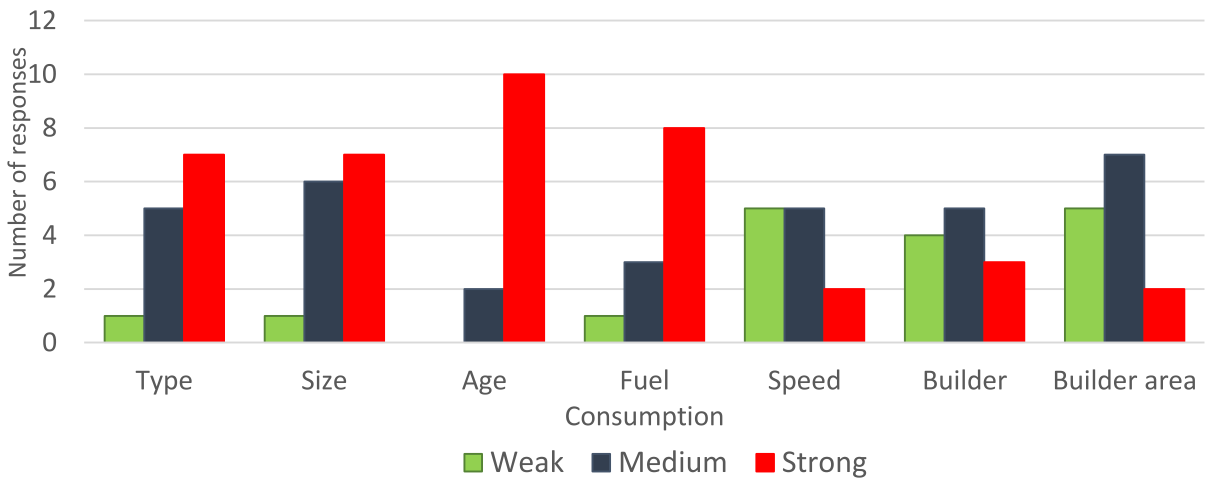


Figure 7.5.Ship Level Characteristics – effect size for first owner

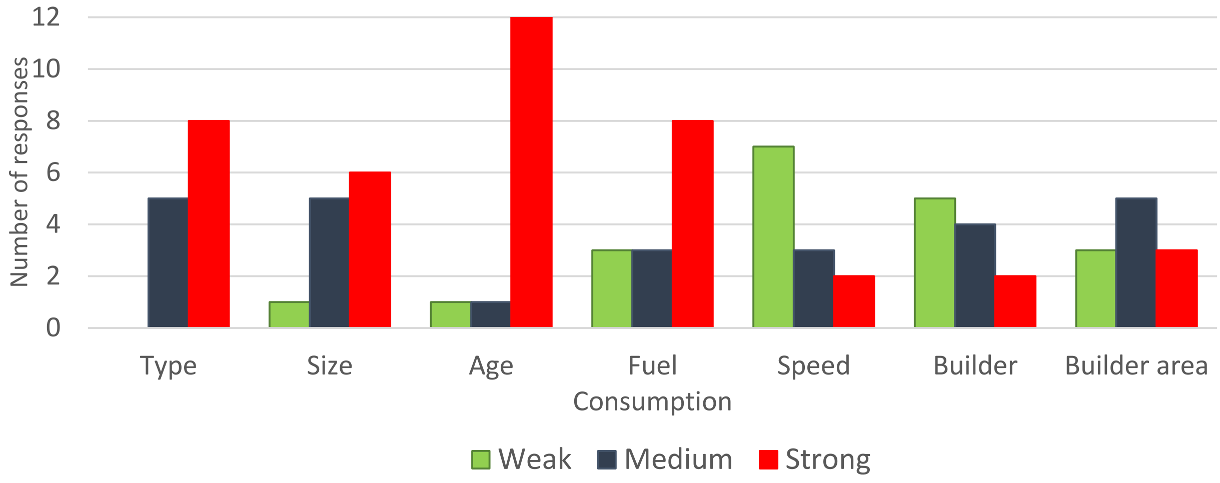


Figure 7.6. Ship Level Characteristics – effect size for subsequent owners

This trend is certainly confirmed by the data gathered regardless of owner number. However, it appears that the effect of the rest of the ship level characteristics, namely speed, builder and builder area, weakens with regards to subsequent owners. It should be noted that this is consistent with the results from the statistical models in regard to the effect of builder area, which seems to be statistically significant across all ship types for first owner, however this is not the case with subsequent owners. As for the effect of speed and fuel consumption, some participants elaborated that it is of considerable importance when it relates to situations where a choice between two similar vessels in terms of type and size needs to be made. For example, if a shipowner has a fleet of tankers of similar size then, ceteris paribus, they will consider the fuel consumption and speed of the vessels and keep the optimal tanker for their preferred operation strategy. Therefore, it can be argued that the perceived effect of speed and fuel consumption does not have a direct impact on periods of ownership in practice.

The second group of characteristics participants were asked to evaluate concerns company level characteristics. These include: company type (financial, private, public, state), company owner nationality and company size.

b) Company level characteristics

As it was indicated from the second phase of the interview process, company level characteristics are perceived to have an effect on periods of ownership with owner nationality being the most frequently selected characteristic for first owner (Figure 7.7). Participants gave identical responses in terms of characteristics that have an effect on periods of ownership for subsequent owners.

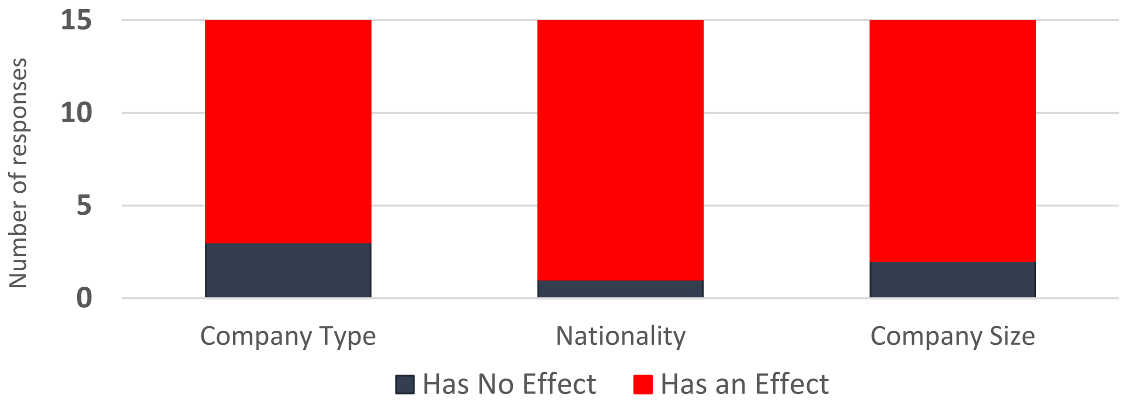


Figure 7.7. Company Level Characteristics – effect on periods of ownership for first and subsequent owners

Interestingly, no participants perceived company type to have a weak effect indicating this characteristic has a serious impact on periods of ownership corresponding to the first owner (Figure 7.7).

Most participants ranked company size to have a medium effect, whereas the perception of the size of the effect of company type is a tie between medium and strong effect. Of all three categories, nationality is perceived by the highest number of participants to have a strong effect on periods of ownership but interestingly is also the category that received the highest number of weak effect size votes too (Figure 7.8).

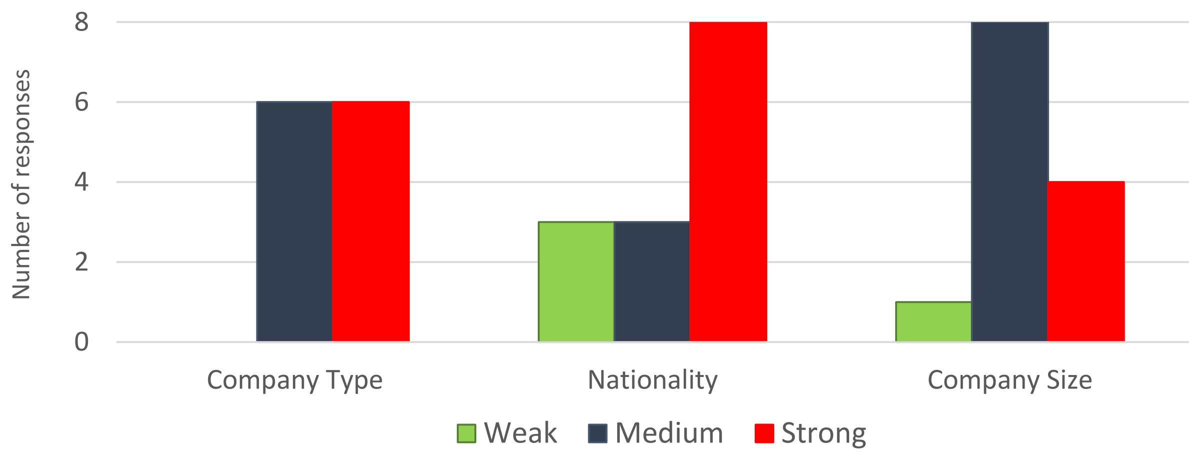


Figure 7.8. Company Level Characteristics – effect size for first owner

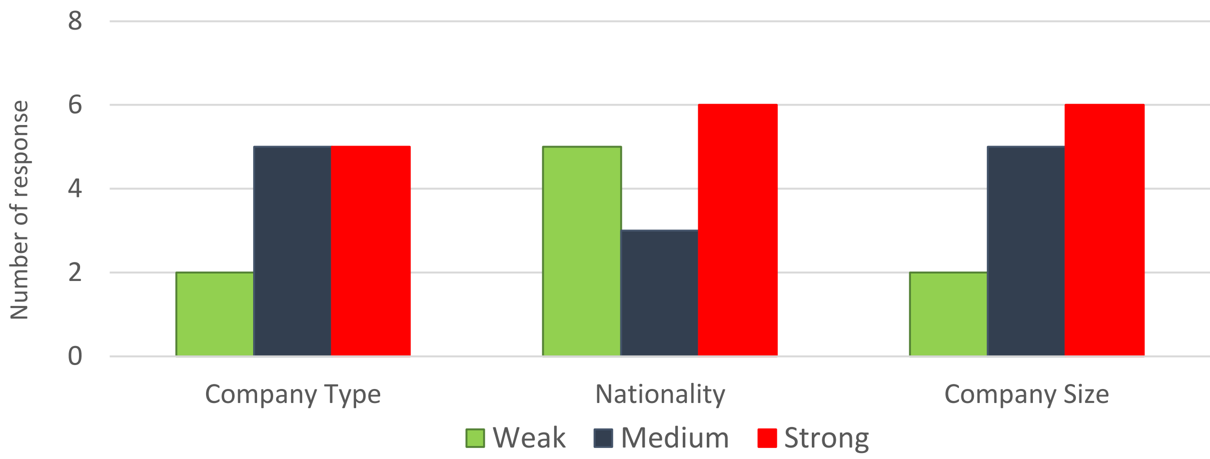


Figure 7.9. Company Level Characteristics – effect size for subsequent owners

The perceived effect of nationality for subsequent owners seems to diminish according to participants, which is somewhat surprising as previously most interviewees discussed that asset trading and shorter investment horizons are more common for subsequent owners and provided examples of famous trading strategies applied by certain nationalities (Figure 7.9).

In general, most interviewees seem to perceive all company level characteristics provided to have an effect on periods of ownership for first and subsequent owners. However, the perceived average effect of company type and nationality seem to be less important for subsequent owners, whereas this might not be the case for company size.

These findings are generally supported by the statistical analyses, according to which company level characteristics have significant effects on periods of ownership corresponding to the first owner, however, for subsequent owners different company level characteristics appear to affect the probability of termination of ownership within the three shipping segments[183]. For example, nationality of control appears to have a significant effect in the bulker segment of the fleet, whereas company size was found to have a more prominent effect in the container segment of the fleet.

c) Economic indicators

The economic indicators that were included in the initial list of characteristics likely to have an effect on periods of ownership could be divided into two groups, namely:

[183] See Chapter 6, section 6.5.2, Table 6.13. Summary of results by owner number and ship type.

- Shipping market indicators: freight rates, newbuilding prices, second-hand prices and demolition prices;
- Global economic indicators: economic growth (industrial production), exchange rate, inflation, interest rates, oil price and bunker price.

All of these indicators are perceived to have an effect on periods of ownership by the majority of the participants, especially for first owner (Figure 7.10).

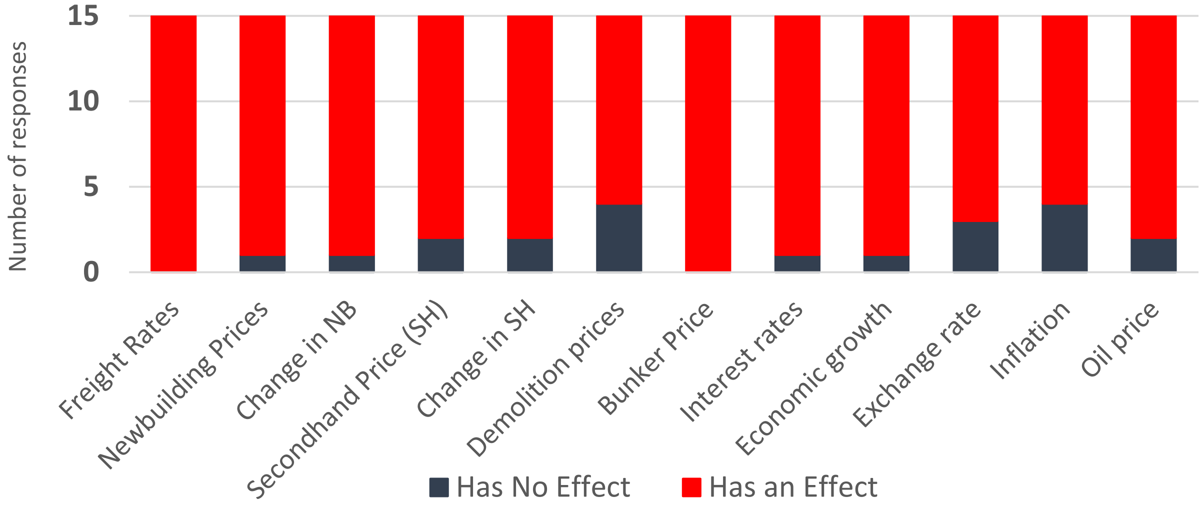


Figure 7.10. Economic Indicators – effect on periods of ownership for first owner

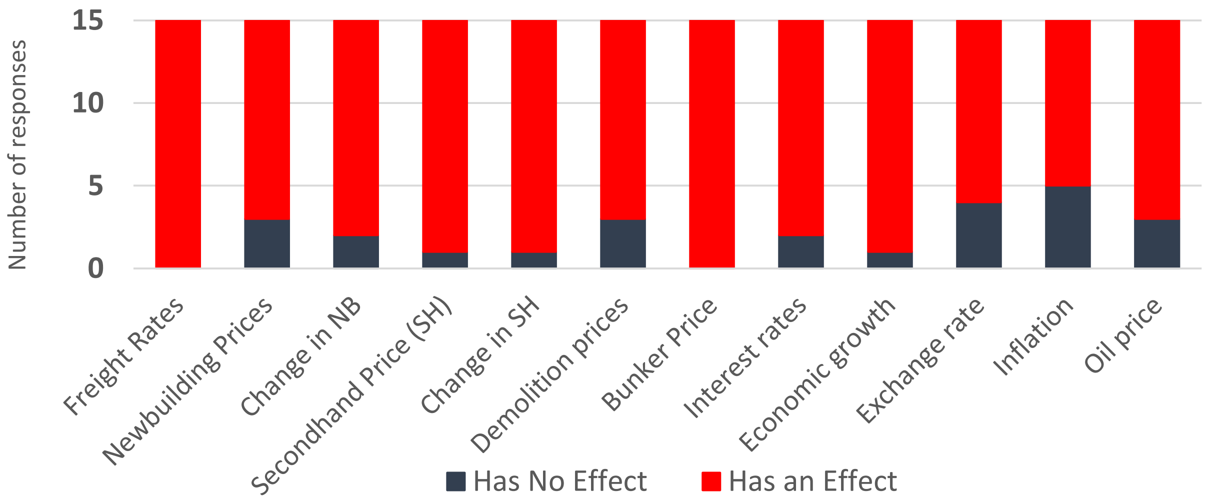


Figure 7.11. Economic Indicators – effect on periods of ownership for subsequent owners

For periods of ownership corresponding to subsequent owners, some of the indicators, such as exchange rate, inflation and oil price, seem to be selected by less participants as having an effect (Figure 7.11).

Freight rates, change in newbuilding prices, second-hand prices, change in second-hand prices, bunker price and economic growth were selected as having an effect on periods of ownership by the highest number of participants regardless of owner number. There is a broad consensus amongst participants that freight rates and newbuilding prices have the strongest effect on periods of ownership corresponding to the first owner. Generally, the indicators related to the shipping markets – apart from demolition prices – are regarded as having a stronger effect on periods of ownership as far as first owner is concerned (Figure 7.12).

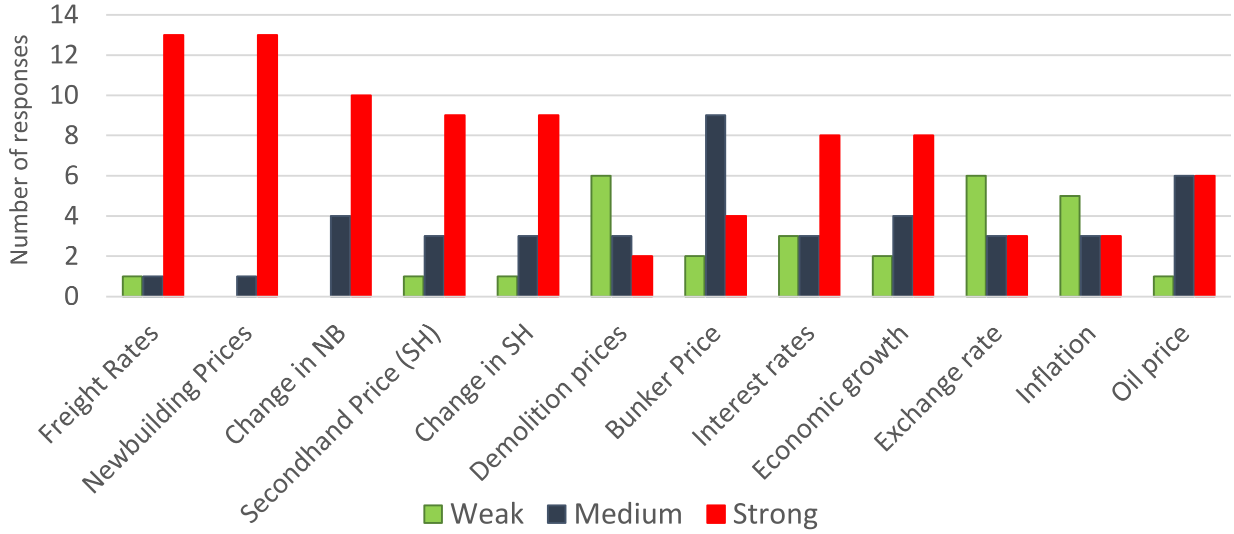


Figure 7.12. Economic Indicators – effect size for first owner

In terms of subsequent owners, shipping market indicators are also perceived to have stronger effect on periods of ownership than global economic indicators, however newbuilding prices are seen as less relevant for subsequent owners (Figure 7.13).

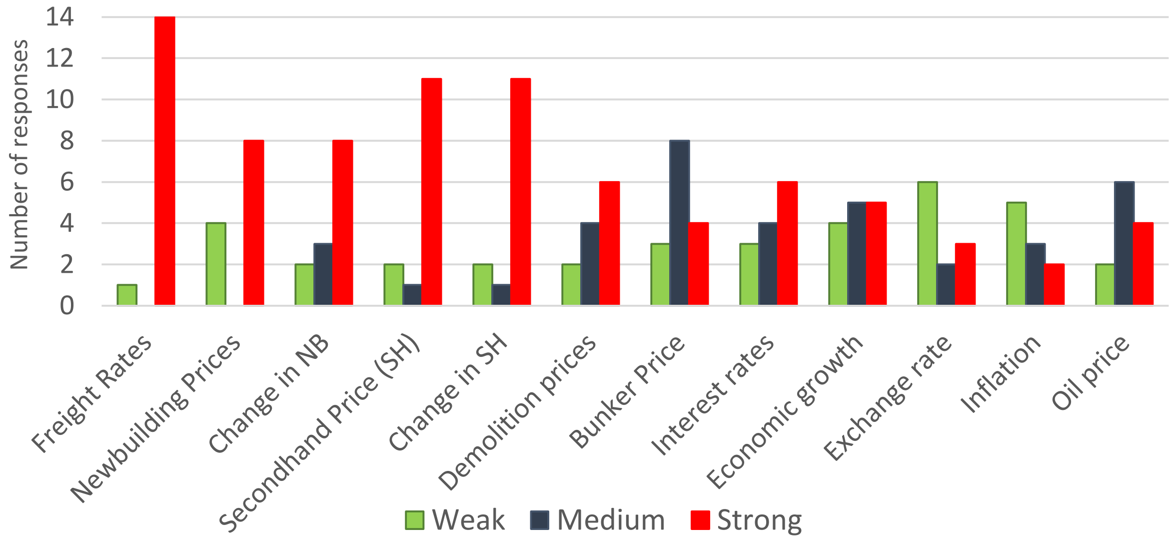


Figure 7.13. Economic Indicators – effect size for subsequent owners

Undeniably, the single most important indicator regardless of owner number is freight rates according to participants. The results regarding the perceived effect size of economic indicators in addition to the high pairwise correlations between all economic indicators (Bijwaard and Knapp, 2009) and the general consensus in the literature regarding the effect of freight rates further supported the decision to include earnings as a measure of the state of the shipping market in the numerical models[184]. Earnings were chosen over freight rates as they are estimated from voyage freight rates where the current bunker costs, estimated port costs and total commission are deducted[185].

As part of the questionnaire, participants were asked to choose the single most important characteristics affecting periods of ownership. Most of the participants pointed out freight rates and ship type to be the two single characteristics which have the strongest influence on length of ownership. Several interviewees even argued that it is implied that periods of ownership would vary across ship types as the decision regarding which shipping segment to get involved in, reflected here by the choice of ship type, is a key strategic decision and which has implications regarding asset trading opportunities. This finding reinforced the decision to stratify the numerical analysis on periods of ownership by ship type.

At the end of the interview participants were asked to rank the three groups of characteristics by their perceived importance in terms of their effect on periods of ownership. Figure 7.14 highlights the perceived importance of the groups of characteristics. There is a broad consensus amongst the participants that economic indicators are the most influential group of characteristics in terms of effect on periods of ownership, followed by ship level characteristics and company level characteristics. This is in agreement with the overall view that market conditions drive strategic decisions such as when to buy or sell an asset.

[184] See discussion in Chapter 2, section 2.2.2.c).
[185] For a discussion on the chosen indicators see Chapter 4, section 4.3.3.

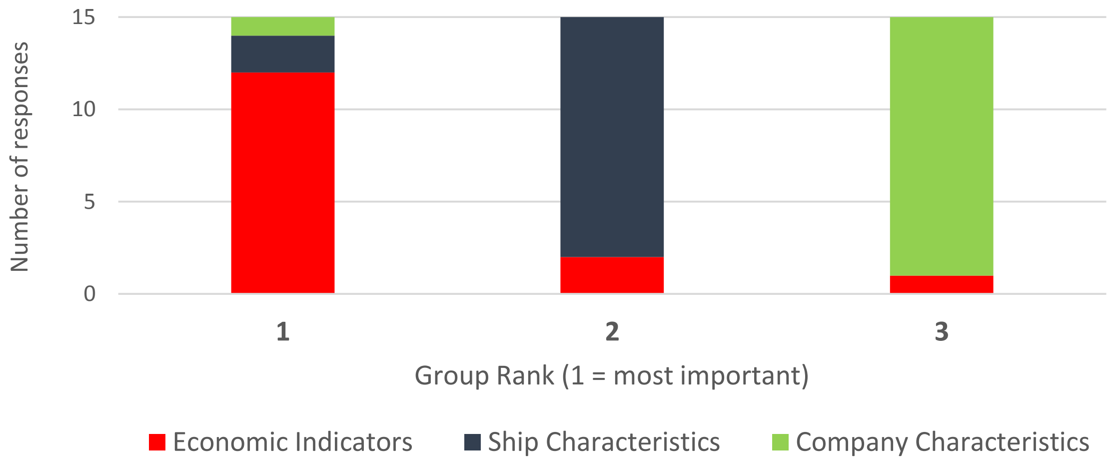


Figure 7.14. Perceived Importance of Groups of Characteristics

d) Comments on the choice of characteristics identified

All participants were encouraged to suggest any additional characteristics that they perceive as likely to have an effect on periods of ownership. The majority of the participants stated that the list they were provided with as part of the questionnaire is exhaustive and that it encompasses all dimensions that influence periods of ownership. The only suggestion received concerned explicitly stating the type of finance used. In the context of this research this is partially accounted for as one of the main differences between types of companies is in the type of ship finance available to them[186]. In the broadest sense, public companies have access to the capital markets, whereas small private companies usually rely on banks specialising in providing ship finance. However, further refinement regarding type of finance should be considered in future studies.

7.3. Concluding Remarks

Despite the limited availability of empirical evidence regarding periods of ownership in shipping, the data gathered through the interviews with shipping professionals revealed that there seems to be a broad consensus within the industry about what constitutes '*long*' and '*short*' periods of ownership in shipping. Participants confirmed that established patterns of ownership exist in shipping and elaborated on how certain characteristics can have an impact on periods of ownership.

[186] See discussion regarding company type in Chapter 2, section 2.2.2.

The findings from the interview stage provide evidence in favour of the decision to investigate length and patterns of ownership in shipping within three different dimensions – ship level, company level and the underlying economic context. The results from the interviews suggest that the perceived effect of certain ship characteristics, such as speed and fuel consumption, is not as significant in practice as to influence periods of ownership directly, but such characteristics are most certainly worthy considerations when it comes to a choice between acquiring or selling ships of similar type and size. With some small exceptions, the perceived effect of covariates as indicated by industry professionals is in agreement with the results from the statistical models aiming to determine the influential characteristics empirically.

Chapter 8 provides an overview of the overall research design and a critical discussion of the main assumptions and findings, followed by recommendations for further research.

Chapter 8. Discussion and Conclusions

8.1. Research Aim and Objectives

Despite the volatile nature of the industry and regulatory changes, the modelling of investment decisions related to sale and purchase practices in shipping is usually based on arbitrary assumptions regarding investment horizons as discussed in Chapter 2. The aim of this research is to investigate periods of ownership in shipping based on evidence from the commercial history of vessels built between 1987 and 2007 in order to determine a likely investment horizon for a vessel owner and to evaluate the influence of certain characteristics that relate to the asset, the ownership structure and the role of the market on periods of ownership.

A summary of the conclusions and the following discussion on main findings are organised by research objectives in relation to respective research questions as shown in Table 8.1.

Research Objectives	Research Question	Method
RO1: To investigate lengths and patterns of ownership in shipping based on evidence from the commercial history of vessels built between 1987 and 2007	RQ1 What can be regarded as likely lengths of ownership in shipping[187]?	Statistical analyses Interviews
	RQ2 What can be regarded as likely patterns of ownership in shipping[183]?	Statistical analyses Interviews
RO2: To evaluate the influence of a number of characteristics on ship level, company level and economic indicators on periods of ownership in shipping	RQ3 What characteristics on ship level and company level influence periods of ownership in shipping?	Statistical analyses Interviews
	RQ4 Do economic indicators, such as earnings, influence periods of ownership in shipping?	Statistical analyses Interviews

Table 8.1. Relationship Between Research Objectives, Research Questions and Methods

8.2. Justification of Overall Research Design

Maritime transportation is defined as *'both, an economic activity in which economic entities are involved and a social phenomenon in which a number of social actors interact'* (Woo *et al.*, 2013). Investigating maritime transportation related topics from an economics perspective allows for phenomena to be measured and analysed with the help of quantitative methods. However, periods of ownership in shipping depend on individual sale and purchase practices as they are directly linked to the decision to buy or sell an asset, which involves a social interaction. Bearing this in mind, this

[187] Based on evidence from the commercial history of vessels built between 1987 and 2007.

research adopts the pragmatist philosophy, which encourages the use of a practical approach that allows for each research question to be addressed by choosing the method deemed most appropriate and it acknowledges the use of methodological triangulation (Tashakkori and Teddlie, 1998). In order to capture the complex nature of periods of ownership in shipping and the characteristics that influence them, the research design of the project is consistent with the structure of a pragmatic inquiry (Johnson and Onwuegbuzie 2004).

In order to address the research questions accordingly, a five-phase research approach was adopted and is described in Chapter 1 (Figure 1.1). The phases involved carrying out the following activities: (i) a literature search and pilot interviews aiming to investigate lengths and patterns of ownership as well as characteristics that may influence periods of ownership; (ii) a desk-based study of nearly 4,000 ships' commercial history records in order to determine changes of ownership and to calculate periods of ownership; (iii) numerical analyses on lengths and patterns of ownership and influence of characteristics; (iv) in-depth interviews with industry professionals and (v) finalising the research findings.

The first research objective was to investigate lengths and patterns of ownership in shipping. In order to achieve this the life histories of vessels in terms of transitions between different owners had to be analysed. This task was achieved through employing a selection of techniques, which are described in Chapter 3, traditionally used in disciplines where transitions between different states are common, such as demographic research. The data on periods of ownership is time-to-event data[188], which resulted in the presence of incomplete (censored) data on periods of ownership as some of the vessels in the sample were still in service at the end of the follow-up period. Therefore, it should be borne in mind that the results on lengths of ownership, where no formal distinction is made between censored and complete observations, as presented in this research are indicative of trends and patterns but are not absolute. The alternative – ignoring incomplete observations, would cause the loss of a substantial amount of data and it would not be representative of the commercial life of vessels that were still in operation at the end of the follow up period.

[188] A definition of 'time-to-event' data and complete and censored observations in the context of this research is provided in Chapter 3, section 3.3.2.

As a result of the literature review, three separate groups of characteristics that are likely to affect periods of ownership in shipping were identified, namely: (i) ship level characteristics; (ii) company level characteristics and (iii) economic indicators. The second research objective was to determine whether the characteristics identified as likely to affect sale and purchase practices during the first research phase (literature review and pilot interviews) influence periods of ownership in shipping. This was achieved through estimating and comparing the probability of termination of ownership based on these characteristics by employing a form of regression analysis capable of handling time-to-event data[189]. The results of these analyses were validated empirically through the use of machine learning techniques similar to methods from the CART (Classification and Regression Trees) family, but modified to accommodate time-to-event data.

The decision to buy or sell an asset, however, involves social actors. Therefore, in order to complement the findings from the numerical analyses, in-depth interviews with industry professionals were conducted. The interviews were used as a means to check the adequacy of the list of characteristics identified as being likely to influence periods of ownership. Furthermore, industry professionals' perceptions of periods of ownership in terms of patterns and influences was explored as part of the interview process. The proposed research design was aimed at addressing the research questions and thus achieving the research objectives by selecting the most appropriate methods reflecting the nature of the problem under investigation. As a result, the quantitative nature of the findings from the statistical analyses was complemented by the perception of industry professionals regarding patterns and influences related to periods of ownership.

8.3. Discussion

8.3.1. Main assumptions and limitations

a) Changes of ownership

In order to gather data on periods of ownership in shipping, changes of ownership had to be identified. The definition of change of ownership[190] adopted in this research is based on sales on the group owner rather than on the registered owner level[191].

[189] Described in detail in Chapter 3, Section 3.3.2.
[190] The definition of '*change of ownership'* and a detailed list of rules used to identify changes of ownership are discussed in Chapter 3, section 3.3.1.
[191] The difference between group and registered owner is discussed in Chapter 2, section 2.4.

Changes of registered owner are common in shipping and are often associated with tax and liability reasons or could even be a prerequisite for a change of a vessel's flag. However, in many of these cases even though there might be a change of registered owner, the vessels remain with the same group owner. The framework used to identify changes of ownership as defined in the context of this research is built on the recommendations of Einarsen (1938) and Stott (2013) and developed further by the author's own experience of reviewing the commercial history records of ships. The commercial history of the 3,908 vessels examined as part of this research was obtained from Sea-Web. All identified changes of ownership were later compared to a bespoke dataset provided by Clarksons Research Services Limited and any inconsistencies were further investigated[192]. Despite the effort put into collating all the information needed to facilitate the examination of periods of ownership and the reputation of the abovementioned data providers, it was recognized that no total proof of the reliability of the data received by the data providers can be claimed.

Further assumptions related to specific parts of the data collection process as well as the adopted data aggregation and classification frameworks are discussed in more detail in Chapter 4 and the respective appendices.

b) Termination of ownership

The focus of this research is on periods of ownership in shipping. In order for periods of ownership to be defined, both the start and termination of ownership are required. The process and data used to calculate periods of ownership is discussed at length in Chapter 4, 4.3.1 e). Termination of ownership in the context of this research is defined as the sale to: (i) a subsequent owner or (ii) a scrap yard. No formal distinction between these events has been made and the act of a sale, regardless of the identity of the buyer (subsequent owner or a scrap yard) is treated as the event of interest. This is in line with the research objectives of this thesis, discussed previously, however extending the definition of termination of ownership is considered and discussed in the section dedicated to further research (Section 8.6).

8.3.2. Critical review of main findings

Before the main findings are discussed, a brief review of the driving factors behind the structure of the reporting in previous chapters is presented. Based on evidence

[192] The steps taken to address inconsistencies as well as a discussion on the reputation of the data providers and the reliability of specific types of shipping related data used are discussed in Chapter 4, Section 4.2.1.

presented in previous studies (Einarsen, 1938; Stott, 2013), the analyses in this research were stratified by owner number, which is the number of the respective owner in the ownership sequence of each vessel. Further analyses were stratified by shipping segment (i.e., ship type) as there is difference between the state of the shipping markets in the short term[193]. Disaggregation by ship type allows for a more realistic representation of trends and patterns.

The changes of ownership of 3,908 ships were recorded as part of the research, however company level data was only gathered for 2,000 of these vessels due to time constraints[194]. In order for all of the data to be utilised, ship level characteristics were analysed separately based on the large dataset on changes of ownership. The results are presented in Chapter 5. The analyses with added company level characteristics and economic indicators, which are based on the data subset (2,000 vessels) are discussed in Chapter 6. Investigating periods of ownership in shipping is a complex problem due to the presence of different levels of analysis, such as owner number, shipping segment (ship type) and types of characteristics that may influence length of ownership. As the research questions are interconnected and complement one another, the findings were not organised in separate chapters. Instead, each part of the chapters dedicated to reporting results from the numerical models addresses a part of each research question. Table 8.2 summarises the structure of the reporting of the results from the numerical models.

Analysis	**Data****		**Research Questions**	**Chapter**
	Ships	Records		
Ship Level	3,908	8,042	Length of ownership (RQ1); Patterns of ownership (RQ2); Influences on periods of ownership - ship level (RQ3)	Chapter 5
Company level	1,998	3,674	Length of ownership (RQ1); Patterns of ownership (RQ2); Influences on periods of ownership - company level (RQ3)	Chapter 6
Economic indicators	1,998	384,267*	Influences on periods of ownership – economic indicators (RQ4)	Chapter 6

*Due to the use of monthly data – discussed in Chapter 6, section 6.4;

** The difference between number of vessels and number of records is discussed in Chapter 4, section 4.1.

Table 8.2. Structure of the Reporting on the Results from the Statistical Models

[193] Discussed in Chapter, section 2.2.2.a) and Appendix B-1.
[194] Sampling frame is discussed in Chapter 4, section 4.2.2.

It should be noted that the research questions addressing the second research objective (RQ3 and RQ4) aim to determine whether certain characteristics affect periods of ownership. This is achieved by estimating the likelihood of termination of ownership in shipping based on these characteristics. However, the reasons behind the effects of any of the characteristics as well as how the effects may vary over time are not included in the scope of this research. Therefore, the findings regarding the presence or lack of effects are reported but no empirically supported claims regarding likely explanations for such behaviour can be made at this stage.

The structure of the presentation of main findings is divided into layers aiming to highlight the research objective and analysis level (ship or company), where applicable, of the findings (Table 8.3). Each main finding is then discussed in terms of the following aspects:

- Description of the finding;
- Consideration of potential practical explanations;
- Discussion of statistical procedures where applicable and future work to validate potential practical explanations.

Research Objectives Level	Analysis Level	Main Findings (MF)	Discussion of Main Findings (MF) Includes
RO1: To investigate lengths and patterns of ownership in shipping based on evidence from the commercial history of vessels built between 1987 and 2007	Ship or Company	MF1 to MF4	MF Description MF Potential explanations; MF Statistical procedures and Future work
RO2: To evaluate the influence of a number of characteristics on ship level, company level and economic indicators on periods of ownership in shipping	NA	MF5 to MF11	

Table 8.3. Structure of the Presentation of Main Findings

a) First research objective (RO1) - Length and Patterns of ownership

Mean and median periods of ownership according to owner number and characteristics investigated as part of this research are presented in respective sections of Chapter 5 and Chapter 6. The mean and median values reported as part of this research are based on the data on periods of ownership. These values are indicative of patterns, however, as they include both complete and censored data and no claims regarding the generalisability of the results on length of ownership in absolute terms can be made. Table 8.4 provides a list of the main findings related to the first research objective based on level of analysis.

Analysis Level	MF	Description	Overview
Ship	MF1	Length of ownership according to owner number	First owners were found to keep vessels for longer than subsequent owners
	MF2	Length of ownership according to ship type	Container ships are kept for longer by the first owner than bulkers and tankers
	MF3	Number of owners according to ship type	Bulk carriers have the highest number of owners on average followed by tankers and container ships
Company	MF4	Company type and size according to owner number	Small private companies dominate the transitions between subsequent owners

Table 8.4. List of Main Findings (MF) Related to the First Research Objective (RO)

Ship level analysis (RO1)

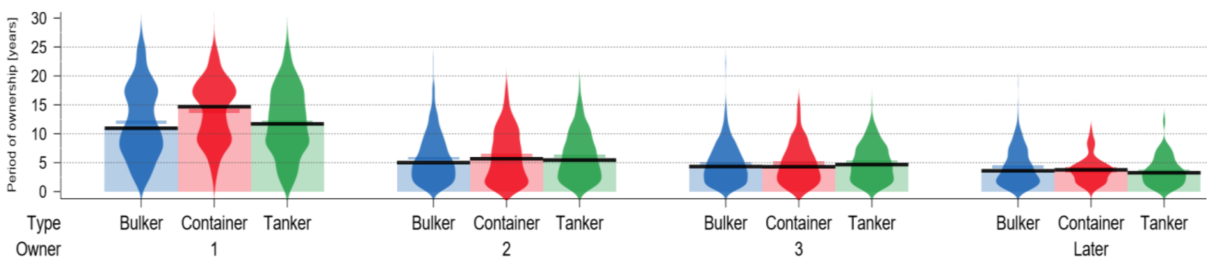
<u>Main Finding 1 (MF1): Length of ownership according to owner number</u>

MF1 Description:

The results on lengths of ownership based on owner number confirm the findings of Einarsen (1938) and Stott (2013), according to which first owners tend to keep vessels for longer than subsequent owners.

Ship level characteristics were analysed independently in Chapter 5. In Chapter 6 company level characteristics were added to the analyses. As the datasets used vary in sample size (Table 8.2), length of ownership was estimated for both samples (Figure 8.1). As can be seen from Figure 8.1 first owners were found to keep vessels for longer. There is barely any difference, however, between second and third owners regardless of the analysis level (ship or company).

(i) Ship level analysis – 3,908 ships



(ii) Company level analysis – 1,998 ships

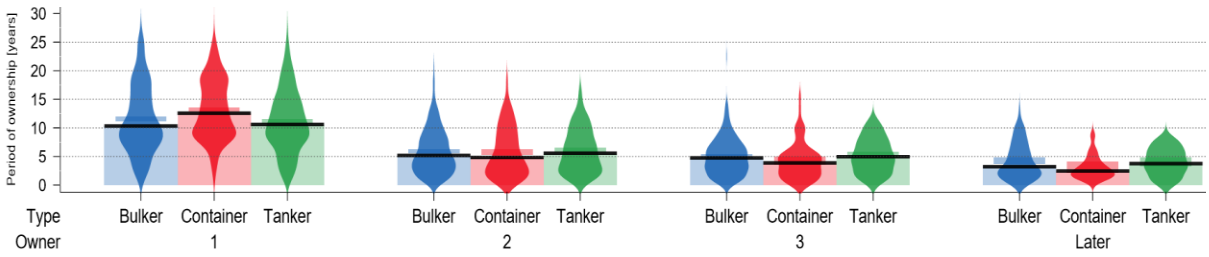


Figure 8.1. Periods of Ownership by Ship Type and Owner Number – comparison

MF1 Potential explanation:

Einarsen (1938) assumed that there are two broad owner stereotypes: (i) those who tend to invest in newbuildings and are motivated by running '*first class modern tonnage'* (p.164) and (ii) those, who buy second-hand ships on the basis of '*cheapness of price'* (p.164). This assumption, although intuitive, appears to be ignoring the role of the market and it does not explain the fact that during the last shipping boom second-hand ship prices were higher than newbuilding prices yet shipowners would still purchase second-hand tonnage. Stott (2013) suggests that the length of first owner period is linked to the special surveys carried out every 5 years by classification societies but no formal investigation of this has been carried out. It is likely that this pattern is a product of a complex combination of reasons, which includes, in addition to maintenance patterns, the type of ship finance and the tenor of the loans or bonds used. According to Harwood (2009) the majority of ship finance loans have a fixed term of up to 12 years, whereas the average term of shipping high yield bonds between 1998 and 2005 was found to be 9.53 years (Nomikos and Papastopolou, 2006; Syriopolous, 2007). According to Paine (1989) and Revenko and Lapkina (1997) lenders are more likely to accept longer tenors for newbuildings of up to 10 years as the tenor of ship financing loans depends mostly on the age of the vessel. Therefore, longer tenors of loans for new vessels may be a driving factor behind the length of ownership corresponding to first owner.

MF1 Statistical Procedures and Future Work:

It should be noted that the median values of containers and tankers are slightly lower according to the reduced dataset used in the company level analysis (Figure 8.1 (ii)). This is attributed to the fact that the ship level analysis data (3,908 ships) constitutes the whole population of vessels built between 1987 and 1997 (2,908 ships) and only 1,000 ships built between 1997 and 2007, which means that the sample consists of more vessels that are approaching the end of their economic lives. Therefore, the number of censored observations belonging to vessels that have never been sold is potentially higher, which explains the increase of mean and median values. However, the trends identified in terms of length of ownership of first and subsequent owners are in agreement. It should be borne in mind that any future work aiming to determine periods of ownership in absolute terms should concentrate on purely historical data[195]. In order to obtain accurate numbers using this approach, the sample should be based on a cohort of vessels which have already reached the end of their economic lives. If the purpose of the research is to gain insights about patterns of ownership of cohorts of vessels that may not have reached the end of their economic lives at the time of analysis, the following need to be taken into account:

- the results on length of ownership are indicative and not absolute because they include censored observations[196];
- a more suitable approach for comparing vessels based on certain characteristics is to investigate the probabilities reflecting termination of ownership[197].

Therefore, the nature of any future work on periods of ownership depends on the desired outcome, the specific research questions and the type of data used.

Overall, the addition of ship finance data will benefit any future studies focusing on explaining why length of first ownership is greater than that associated with subsequent owners.

Main Finding 2 (MF2): Length of ownership according to ship type

MF2 Description:

Container vessels were found to be kept for longer by the first owner in comparison with tankers and bulkers (Figure 8.1), which is in agreement with the results reported by Stott (2013).

MF2 Potential Explanation:

It should be noted, that the proportion of container vessels that were sold for scrap by the first owner (13.6% of all container ships in the sample) is higher than in the case

[195] For example, see Stott (2013).
[196] For more information see Chapter 3, Section 3.3.2.a).
[197] For example, see Einarsen (1938). He used actuarial tables (or life-tables as commonly referred to in the survival analysis literature) to investigate the probability of vessels built in a specific year to be replaced (sold) at a given age.

of both bulkers (7.1% of all bulkers) and tankers (6.9% of all tankers)[198]. Such vessels spent their economic lives in the possession of the first owner, which results in ownership periods of about 20 years. However, the average periods of ownership corresponding to the first owner for container vessels, are generally higher in comparison to bulkers and tankers, irrespective of the subsequent number of owners throughout the vessels' economic lives. This trend disappears in the case of subsequent owners as the period of ownership of container vessels corresponding to subsequent owners is equal to or shorter to that of bulkers and tankers.

One likely reason for this is that companies which acquire new container vessels are usually either (i) one of the dominant private companies in this highly consolidated market or (ii) state operators. In the container segment of the fleet, capacity is an important aspect of competitiveness. Fusillo (2003) provides evidence that dominant firms tend to add capacity whenever a threat of entry or expansion by potential competitors is detected. Therefore, it is likely that the high rate of scrapping of containers by their first owner could be part of the entry-deterring behaviour of large companies, which would rather scrap the excess capacity than sell it to potential competitors.

Another competitive advantage in the container sector is based on the efficiency and sustainability of the tonnage provided by an owner. Generations of container ships are vulnerable to technological obsolescence as larger and more efficient vessels are introduced to the market. According to Ole B Hjertaker, CEO of Ship Finance Management in Oslo, a shift in the design of container vessels occurred after 2009 as a result of energy efficiency initiatives, which is believed to have an effect on the lifecycle of vessels (Reinikainen, 2017). Container operators agreed that design speed should be lower, which affects the hull form and the engine output of newer vessels. It is likely that the initiatives for cleaner shipping will result in shorter economic life of existing vessels and changes in ownership patterns between container vessels built before and after 2009.

MF2 Future work:

Further investigation of the impact of energy efficiency measures on length of ownership and investment horizons is necessary in future.

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[198] See Chapter 5, Table 5.2, p 105-106.

Main Finding 3 (MF3): Number of owners according to ship type

MF3 Description:

The results show that bulk carriers have the highest number of owners on average, followed by tankers and container ships, which is in line with results reported by Bijwaard and Knapp (2009) and Stott (2013). Bulk carriers were found to have 2.35 owners on average, followed by tankers with 2 owners on average and containers with 1.7 owners on average[199].

MF3 Potential Explanation:

Bulk carriers were found to have a higher average scrap age than tankers and container vessels[200]. The oldest ship in the sample is a 28 year old bulk carrier, built in 1987 and that was still in operation in 2015. Although the high number of owners could be partially attributed to the higher scrap age, it also indicates that bulk carriers are more frequently traded than ship types. This is a result of the market for dry bulk carriers having low barriers to entry in comparison to: (i) the tanker market, which is very demanding in terms of vessels' condition and (ii) the container market, which is highly consolidated and dominated by large companies[201].

MF3 Future work:

The fact that bulk carriers seem to be the most traded ship type is linked to the nature of the dry bulk market. For this trend to evolve or disappear, a significant change in the structure of the shipping segments is required.

Company level analysis (RO1)

Main Finding 4 (MF4): Company type and size according to owner number

MF4 Description:

Interesting findings when company level characteristics were added to the analyses (Chapter 6) concern the distribution of companies across owner numbers and the transitions between different owners. The proportion of private companies acting as subsequent owners grows, whereas the proportion of all other types of companies decreases as the owner number increases (Table 8.5).

[199] See Section 4.3.1.c), page 80-81
[200] See Data Annex Chapter 4, Section 1, p 1.
[201] For further discussion on the nature of the shipping markets see Chapter 2, Section 2.2.2.a).

Company Type	Owner Number				
	1	2	3	4	5
Financial	3%	3%	2%	1%	3%
Private	**55%**	**73%**	**73%**	**69%**	**83%**
Public	34%	20%	18%	15%	11%
State	7%	4%	7%	15%	3%

Table 8.5. Proportions of company types based on owner number

A similar trend is also observed within the distribution of small companies, which indicates that smaller, private companies tend to dominate transitions between subsequent owners. Figure 8.2 shows the distribution of companies by type, size and owner number. It is clear that the proportion of small companies acting as subsequent owners increases with each following owner number, especially in the case of financial and private companies.

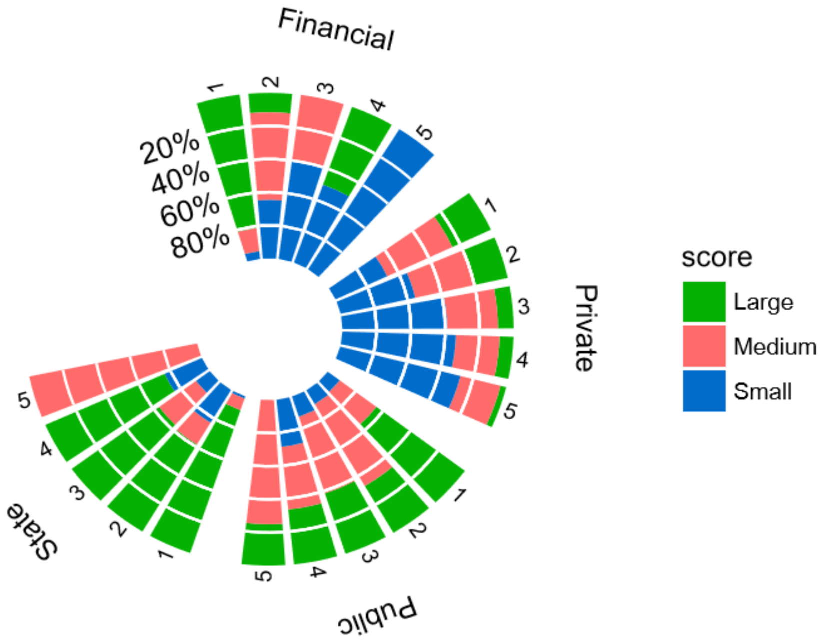


Figure 8.2. Company distribution by type, size and owner number

MF4 Potential explanation:

This finding empirically confirms the perceptions that: (i) large companies with access to funds tend to order new vessels and (ii) the second-hand market is dominated by smaller private companies.

MF4 Future Work:

Future work should focus on examining how these trends may vary by ship type and size. It would also be interesting to examine the ownership structure of the market for specialised vessels such as LNG carriers. The case of LNG carriers is of particular interest as these vessels were traditionally purchased as a result of confirmed long term charters (Tusiani and Shearer, 2007). However, as the barriers to entry lowered (Tusiani and Shearer, 2007) and the LNG spot market increased - it was estimated as 20% of the total global market for LNG in 2012 (Norton Rose Fulbright, 2012), a more detailed examination of the current patterns of ownership in the market for LNG ships may result in interesting insights.

b) Second Research Objective (RO2) - Characteristics' influence

In order to determine whether the list of ship and company level characteristics and economic indicators influences periods of ownership, the probability of termination of ownership based on the above characteristics and indicators was investigated. This was achieved through employing techniques common in survival analysis. The choice of technique was primarily driven by its capability to handle time-to-event data such as the data on periods of ownership. The Cox Proportional Hazards (PH) model was selected as it: (i) handles time-to-event data; (ii) accommodates time-varying covariates allowing the inclusion of monthly data on economic indicators and (iii) is widely used due to its robustness[202]. However, it should be noted that the Cox PH model provides only an estimate of the effect of covariates on average over time, which suggests that no empirically tested conclusions regarding how the effects of covariates may vary over time can be reported. In the context of this research, however, this is not considered as a limitation as the second research objective aims to determine whether the characteristics have an effect on periods of ownership as opposed to how these effects may vary over time. Time-varying covariates should not be confused with time-varying effects, a mistake that often arises in the literature due to the similarities in terminology. Time-varying (or time-dependent) covariates refer to characteristics, which vary over time, such as economic indicators for example. The Cox PH model is perfectly capable of handling such covariates. The term *'time-varying effects'*, however, refers to an extension of the technique which allows for different estimates of the coefficient of the same covariate to vary over time. Although the investigation of how effects vary over time is not part of the scope of this project per se, the overall research design partially accounts for the potential variation of the effects over time as the analyses are stratified by owner number. This means that in the cases of vessels with more than one owner, the stratification by owner number also acts as a stratification by time. The sizes of the effects of covariates are not

[202] Robustness refers to the fact that no assumptions regarding the underlying distribution have to be made – see discussion in Chapter 3, section 3.3.2.

formally reported as: (i) they represent the average effect over time and (ii) because answering the research questions required noting the significance of the effects and their interpretation only. Table 8.6 provides a summary of the statistical significance (at the 95% level) of the chosen covariates and how the effects vary according to ship type and owner number.

Covariates	Bulkers				Tankers			Containers		
	1st	2nd	3rd	Later	1st	2nd	3rd	1st	2nd	3rd
Ship Size	Significant	Significant	Significant	Significant			Significant			
Delivery Year*		Significant	Barely Significant							
Age at Purchase		Significant	Significant	Significant		Significant	Significant		Significant	Significant
Company Type	Significant				Significant			Significant		
Company size	Significant	Significant			Significant	Significant		Significant	Significant	Significant
Nationality	Significant	Significant		Significant	Significant		Significant	Significant		
Earnings	Significant	Significant		Significant	Significant		Significant	Significant	Significant	Significant
Significant	*P-value <0.01*									
Barely Significant	*0.01 < P-value < 0.05*									

**Delivery year is only significant in the models with fixed covariates (ship and company level)*

Table 8.6. The Effect of Characteristics based on Ship Type and Owner Number

The findings of the effects of different covariates including economic indicators are summarised and discussed in Chapter 5 and Chapter 6, therefore the following section will report and discuss only main or unexpected findings. Table 8.7 provides a list of the main findings related to the second research objective.

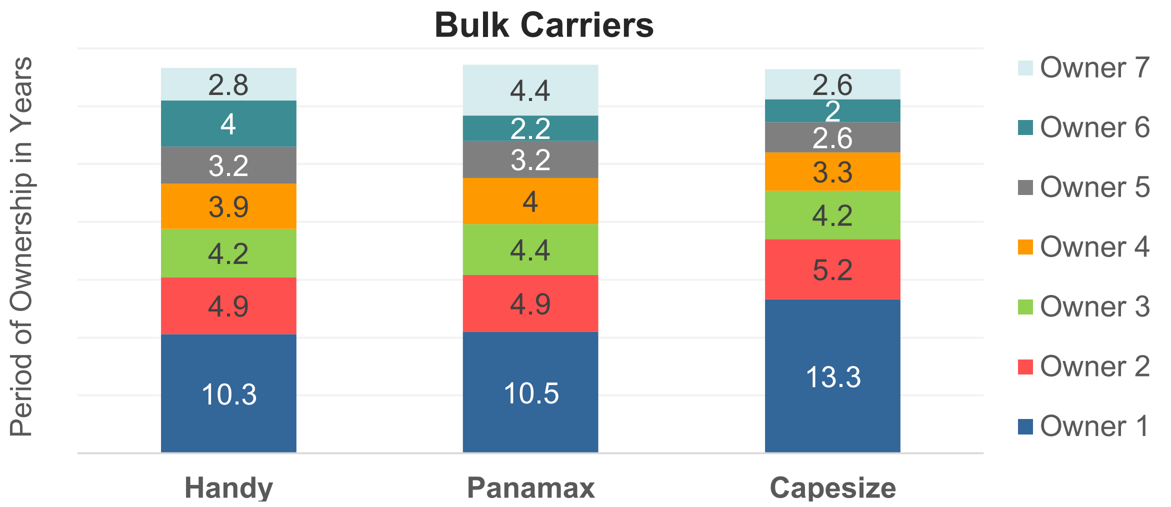
MF	Description	Overview
MF5	Effect of ship size – bulk carriers	Ship size is significant throughout the economic lives of bulk carriers. Large bulkers are kept longer by the first owner but are more likely to experience termination of ownership by subsequent owners.
MF6	The effect of delivery year	Limited evidence that ships built at the early stage of the delivery profile of the sample (i.e., before the late 90s) are more likely to experience termination of ownership. Further investigation needed.
MF7	The effect of company size	Company size is significant regardless of owner number in the container segment of the fleet and for first owners in the case of both bulkers and tankers.
MF8	The effect of nationality of control-selected nationalities	Nationality is significant in the case of first owners for all ship types and for later owners in the case of bulkers and tankers. The main findings concern Japanese and Greek owners.
MF9	The effect of earnings	Earnings have a significant effect in general, apart from in the case of intermediate owners within the bulker and tanker segments.
MF10	Timescales	The trends identified for later owners in the case of bulk carriers are comparable with the ones corresponding to third owner for tankers.

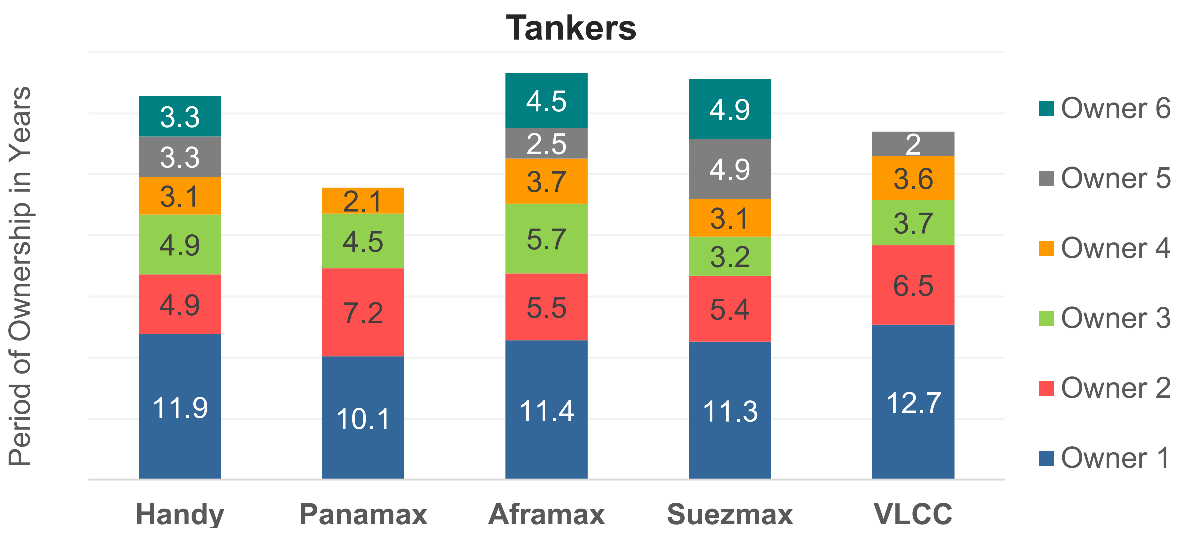
Table 8.7. List of Main Findings (MF) Related to the Second Research Objective (RO)

Main Finding 5 (MF5): Effect of ship size – bulk carriers

MF5 Description:

The results on the influence of characteristics discussed in Chapter 6 suggest that ship level characteristics, especially ship size, influence periods of ownership in the case of bulkers regardless of owner number (Table 8.6). Large bulk carriers are found to be less likely to experience termination of ownership in the case of first owner but they are more likely to experience termination of ownership by subsequent owners. The median periods of ownership by owner number and ship size are presented in Figure 8.3. The median periods of ownership corresponding to later owners (≥4) in the Capesize bulkers category are relatively shorter in comparison to smaller bulkers, which indicates the presence of the effect of size discussed earlier.





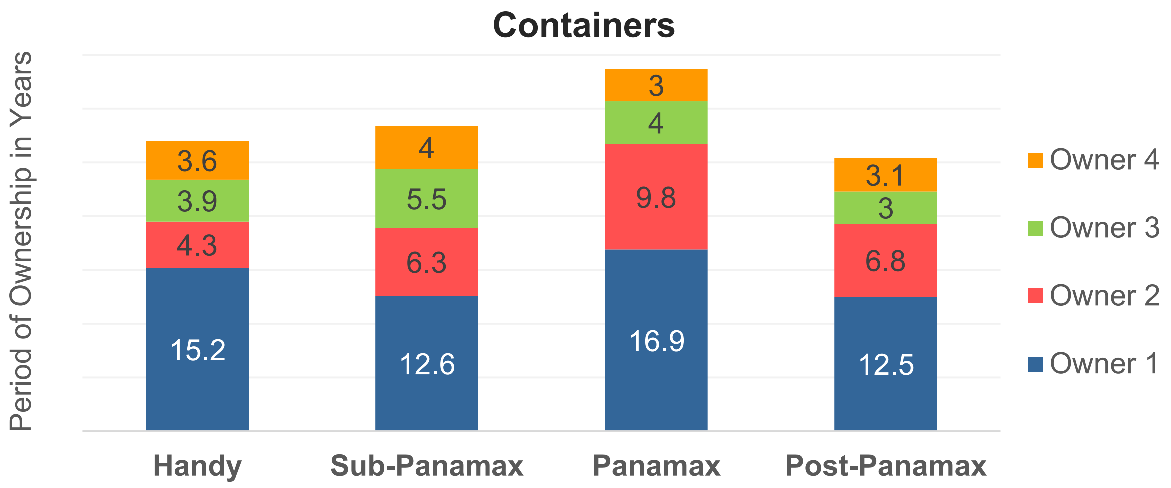


Figure 8.3. Median Periods of ownership by ship type and size

Note: Data on later owners (≥4) is based on limited sample sizes, especially in the case of container vessels.

MF5 Potential explanation:

The volatility of second-hand prices is larger for larger vessels, which suggests more pronounced opportunities for asset trading (Kavussanos, 1996, 1997; Glen and Martin, 1998). This might encourage subsequent owners to be more speculative, which would result in shorter periods of ownership and more frequent transactions involving Capesize vessels later in their lives.

Industry sources have alluded that economic lives of vessels have shortened significantly due to poor market conditions, technological developments and owner preferences, a trend especially visible in the Capesize bulkers category (Reinikainen, 2017). As the event of interest in the analysis is termination of ownership, which does not distinguish between sale or scrap, the fact that the effect of ship size reverses within the Capesize category could be a product of these vessels' economic lives shortening.

MF5 Future work:

Further investigation of the effect of size is needed in the future, especially in the case of bulk carriers. Additional insights may be gained if the ownership history of vessels is modelled in a multistate setting and sale and scrapping are represented as competing risks[203].

Main Finding 6 (MF6): The effect of delivery year

MF6 Description:

Delivery year was included in the models as a means to incorporate a control for calendar time. According to the results based on ship level characteristics (Chapter 5) ships built at the early stage of the delivery profile of the sample (i.e., before the late 90s) are more likely to experience termination of ownership, age for age, than vessels built in the early 2000s. When company level characteristics and economic indicators are added to the analyses, the effect of delivery year becomes insignificant.

MF6 Potential Explanation:

A likely reason is the fact that economic indicators change with calendar time as well and therefore delivery year acted as a proxy for the state of the market. Furthermore, the large sample used to investigate ship level characteristics (Chapter 5) included more vessels built between 1987 and 1997, which also could explain the results. Another explanation is that many vessels were scrapped in the period 2010-2015 due to poor market conditions and it is likely that older tonnage (ships built in the 90s) were the most likely candidates.

MF6 Statistical Procedures and Future work:

In the context of this research, termination of ownership does not distinguish between a sale to a subsequent owner or a sale to a scrap yard because the focus is on detecting trends rather than ranking the motivation behind shipowners' decisions. A natural progression of this research is to consider motivation. In order to investigate the effect of delivery year further and to expand the definition of '*termination of ownership'*, future research should consider modelling different types of sales (to a subsequent owner or a scrap yard) as competing risks. Future work should also investigate the effect of a potential interaction between delivery year/age and state of the market.

Main Finding 7 (MF7): The effect of company size

[203] This is discussed in more detail in Section 8.6, which summarises the possibilities for future research as a result of this thesis.

MF7 Description:

The results (Chapter 6) indicate that company size has a significant effect on termination of ownership, regardless of owner number in the container segment of the fleet and for early owners in the case of both bulkers and tankers (Table 8.6).

MF7 Potential explanation:

One of the limitations of this research is the fact that company size data refers to the owned fleet of the company at the time of the data collection process and it is treated as a fixed covariate. In practice, company size varies with time and a more accurate classification can be achieved with historical data on fleet size. This was attempted and historical time series of fleet sizes were obtained from CRSL. However, CRSL's data starts in 1994, which is almost half-way through the delivery profile of the sample and thus only covers about 40% of the data records. Although this approach could have arguably increased the reliability of the analysis on company size, the methods used to determine a change of ownership in this research would still differ to the ones used by data providers. The company size categories used in this research, namely small (≤10 ships), medium (11-50 ships) and large (>50 ships) are relatively broad in the hope that this would mitigate the possibility of companies being re-classed as time progresses. For example, it is assumed that small private companies of 1-2 ships are likely to stay within the 10 vessels margin given that the most frequent fleet size within this category is 3 vessels. It is believed that regardless of the limitations of the approach, the analyses provide at least an indication of the impact of company size on periods of ownership.

MF7 Future Work:

Future work should use alternative approaches for representing company size or historical fleet size data, if available, to model company size.

<u>Main Finding 8 (MF8): The effect of nationality of control – selected nationalities</u>

Findings of interest regarding nationality of control refer to Japanese and Greek owners. In order to avoid repetition and to summarise potential future work on nationality of control the commentary is structured as follows:

- *Description* followed by *Potential Explanation* for findings related to Greek owners (MF8-1) and Japanese owners (MF8-2);

- *Future Work* regarding nationality of control.

MF8-1 Description (Greek owners acting as first owners and later owners):

The results show that ships ordered by Greek owners tend to be the least likely to experience termination of ownership on average in the bulker and tanker segments[204]. Furthermore, later Greek owners (≥4) are also found to keep bulk carriers for longer than the rest of the nations or groups of nations involved in the dry bulk segment of the fleet[205].

MF8-1 Potential explanation:

Bragoudakis *et al.* (2013) found a shift in the behaviour of Greek owners, who have been known to prefer anticyclical investment strategies (Thanopoulou, 1996). According to Bragoudakis *et al.* (2013), there is no evidence of Greek owners exhibiting anticyclical investment patterns after 2006. The empirical findings regarding Greek owners who tend to purchase new ships and keep them for longer in comparison to other owners are likely a product of this shift in behaviour, the state of the market, the ageing Greek fleet and the fact that Greek owners have been exploring the possibilities presented by access to capital markets.

The finding regarding the behaviour of later (≥4) Greek owners confirms a pattern of ownership suggested by one interviewee, according to which Greek owners, who acquire old bulk carriers tend to operate them and keep them for as long as possible[206]. According to the interviewee, this strategy is likely used by very small family companies with limited access to capital markets, which cannot afford to invest in newer vessels.

MF8-2 Description (Japanese owners):

More than 85% of the records associated with Japanese owners refer to new ships. The results confirm that Japanese owners tend to: (i) purchase predominantly new tonnage, (ii) are not active in the second-hand market for ships; (iii) sell vessels earlier than any other nation or groups of nations included in the analyses.

MF8-2 Potential Explanation:

[204] See Chapter 6, Section 6.3.1. b).
[205] See Chapter 6, Section 6.3.4. b).
[206] See Chapter 7, Section 7.4.2.

It should be noted that the median length of ownership of Japanese ships is 9.8 years for first owner and 5.2 years for second owner, which coincides with the idea that termination of ownership in the case of Japanese owners might be triggered by special surveys as suggested by Stott (2013) and one interviewee.

MF8 Future work (regarding nationality of control):

Studies concentrating on specific nationalities of control will provide a more detailed review of trends and patterns.
Future work should also consider ways to enhance '*nationality of control'* by adding cultural constructs as discussed in Section 8.6.

<u>Main Finding 9 (MF9): The effect of earnings</u>

MF9 Description:

The findings concerning the effect of shipping earnings show clear patterns regarding the sales policy of owners that are involved in the bulker, tanker or container trades. On average, bulkers and tankers were found to be sold by early (that is 1st and 2nd) owners when earnings are high, whereas the trend reverses for third and later owners. In the container sector, owners are less likely to sell when shipping earnings have been high over the past 3 or 6 months. According to the results, the effect of shipping earnings is not significant for intermediate owners in the bulk carrier (3rd owner) and tanker (2nd owner) segments of the fleet.

MF9 Potential explanation:

The interpretation of these results might seem counter-intuitive when the lack of significant effect is analysed individually. For example, one would assume that shipping earnings have a significant effect for third owners in the bulk carrier segment of the fleet as subsequent owners are often associated with speculative behaviour. However, if the number of owners is considered as a continuum then the intermediate owners are where the change in the effect's direction occurs – from positive and associated with increased probability of termination of ownership when the earnings are high (1st owner) to negative and associated with lower probability of termination of ownership when the earnings are high (later owners).

MF9 Statistical procedures and Future research:

The stratification of the statistical analysis by owner number in this research facilitates the investigation of periods and patterns of ownership. However, the approach does not model vessels' life histories but individual ownership periods. In order to investigate how the effect of earnings may change over the life history of a vessel, a multistate approach should be adopted. This topic is further discussed in the section regarding recommendations for further research (Section 8.6).

Main Finding 10 (MF10): Timescales

MF10 Description:

As discussed earlier, bulk carriers were found to have more owners on average than tankers and container vessels, which facilitates the analysis for later owners as there were sufficient observations for the analyses to be carried out. However, the distribution of significant effects across owner numbers and ship types suggests that the trends identified for later owners in the case of bulk carriers are comparable with the ones corresponding to third owner for tankers (Table 8.6).

MF10 Potential Explanation:

A potential explanation, which requires further tests, might be that the effects of certain characteristics vary with vessels' age or rather, some effects are specific to certain stages of vessels' lives.

MF10 Statistical Procedures and Future work:

As the focus of this research is periods of ownership in shipping, the timescale[207] chosen for the statistical analysis is based on ownership time, e.g. the entry point for each stage of the analysis as stratified by owner number is the date the ship entered in possession of the respective owner. However, an alternative approach, which can account for the imbalances between total number of owners across ship types, is to use age of the vessel as a timescale in a multistate setting.

8.4. Potential Beneficiaries

The primary purpose of this research is to fill a knowledge gap in the maritime transport literature regarding the length of likely investment horizons in shipping. The data on investment horizons in shipping is a fundamental piece of knowledge, which albeit

[207] For a more detailed explanation on 'timescales' see Chapter 3, Section 3.3.2. For an example of timescales, see Figure 3.4.

lacking an immediately obvious, tangible application, is a powerful indicator for shipowners' behaviour and corporate strategy[208]. The greatest advantage of such information is that it provides a realistic estimate of investment horizons based on empirical data, which can be integrated into a variety of existing frameworks leading to increased accuracy of models based on expected behaviour.

This section aims to summarise some of the potential practical applications of the research. Table 8.8 provides a list of some potential industry beneficiaries and a short explanation of how the outcome of this research may add value to their activities.

Beneficiaries	What can be achieved through integration of the results into existing frameworks?	Type of benefit
Ship Equipment and Systems Manufacturers	Increased awareness of customers' behaviour allowing companies to develop products which best serve the needs of their customers and to target the most appropriate potential buyers based on likely investment horizons.	Economic
Sale and purchase brokers	Increased awareness of customers' trading patterns and behaviour allowing brokers to employ proactive marketing strategies and to identify potential buyers based on established trading patterns.	Economic
Inspection Regime (especially PSC)	An improved framework for determining inspection priority based on typical periods of ownership and owner characteristics, which may be valuable indicators for safety and safety culture onboard.	Safety-related
Insurance Policies	An improved framework for calculating risk and determining insurance premiums based on typical length of ownership according to the shipowning company's characteristics (such as type, size and nationality) – especially useful in cases where the company is '*new*' and it does not have an established track record in shipping.	Economic and safety-related
Banks and Financial Institutions	An improved framework for assigning credit ratings to shipowners based on typical periods of ownership, which could be integrated into the measures for '*Character*' and '*Company*' used for credit risk analysis. Potential for creating an '*asset liquidity index'* to represent the tradability of vessels of different types and sizes and thus help financial institutions improve the finance lending process.	Economic
Policy makers	An improved framework for determining adequate compliance periods based on expected asset life and typical periods of ownership.	Economic and safety-related

Table 8.8. List of Some Potential Beneficiaries

[208] For more information on the relationship between investment horizon, corporate strategy and behavioural routines, see Souder *et al* (2016).

More detailed explanations regarding the potential beneficiaries listed in Table 8.8 accompanied by brief examples, where applicable, are presented next.

8.4.1. Ship Equipment and Systems Manufacturers

A likely starting point in the evaluation of the purchase of a piece of equipment/system or the investment in a new technology[209] is the cost-effectiveness of such decision. In general, the purchase of equipment/systems is carried out for at least one of the following reasons:

- to improve performance with regards to operation (e.g. air lubrication systems);
- to satisfy (new) regulatory requirements (e.g. ballast water treatment systems BWTS);
- to substitute a piece of equipment/system (e.g. failed pump, antifouling system, any other maintenance and repair operation).

One of the main considerations regarding a potential purchase, especially in the cases when the decision is driven by the customer rather than by regulatory bodies, is whether the technology is economically viable. A common approach used by manufacturers to determine the likelihood of consumers to purchase a new technology is to calculate the life-cycle-cost (LCC) associated with the installation and the use of the product. Such evaluations are usually calculated as a function of discount rates, the expected life of the product and a variety of other key variables. For some types of equipment/systems it is often assumed that they will last until the end of the economic life of the vessel – for example BWTS equipment is assumed to last about 26 years (Rivas-Hermann *et al.*, 2015). However, life-cycle-cost may not be the most appropriate way to estimate the likelihood of purchase as there is a large number of vessels which are sold multiple times. A more accurate and realistic evaluation of the likelihood of purchase could be achieved by using typical periods of ownership as an indicator of likely investment horizon.

Recent research suggests that payback periods are still the most frequently used tool for investment appraisal in shipping (Rehmatulla *et al.*, 2017). However, payback periods alone do not provide any information about the needs of customers. In order to remain competitive equipment/systems manufacturers need to have a better

[209] A 'new technology' is a relative term in this context as it refers to types of equipment/systems that are more sophisticated than the ones previously available on the market and it does not necessarily refer to a completely new (disruptive) type of technology being developed by manufacturers.

understanding of customer needs and customer behaviour. This includes a better understanding of investment horizons.

A recent study conducted by DNV GL (2017) provides an evaluation of the available technologies for reduction of greenhouse gas emissions. The study recognises that the uptake rate of technologies depends on the payback period of the technology combined with the investment horizon of the shipowner. Furthermore, payback periods are estimated for a selection of energy efficiency measures (Figure 8.4 and Figure 8.5) and ship types.

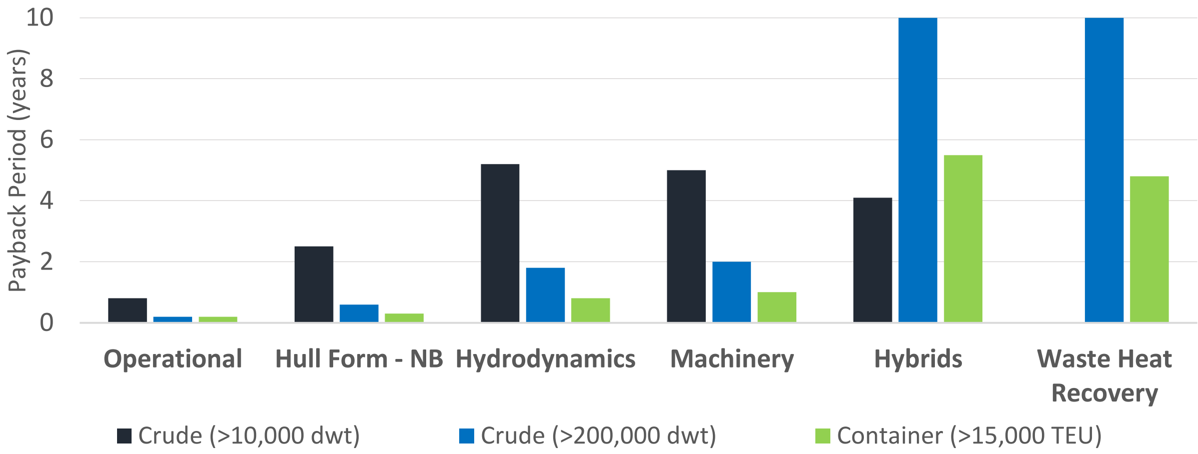


Figure 8.4. Examples of Payback Periods for Energy Efficiency Measures

**Adapted from DNV GL (2017), p 23.*

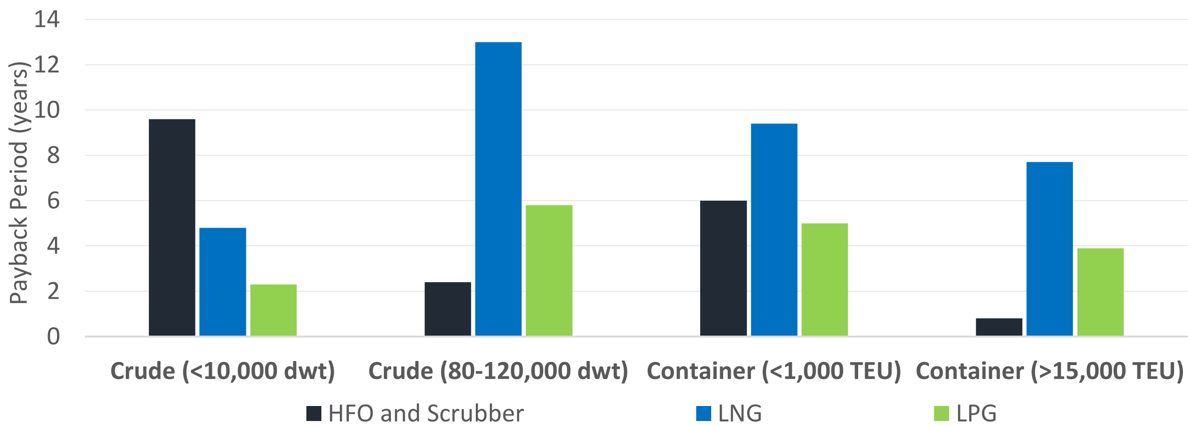


Figure 8.5. Estimated Payback Periods for Scrubbers, LPG and LNG Installation (NB)

**Adapted from DNV GL (2017), p 24.*

The payback periods estimated by DNV GL (2017) presented in Figure 8.4 and Figure 8.5 clearly show that manufacturers of different systems need to develop different strategies based on shipowners' expected investment horizons. For example, in the case of large crude carriers, hybrid systems manufacturers and LNG systems manufacturers should prioritise targeting shipowners who tend to keep tankers for at least 10 years. Although the DNV GL (2017) study recognises the importance of investment horizons and their effect on the uptake level of new technologies, the assumptions regarding short/long investment horizons are not based on empirical evidence. The outcome of this research allows systems and equipment manufacturers to identify the most likely investors based on likely investment horizon. For example, according to the findings of this research the most likely investors that should be targeted by hybrid systems manufacturers and LNG systems manufacturers in the large crude tanker segment are[210]:

- large state companies from emerging maritime nations such as China as the tankers owned by such companies have more than 90% probability of remaining with their original owner at the age of 10;
- large private or public Greek companies as Greek shipowners investing in newbuild tankers were found to be the least likely ones to sell their assets on average.

On the other hand, small companies (with no more than 10 vessels) in general and Japanese owners, regardless of company size, should not be a priority for hybrid systems manufacturers and LNG systems manufacturers in the category of large crude carriers as these owners were found to be the least likely ones to retain their tanker fleets on average. For example, according to the findings presented in Chapter 6 only 50% of tankers owned by small private and public companies tend to remain with their first owners for more than 10 years.

Based on the above, it comes as no surprise that Japanese oil companies have opted for scrubbers with respect to VLCC tankers according to an article published in TradeWinds on the 7th of December 2017 (Corbett, 2017).

It should be mentioned that manufacturers, especially those specialising in capital intensive technologies should base their product development strategies on informed decisions about the potential demand based on owners with investment horizons that suit the expected payback periods prior to substantial investment in R&D.

[210] See page 192-193 for results on company level characteristics for tankers (1st owner).

8.4.2. Sale and Purchase (S&P) Brokers

A potential seller or buyer of a vessel often appoints a sale and purchase broker to handle the transaction. Generally, S&P brokers draft an invitation for offers based on the ship's particulars and act as intermediaries between the seller and the buyer. The S&P brokers develop a rich knowledge of ownership patterns over time. However, documented information on typical periods of ownership and trading patterns could provide a useful tool for strategy development and proactive marketing. The breakdown of transfer of ownership by company type, size and nationality can be used as a starting point in developing elaborate marketing strategies allowing S&P houses to target:

- owners likely to be considering selling an asset or assets (for example, a Japanese company with average fleet age of 8 years might soon be looking into selling some of the older assets[211]);
- likely potential buyers based on the type, the age and the ownership history of a vessel (for example, German owners are more likely to buy a second hand vessel from another German owner than from owners from emerging maritime nations[212]).

8.4.3. Inspection Regime (focus on Port State Control - PSC)

Vessels, especially tankers, are subjected to a variety of inspections designed to ensure their seaworthiness and to confirm their compliance with safety and environmental regulations. Research into the effectiveness of ship inspections considers the effect of recent changes of ownership and the nationality of the owner on the incidence rate of vessels (Bijwaard and Knapp, 2009). The results suggest that both variables have an effect on the risk profile of vessels based on their type. For example, bulkers and tankers in the possession of owners from least developed countries, who usually serve as subsequent owners[22], were found to be more likely to have a higher incidence rate. This observation supports comments made by several of the interviewees regarding the relationship between owners with short term investment horizon (usually subsequent owners) from emerging maritime nations and substandard shipping.

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[211] For more information see Data Annex Chapter 7, section 1.1.

[212] For more information see Chapter 6, Figure 6.13. Ship Sales by Nationality of Control and Owner Number, p. 183.

The frequency of PSC inspections is based on the ship risk profile (see Appendix B-6), which is a function of:

- the performance of (i) the Flag State, (ii) the recognized organization (RO), which is usually a Classification society and (iii) the ISM company;
- the particulars of the vessel;
- the inspection history of the vessel.

However, none of these refer to the owner's profile. Although the performance of the Flag State and the performance of the ISM Company are used as a proxy for safety and safety culture, it is unlikely that these entities (the Flag State and the ISM Company) are capable of inspecting and maintaining all vessels with the same rigor at all times in terms of all aspects of safety they are responsible for. It can be argued that reviewing the owner's safety performance (the Group owner/beneficial owner as opposed to the registered owner) in terms of types of deficiencies and detentions, the ownership history and profile will improve the process used for determining the risk profile of a vessel. Information about the ownership history of vessels will result in increased transparency of the existing PSC ship risk profile framework because the performance of all the entities currently measured is based on a large sample of vessels with different ownership histories, operational patterns and structural conditions. Furthermore, these entities serve the owner of the vessel, who may choose a different service provider at any given time. Such a relationship between the owner and the entities responsible for ensuring the safe operation and management of the vessel may pose a conflict of interest in situations where compromising safety might translate into accruing large savings[213]. Although the introduction of the PSC regime in 1982 has led to a significant improvement in the safety of shipping (Li and Zheng, 2008), the framework for targeting substandard vessels should be continuously evaluated and revised as there are additional indicators that may increase the effectiveness of the inspection framework such as ownership profile and history.

For example, a 15-year-old bulk carrier flagged in Panama with no detentions in the last 36 months and represented by a well-performing RO and ISM company will most likely be assigned a '*Standard Risk Profile'* according to the Paris MOU Risk Calculator (Paris MOU, 2017). However, what if that same ship has been sold three times since its last special survey and is now currently in the possession of an owner, who is

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[213] A report issued by the OECD (2003) investigates the amount of savings stemming from non-compliance with international regulations.

already looking into selling the asset and whose fleet has an average period of ownership of under 1.5 years? It is not unlikely for an asset that has changed hands several times within a relatively short timeframe to have experienced a period of lower maintenance intensity even if is currently represented by well-performing Flag, RO and ISM Company. The overall performance of these entities does not ensure the absolute safety of an asset due to variability in the inspection rigor which is influenced by factors such as: (i) the knowledge and experience of individual inspectors, (ii) the availability of the workforce and (iii) vested commercial interests. Furthermore, developing and maintaining a safety culture onboard requires time and commitment on behalf of the ISM Company (Anderson, 2003). However, often a change of ownership[214] comes with a change of the Flag, the RO and the ISM Company. Such changes bring disruption to established practices and require time for the personnel to get used to the new practices, protocols and paperwork. This can have a serious adverse effect on onboard safety and maintenance.

Therefore, the integration of indicators such as likely periods of ownership, number of owners (ownership history) and owner-specific characteristics such as nationality may increase the veracity of the existing PSC inspection framework.

8.4.4. Insurance Policies

There are three main types of insurance in shipping – hull and machinery, cargo and protection and indemnity (P&I). The largest potential claims in shipping (general average, pollution, etc) are usually covered by P&I insurance, which is the shipowner's insurance cover for liabilities to third parties. P&I insurance is based on mutuality – shipowners enter their vessels into a '*club*' thus pooling their resources. When a shipowner contacts a P&I club with the intention to become a member, the Club's underwriter is tasked with determining the risk profile of the vessel or the fleet of vessels by considering information such as (Skuld, 2017):

- vessel's particulars including size (GT), year of build, type, range of cargoes;
- trading patterns/areas;
- Classification society;
- management expertise;
- P&I history.

[214] Even a change of the registered owner often entails a change of Flag, ISM Company, etc.

The risk profile of a vessel from the point of view of a P&I club and marine insurers is similar to that of PSC in the sense that compromised safety can lead to accidents, which for the insurers result in substantial claims. Therefore, the arguments in favour of including additional information based on likely investment horizons and other owner characteristics are the same – such information is an indicator for owners' behaviour and trading patterns.

Although P&I clubs and marine insurers focus on both the asset and the owner as the owner represents the client, factors, which may offer valuable insight regarding safety and safety culture such as periods of ownership, ownership history and owner profile are largely ignored.

8.4.5. Banks and Financial Institutions

Bank loans are still the most popular type of ship finance (Schinas *et al.*, 2015). When a bank is performing a credit risk analysis to establish whether to grant a loan to a shipowner, there are several different types of factors that are considered. Grammenos (2010) introduced the six '*Cs*' of credit risk in shipping finance:

- Character;
- Capacity;
- Capital;
- Conditions;
- Collateral;
- Company.

The categories of interest, which are supposed to reflect the ownership profile, are '*Character'* and '*Company*'. The category '*Character*' concentrates on establishing the strategy of the people in charge and the level of experience. The category '*Company*' takes into account the structure of the company and the budget in order to establish a measure for the stability of the income.

Although banks appear to use the most thorough type of analysis, which focuses on ownership profiles, likely period of ownership or historical ownership patterns seem not to be included as indicators for the future performance and reliability of loan applicants. This is surprising as the link between periods of ownership, investment horizon and strategy have been discussed in the corporate strategy literature (Reilly *et al.,* 2016; Switzer and Wang, 2017).

Another potential application of the information on periods and patterns of ownership, which can aid banks in their credit risk analysis is the development of asset liquidity index (ALI). ALI would be a measure of the tradability of specific assets and how this tradability changes with the market conditions. This information can be valuable to financial institutions as often ships are used as collateral for the repayment of the loan. If shipowners cannot honour their loan obligations, the financial institution gains possession of the vessel(s). ALI would take into account average number of owners according to ship and company characteristics and the likelihood of owners to buy or sell with the change of the market conditions. Such tool can be particularly useful to financial institutions with limited experience in shipping.

The existence of more sophisticated tools for credit risk analysis leads to establishing an adequate mechanism for granting finance to parties interested in investing in shipping. The improvement of such tools means that financial institutions will be better equipped to deal with overconfidence and positive market expectations of shipowners and would be capable of making decisions based on realistic asset liquidity expectations.

8.4.6. Policy Makers

Apart from aiding policy makers to optimise the existing inspection and maintenance regimes, the information on typical periods of ownership can provide valuable insight into the behavioural patterns of owners. Reliable information regarding typical periods of ownership and investment horizons could be used to evaluate the potential uptake rate of new technologies (discussed in Section 8.4.1). If such evaluations are: (i) carried out prior to introducing regulations that require costly retrofits and (ii) based on realistic information regarding payback periods and typical investment horizons, they can aid policy makers in determining adequate and realistic compliance periods. This can lead to savings for shipowners which in turn should have a positive impact on the number of regulatory non-compliance attempts.

Improving safety in shipping on global level depends on how willing shipowners are to comply with existing and new regulations, which is a function of factors such as financial pressures, incentives, attitudes. Therefore, setting achievable and realistic compliance periods based on formal assessment of the potential technological uptake will lead to economic and safety-related benefits for the industry.

The list of potential beneficiaries discussed is not exhaustive but aimed to provide examples of how the outcome of this research can be used to benefit the shipping industry.

8.5. Contribution to Knowledge and Impact

The main contributions of this research[215] can be summarised as follows:

- Provision of more accurate and reliable estimation of length of ownership in shipping;
- Provision of a comprehensive review of length and patterns of ownership in shipping at a disaggregated ship and company level, which accounts for inherent differences within shipping segments and ownership structures; thus more thorough understanding of ownership behaviour is obtained;
- Contribution to understanding the characteristics that influence periods of ownership in shipping based on estimating their average effect on periods of ownership over the period 1987 to 2015;
- Contribution to the application of techniques common in biomedical science and demographical research to maritime economics.

Based on the above, this research has the potential of benefiting both academia and industry alike. The following sections explore how this can be achieved.

8.5.1. Academia

The academic impact of this research can be summarised as follows:

- Advancing the knowledge on strategic behaviour in shipping

Investment horizons have been linked to strategy but despite their importance to understanding resource allocation (Reilly *et al.*, 2016) and investor types (Switzer and Wang, 2017) no large scale empirical attempts to capture investment horizons and the factors that affect them in the context of shipping have been made recently[216]. This research provides an insight on periods of ownership and therefore investment horizons on a project level, where each individual vessel represents a 'project', based on empirical evidence from vessels built between 1987 and 2007. Estimating

[215] See Chapter 1, Section 1.4.

[216] The first and also latest such study, apart from the one undertaken by Stott (2013), being the research on reinvestment cycles carried out by Einarsen in 1938.

investment horizons on an individual project level is the first step towards a formal investigation of strategic behaviour in shipping based on group ownership.

Furthermore, investigating the effects of characteristics on periods of ownership on a disaggregated ship (ship type) and owner (owner type and number) levels provides further insights into the strategic behaviour in shipping. According to the results, certain asset and company characteristics' effects change with owner number, which provides indication that the motivation behind sale and purchase decisions varies and that strategic behaviour in shipping should be further investigated at a disaggregated level.

- Providing a benchmark for likely periods of ownership based on empirical data

Section 2.3 of the literature review aimed to provide a short review of assumptions regarding periods of ownership used in the maritime economics and ship investment literature. On the basis of the literature review on assumptions regarding periods of ownership it was concluded that authors use either: (i) arbitrary numbers based on anecdotal evidence or (ii) ambiguous terms such as '*long term*' or '*short term*' investment horizon without defining what these terms entail. Therefore, apart from advancing the knowledge on strategic behaviour in shipping, this research also provides a more accurate benchmark for researchers engaged in maritime economics and ship investment to base their estimates of likely periods of ownership on. This will lead to more realistic modelling of behaviour.

- Demonstrating how techniques common in other disciplines, such as biomedical research, can be applied to maritime economics.

The application of survival analysis is common in disciplines such as biomedical research, economics, engineering and politics as discussed in Chapter 3, Section 3.3.2. The wide application of this family of techniques is due to the capability of handling time-to-event data. However, survival analysis has been applied to a very limited range of topics within maritime economics[217]. This research shows how a variety of techniques (Kaplan-Meier estimator, Cox Regression and extended Cox) can be applied to the investigation of ownership periods and patterns in shipping and demonstrates the potential of these techniques in the context of maritime economics. Furthermore, additional techniques that have recently been introduced, such as

[217] See Chapter 3, Section 3.3.2.b).

random survival forests[218] have been used in conjunction with established survival analysis techniques for the first time in the context of maritime economics.

8.5.2. Industry

The research resembles '*blue sky research',* defined by Linden (2008) as research where the *'main goal is to advance knowledge and understanding'* as opposed to pursuing a particular application. Although the information on periods and patterns of ownership in shipping is a fundamental piece of knowledge and as such may not have a tangible application, its integration in models aiming to predict ownership behaviour developed by academia[219] and industry[220], will improve the reliability of future findings.

The impact of this research in relation to the shipping industry based on potential applications discussed in section 8.4 can result into:

- economic savings stemming from more efficient and reliable forecasting;
- enhanced maritime safety stemming from more accurate models for estimating risks associated with vessels based on their ownership history.

8.6. Further research

This section aims to summarise the possibilities for extending this research based on the main findings (section 8.3.2) and any other considerations that have arisen as a result of the analysis.

The number of characteristics considered on ship level could be extended by including ship efficiency measures. This was initially attempted by using ships' speed and fuel consumption as proxies, however these characteristics were omitted from the analyses for reasons described in detail in Data Annex Chapter 4 (section 3) and Data Annex 5 (section 3). Furthermore, the type of finance used to secure the asset is also of great interest as it may be linked to length of ownership by the first owner.

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[218] Ishwaran et al (2008) extended the random trees method introduced by Breiman (1984) to accommodate censored data. Recent studies (see Walschaerts et al, 2012) suggest that for the best results to be obtained, Cox regression results and random survival forests should be used in a complementary fashion. For more information see Chapter 3, Section 3.3.2., p 59.

[219] It refers to ship investment research and arbitrary assumptions regarding periods of ownership in the maritime transport literature discussed in Chapter 2, Section 2.3.

[220] It refers to some of the examples regarding potential beneficiaries and the use of the results for successful business development evaluations, forecasting, improving inspection regime framework and contributing to more realistic and representative owner profile evaluations as discussed in Chapter 8, Section 8.4.

It should be noted that no sector preferences have been assigned to individual companies as part of this research, which would potentially facilitate the comparison between companies with diversified portfolios and the more specialised, sector-specific companies. Another useful way of classifying companies could be based on core competencies, for example pure tonnage providers versus dedicated operators. However, both of these classifications include data which varies with time, therefore obtaining reliable data especially on group ownership level would be a very challenging task. In terms of patterns of ownership based on builder area, a larger sample size would allow for examining the combined effect of builder area and nationality of control. In terms of company type, a larger sample would again also benefit further research as the limited number of state and financial companies did not allow for a detailed analysis of the effect of company type for subsequent owners. Furthermore, the behaviour of family owned companies in terms of periods of ownership could be examined. The issue with including family owned companies stems from the difficulties in defining what is a family owned business given that often it is a matter of holding enough of the voting rights. However, the amount of voting rights necessary for a company to be classified as '*family owned'* varies significantly across frameworks. The matter is further complicated by the fact that private family owned companies are not required to share details regarding the operation of the enterprise.

Nationality of control has been used in this research as many stereotypes in shipping are based on the nationality of the owners. However, it is recognized that the differences in nationality of control are based on a combination of national culture, time and country specific regulatory reforms and on other factors that can trigger shifts in behaviour. Therefore, further research on comparing national cultures based on further disaggregation of cultural constructs might provide further elucidation on the results based on nationality of control. Some such constructs are, for example, temporal orientation and uncertainty avoidance.

Further research should aim to examine the effects of regulations that may require costly retrofits on periods of ownership. Examples of regulations that may affect vessels' economic lives and periods of ownership are:

- The Ballast Water Management (BWM) Convention – entered into force in September, 2017;

- MARPOL Annex VI introducing the 0.5% sulphur limit – enters into force in 2020.

In order for the effect of these regulations to be examined, however, a sufficient longitudinal data is required.

Throughout this research, the sale and purchase process has been analysed from the perspective of the seller. However, in order for a sale to occur, there needs to be a willing buyer. Modelling such a process can be achieved in a multistate setting where each sale is represented as a transition between different states. This will allow for the transitions between different companies to be analysed and thus providing a better understanding of the overall profile of companies that resort to anticyclical asset trading strategies. Furthermore, this research does not distinguish between types of termination of ownership as the focus is on determining whether certain characteristics affect periods of ownership. However, it is possible that the effects of certain characteristics, such as vessel size, vary based on the motivation behind the type of buyer. Including competing risks by distinguishing between a sale to a subsequent owner or to a scrap yard as well as allowing for variation of the effect coefficients over time will benefit future research by providing further insight on how the effects of the characteristics vary over calendar time and over vessels' economic lives.

For the purposes of this research, shipping companies were defined on the basis of the vessel viewed as a unit of production. This allowed for the data on periods of ownership to be used as an indication for the investment horizon on individual ship level. An alternative approach would be to shift the focus from the asset to the company by including corporate case studies which will allow for asset management decisions of specific organisations to be examined over time. In this way, further insights about the strategic behaviour of specific organisations can be obtained.

8.7. Conclusion

This chapter provided an overview of the aim and objectives of the research and the overall research design. Furthermore, the main findings of the research were summarised and discussed in terms of potential explanation in practice and future work. The chapter also aimed at providing examples of how the outcome of this research advances the state of the knowledge on periods of ownership in shipping and associated ownership patterns and how this knowledge can be used to benefit industry and academia.

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List of Appendices

Appendix A. Definitions

Appendix A-1. Types of Companies Involved in the Ownership of Ships

The following definitions were adopted as part of this research based on the definitions used in the Sea-Web database as compiled by IHS Fairplay (2017) [221].

1. **Registered Owner** - The legal title of ownership of the vessel that appears on the ship's registration documents. It may be an Owner/Manager or a wholly-owned subsidiary in a larger shipping group; or a bank or one-ship company vehicle set up by the bank; or of course, it may be a “brass-plate” company created on paper to legally own a ship and possibly to limit liability for the "real" owners and/or benefit from off-shore tax laws. It may anyway be a legal-requirement of the flag-state with whom the ship is registered for the legal owner to be a company registered in that country.

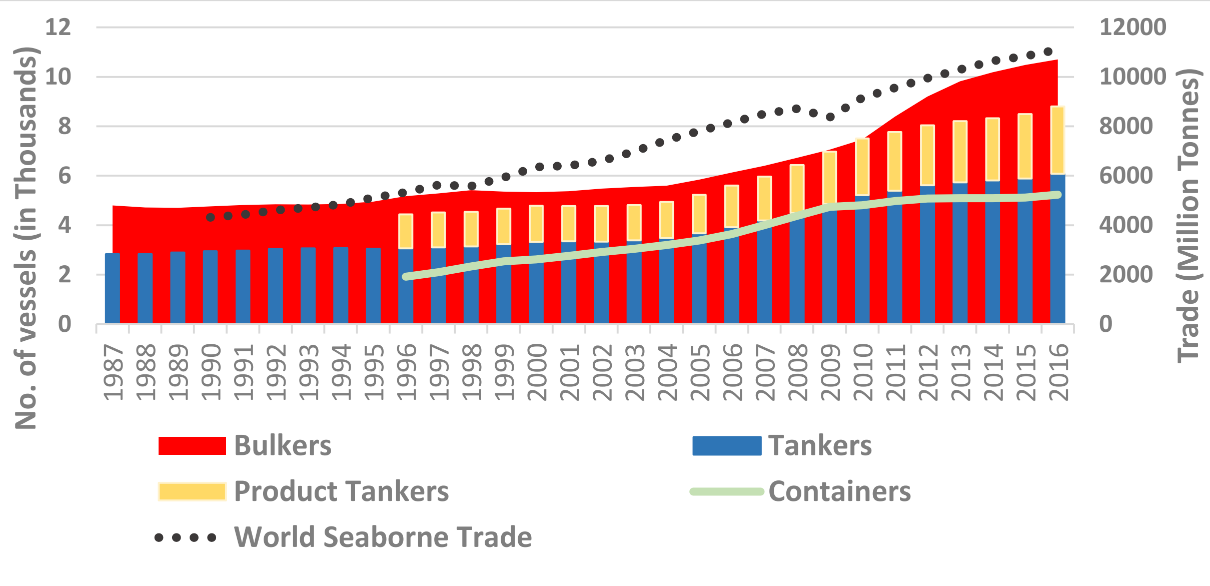
2. **Group Beneficial Owner** – This is the parent company of the Registered Owner, or the Disponent Owner if the ship is owned by a bank. It is the controlling interest behind its fleet and the ultimate beneficiary from the ownership. A Group Beneficial Owner may or may not directly own ships itself as a Registered Owner. It may be the Manager of its fleet, which is in turn owned by subsidiary companies. Its ships may also be managed by a 3rd party under contract.

[221] The full list of roles in respect to the Ownership, Management and Operation of Ships as compiled by IHS Fairplay (2017) is available here: http://www.ihsfairplay.com/About/Definitions/definitions.html.

Appendix B. Additional Data Information

Appendix B-1. World Fleet Development (late 1980s – 2016)

The demand for shipping is a derived demand and it is intrinsically linked to the development of world economy (Bijwaard and Knapp, 2009; Chang and Lai, 2011). Generally, the demand for shipping capacity increases with the growth of seaborne trade, which has had a positive year on year growth since 1990 with the exception of 1998 and 2009. The number of vessels of 100 GT and above has almost doubled in each of the three main segments – bulker, tanker and container ships since the late 80s (Figure B-1.1).



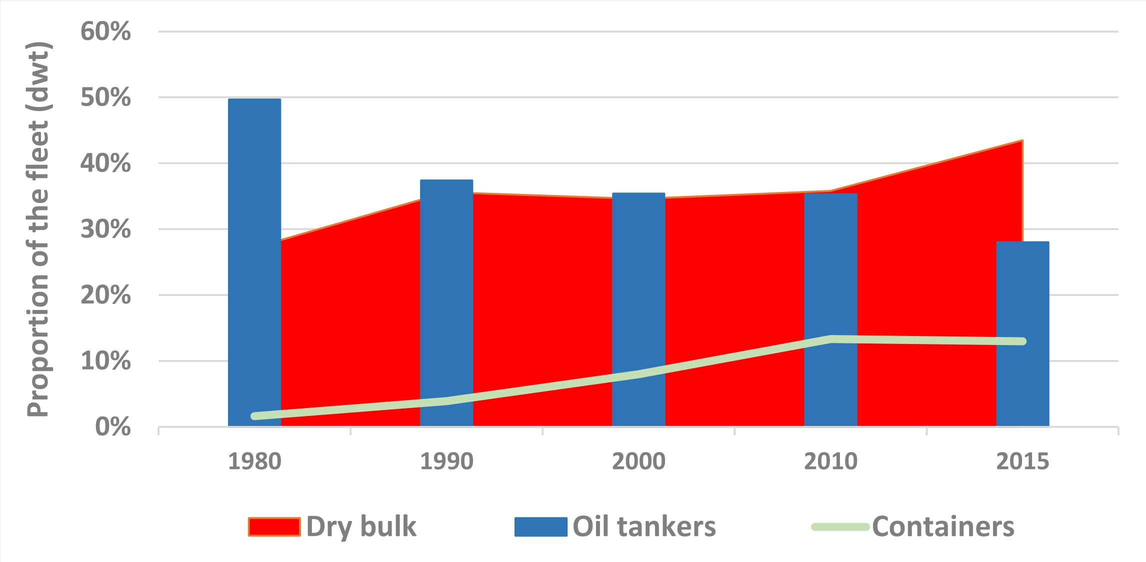
Data: CRSL (2016)

Note: Propelled seagoing merchant vessels of 100 GT and above. Tanker and Product Tanker categories include only vessels of 10,000 dwt and above.

Figure B-1.1. World fleet development by ship type (number of vessels)

The size of the world fleet is usually measured in million tonnes deadweight, million TEU where appropriate or number of vessels. In this case, number of vessels was chosen as the purpose of Figure 1 is threefold: to employ a standard unit for measuring both the bulk and container fleets; to show that the number of vessels servicing the global seaborne trade has increased since the late 80s and to provide an overview of the growth of seaborne trade.

The introduction of dry bulk carriers in the late 1950s and cellular container ships in 1966 was a game changer in shipping leading to a rapid increase in the number of such vessels at the expense of the general cargo fleet (Stopford, 2009). Although in terms of shipping capacity tankers dominated the world fleet in the 1980s, by the beginning of 2015 the share of the dry bulk fleet reached 43.5% of the total capacity (UNCTAD, 2015). The changes in the world fleet in terms of capacity are presented in Figure B-1.2.



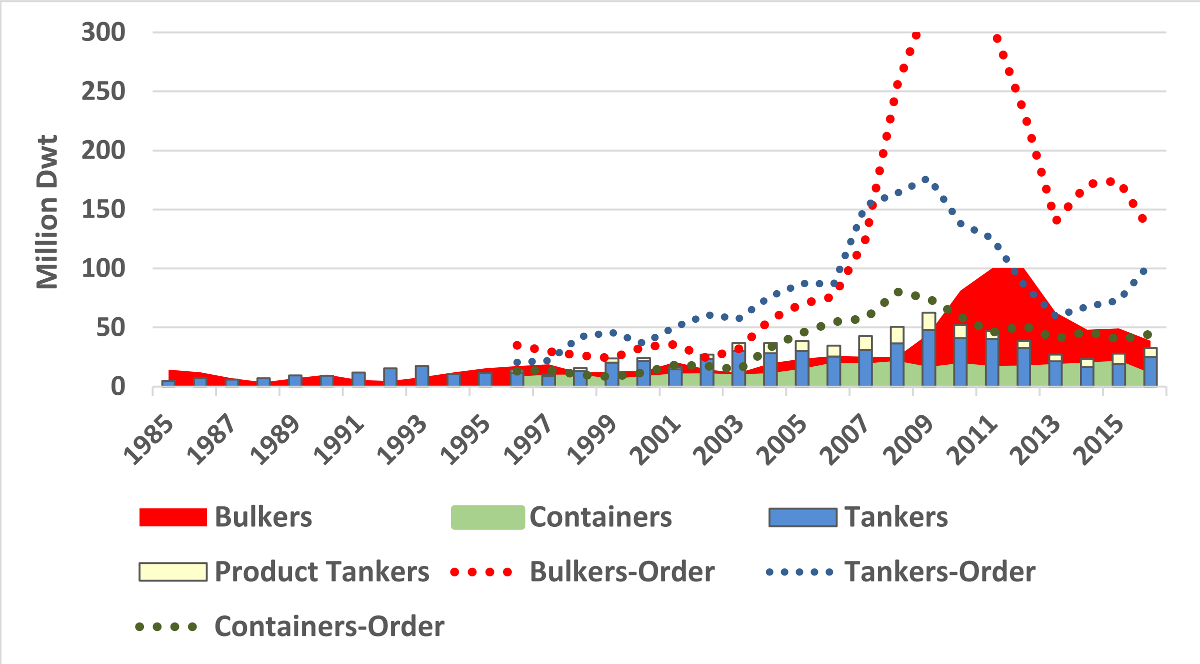
Source: Adapted from UNCTAD (2015, p.31)

Data: UNCTAD based on CRSL data and various issues of the Review of Maritime Transport

Note: All propelled seagoing merchant vessels of 100 GT and above, excluding inland waterway vessels, fishing vessels, military vessels, yachts and offshore fixed and mobile platforms and barges.

Figure B-1.2. World fleet development by ship type (percentage share of dwt)

Apart from the introduction of more specialised types of vessels, the world fleet experienced a substantial escalation in ship sizes since the 1980s, especially in the dry bulk and container segments. The increase in size is a function of various factors such as economies of scale, the development in port facilities to accommodate bigger vessels and the ability to handle larger parcel sizes. The average bulk carrier in 1980, for example, was about 34,000 dwt, whereas by 2005 the average size increased to 56,000dwt (Stopford, 2009). This trend is certainly valid for container vessels as well. In 1980, the largest container vessel – the Frankfurt Express – had a capacity of 3,050 TEU, which is a relatively small vessel compared to the container ships of today reaching a capacity of more than 19,000 TEU. Tanker vessels, being more mature, experienced a substantial growth in size but in the period 1950-1980, during which the largest tanker size grew from 30,000 dwt to 555,843 dwt (Seawise Giant after lengthening in 1980). However, trends in tanker sizes became more stable since then and due to structural changes in the fleet the average size of tankers decreased between 1980 and 2005 from 96,000 dwt to 86,000 dwt (Stopford, 2009).



Data: CRSL (2016)
Note: Propelled seagoing merchant vessels of 100 GT and above. Tanker and Product Tanker categories include only vessels of 10,000 dwt and above.

Figure B-1.3. Deliveries and Orderbook by ship type (million dwt)

In order for the balance between supply and demand to be preserved in a state beneficial to shipowners, the amount of shipping capacity delivered each year should not exceed the demand for it. In the early 2000s world economy entered a phase of growth, which can be attributed to a complex function of factors including China's accession to the World Trade Organization (WTO) in 2001. This led to an increase in industrial production and seaborne trade (Figure B-1.1), which generated a high demand for transporting goods. Revenko and Lapkina (1997) point out that one of the main reasons for acquiring new tonnage is the expectation of increase in profits in the future. The continuous growth created an optimistic sentiment amongst shipowners, who kept the shipyards very busy since the mid-2000s (Figure 1.3). For example, the number of bulk carriers delivered went from 181 in 2000 to 321 in 2005 until it reached a substantial peak in 2012 amounting to 1,247 vessels. The rate of ordering ships after the year 2003 grew extremely fast with the orderbook for bulk carriers reaching 326 million dwt in bulk carrier orders in 2009. The placing of ship orders and the amount of tonnage delivered led to more than 30% shipping surplus after 2010 (SIW, 2013).

The brief overview of international shipping focusing on fleet development aimed at familiarising the reader with the main developments that took place since the late 1980s in order to introduce the main characteristics of international shipping as they were used as a base for the design of the sampling framework. After a brief review of the world fleet development in the last 35 years, it was established that the three main shipping segments – dry bulk, tanker and container, although bound by the same ultimate demand and supply forces, developed in a different way over time due to technology availability, trade patterns and external factors.

Appendix B-2. Classification of Ship Level Characetristics

1. Definition of Ship Types (Cargo Specialisation)

Ship particulars data including, ship type and size, were retrieved from Sea-Web. The data collection was based on the most conventional ship types in order to avoid the inclusion of highly specialised vessels serving niche markets as it is believed that they might be subjected to different trading patterns. The definitions provided by Sea-Web regarding the types of vessels based on cargo specialisation included in this research are provided in Table B-2.1.

Ship Type	Cargo Specialisation	Definition
Bulker	Bulk Carrier	A single deck cargo vessel with an arrangement of topside ballast tanks for the carriage of bulk dry cargo of a homogeneous nature
	Ore Carrier	A single deck cargo ship fitted with two longitudinal bulkheads. Ore is carried in the centreline holds only
	Wood Chips Carrier	A single deck cargo vessel with high freeboard for the carriage of wood chips. May be self discharging.
Container	Container ship	A single deck cargo vessel with boxed holds fitted with fixed cellular guides for the carriage of containers
Tanker	Chemical Products Tanker	A chemical tanker additionally capable of the carriage of clean petroleum products
	Crude Oil Products Tanker	A tanker for the bulk carriage of crude oil but also for carriage of refined oil products
	Crude Oil Tanker	A tanker for the bulk carriage of crude oil
	Products Tanker	A tanker for the bulk carriage of refined petroleum products, either clean or dirty

Table B-2.1. Ship Type Definitions

2. Ship Size – Aggregated and Detailed Categories

The aggregated ship size benchmark used in this research is consistent with CRSL's classification of the main ship sizes. Table B-2.2 shows the distribution of the detailed Sea-Web ship size categories across the aggregated main ship size categories used as part of this research. The minimum and maximum deadweight (and TEU where applicable) values corresponding to the 3,908 ships included in the dataset are shown. The dataset comprises bulker and tankers of 30,000 dwt and above and container vessels of 1,000 TEU and above.

Ship Type	Ship Size (Aggregated)	Sea-Web Size (Detailed)	DWT		TEU	
			Min	Max	Min	Max
Bulker	Handy (30-60,000 dwt)	Large Handy	30046	39988	NA	NA
		Handymax	33800	55593	NA	NA
		Supra/Ultramax	50198	57646	NA	NA
	Panamax (60 -100,000 dwt)	Panamax	62303	65517	NA	NA
		Supra/ Ultramax	61362	64982	NA	NA
		Kamsarmax	65029	84914	NA	NA
		Post Panamax	86041	99761	NA	NA
	Capesize (> 100,000 dwt)	Mini Capesize	109009	113957	NA	NA
		Capesize	122259	322941	NA	NA
Container	Handy (1-2,000 TEU)	Regional Feeder	10345	33668	1000	1939
	SubPanamax (2-3,000 TEU)	Feedermax	24757	47625	2004	2996
	Panamax (3-4,000 TEU)	SubPanamax	39932	51046	3028	3853
		Panamax	38953	59804	3005	3961
	PostPanamax (>4,000 TEU)	Panamax	50137	68178	4024	5095
		Baby PostPanamax	54655	67958	4045	5390
		PostPanamax	63216	117063	5468	9578
		ULCS	156907	156907	15550	15550
Tanker	Handy (30-60,000 dwt)	MR1	30363	40432	NA	NA
		MR2	40041	53815	NA	NA
	Panamax (60-80,000 dwt)	Panamax	60959	78657	NA	NA
	Aframax (80-120,000 dwt)	Aframax	81351	117055	NA	NA
	Suezmax (120-200,000 dwt)	Suezmax	134441	193048	NA	NA
	VLCC (>200,000 dwt)	VLCC	214862	320472	NA	NA
		ULCC	441585	441585	NA	NA

Table B-2.2. Ship Size Classification

Appendix B-3. The Phasing Out of Single Hull Tankers

Apart from the introduction of a phasing out timetable, OPA’90 marked the beginning of a rigorous regulatory change governing the tanker segment on unilateral, regional and international level. OPA’90 postulates that 23-year-old single-hull tankers of 60,000 dwt and above will not be allowed to trade in US waters (National Academy of Sciences, 1998). On international level, Regulations 13F and 13G[222] of the 1992 Amendments to Annex I of MARPOL 73/78 promulgated that single-hull oil tankers[223] should be retired at the age of 30 years but in order to be deemed fit to trade beyond the age of 25 years, all pre-MARPOL must retrofit protectively located spaces or use hydrostatically balanced loading - HBL (National Academy of Sciences, 1998).

Following the Erika and the Prestige accidents in EU waters, the European Commission adopted the Erika packages[224]. According to the EU adopted timetable for the phasing out of single hull oil tankers concerning (i) vessels entering into ports and offshore terminals on the territory of Member states and (ii) vessels flagged by any of the Member States, Category 1 tankers[225] were to be withdrawn from operation in 2005 with an age limit of 23 years, whereas the age limit for Category 2 tankers is 28 years or 2010. Category 1 and 2 tankers that had not reached the age limits, were allowed to remain in operation after 2005 or 2010 respectively upon a satisfactory inspection under the Condition Assessment Scheme (CAS). After the Prestige accident, a further amendment banned pre-MARPOL tankers older than 23 years from EU waters and subjected all remaining single-hull tankers to CAS as of the age of 15

[222] In January 2007, Regulation 13F and 13G (and later 13H) were renamed to Regulation 19 and Regulation 20 (and 21) respectively (Stopford, 2009, p. 683).
[223] According to Annex I of MARPOL 73/78 an oil tanker means ‘a ship constructed or adapted primarily to carry oil in bulk in its cargo spaces and includes combination carriers and any "chemical tanker" as defined in Annex II of the present Convention when it is carrying a cargo or part cargo of oil in bulk’. According to this definition the phasing out timetable refers to all ship types included in this project - chemical and product carriers as well as crude oil and oil products carriers.
[224] The topics covered in the Erika packages are out of the scope of this research project, however, for more information see EUR-Lex (2016): http://eur-lex.europa.eu/legal-content/bg/TXT/?uri=CELEX:52002PC0780
[225] Category 1 tankers: "pre-MARPOL" single hull oil tankers, including crude oil tankers of 20,000 tons deadweight and above and oil product carriers of 30,000 tons deadweight, which have no segregated ballast tanks in protective locations, generally built before 1982. Category 2 corresponds to "MARPOL" single hull tankers, being of the same size as category 1, but which are equipped with segregated ballast tanks in protective locations, generally built between 1982 and 1996. According to this official grouping all single-hull tankers included in the ship level sample are Category 2 ships.

(Wene, 2005). On an international level, after few changes to the original phasing out plan, the timetable adopted is similar to the EU one with the exception that the phasing out of all tankers (including Category 3) should be completed by 2010 (Wene, 2005). Flag states, however, retained the right to extend the operation of Category 2 and 3 oil tankers beyond 2010 subject to satisfactory CAS until 2015 or until the ship reaches 25 years of age, whichever is earlier (Steamship Mutual, 2005). This means that single-hull oil tankers[226] built in 1990 could get an extension to trade until 2015, for example. However, port states could deny entry of such vessels. In the light of the above, choosing to scrap single-hull vessels in their early 20s instead of investing in costly retrofit and bearing the increased cost of maintenance seems like a logical choice. According to CRSL's SIW (2013), however, from the 376 VLCCs in service in 1996, when the last single-hull VLCC was built, only 243 ships were scrapped, 3 remained in service and the rest were converted into FPSOs[227] or ore carriers. According to CRSL data, by June 2013 there were only 52 single hull tankers above 40,000 dwt in existence, almost half of which were laid up and the rest trading into Brazil, China, India, Indonesia, West Africa and the Far East (SIW, 2013).

[226] Including oil tankers fitted with either double bottoms or double sides but not used for the carriage of oil and extending to the entire cargo tank length or double hull spaces (Steamship Mutual, 2005).
[227] Floating Production, Storage and Offloading (FPSO) unit.

Appendix B-4. Classification of Company Level Characteristics

1. Company Type Classification

Company type data was retrieved from CRSL. CRSL's Primary Company Type data refers to the 'core activity of that company' (SIWa, 2016). There are 17 different categories in the dataset provided by CRSL on primary company type which corresponds to the ownership history of the vessels examined as part of this research. The number of categories was found to be too large, therefore the company type data was aggregated into four main categories, namely – (i) financial companies (institutional investors, i.e. banks and investment funds); (ii) private companies; (iii) public companies and (iv) state companies. Table B-4.1 shows how the CRSL's primary company type categories are distributed across the newly formed aggregated categories.

Aggregated Company Type	CRSL's Primary Company Type	No. of records
Financial	Bank	3
	Financial	106
	Financial Affiliate	2
Private	Cargo Interest Affiliate	3
	Cargo Interests	30
	Independent Private	2057
	Private Affiliate	226
Public	International Oil	4
	International Oil Affiliate	8
	Non-Active Yard	2
	Oil Major	12
	Oil Major Affiliate	7
	Public	899
	Public Affiliate	75
State	National Oil	12
	National Oil Affiliate	5
	State Interests	222

Table B-4.1. Company Type Classification

2. Nationality of Control Classification

2.1. By geographical area

Table B-4-2.1. lists the countries included in the database as 'nationality of control' (78 countries) according to geographical area. The classification is based on the one proposed by UNCTADstat (2017a).

Area	Country
Africa	Angola; Egypt; Libya; Morocco; Nigeria; South Africa
Asia	Bangladesh; China; Chinese Taipei; Georgia; Hong Kong; India; Indonesia; Iran; Israel; Japan; Korea; Kuwait; Malaysia; Myanmar; Pakistan; Philippines; Qatar; Saudi Arabia; Singapore; Thailand; Turkey; United Arab Emirates; Vietnam
Europe	Austria; Belgium; Bulgaria; Croatia; Cyprus; Czech Republic; Denmark; Finland; France; Germany; Gibraltar; Greece; Iceland; Irish Republic; Isle of Man; Italy; Jersey; Latvia; Malta; Monaco; Montenegro; Netherlands; Norway; Poland; Portugal; Romania; Russia; Slovenia; Spain; Sweden; Switzerland; UK; Ukraine
North America	Bermuda; Canada; USA
Central America	Bahamas; Mexico; Panama
South America	Argentina; Brazil; Chile; Ecuador; Paraguay; Peru; Venezuela
Oceania	Australia; Samoa

Table B-4.2.1. Nationality of Control Classification – Geographical Area

2.2. By economic development status

The classification by development status is based on UNCTADstat (2017b)[228] framework.

Economic Development Status	Country
OECD (Organization for Economic Cooperation and Development)	Australia; Austria; Belgium; Canada; Chile; Czech Republic; Denmark; Finland; France; Germany; Greece; Iceland; Israel; Italy; Japan; Korea; Mexico; Netherlands; Norway; Poland; Portugal; Slovenia; Spain; Sweden; Switzerland; Turkey; UK; USA
Developed Countries	Bermuda; Bulgaria; Croatia; Cyprus; Gibraltar; Irish Republic; Isle of Man; Jersey; Latvia; Malta; Monaco; Romania
Developing Countries	Argentina; Bahamas; Brazil; China; Chinese Taipei; Ecuador; Egypt; Hong Kong; India; Indonesia; Iran; Kuwait; Libya; Malaysia; Morocco; Nigeria; Pakistan; Panama; Paraguay; Peru; Philippines; Qatar; Samoa; Saudi Arabia; Singapore; South Africa; Thailand; UAE; Venezuela; Vietnam
Least Developed Countries	Angola; Bangladesh; Myanmar
Countries in Transition	Georgia; Montenegro; Russia; Ukraine

Table B-4.2.2. Nationality of Control Classification – Economic Development Status

[228] http://unctadstat.unctad.org/EN/Classifications/DimCountries_DevelopmentStatus_Hierarchy.pdf

2.3. By maritime traditions

According to Alderton and Winchester (2002) two major shifts occurred in the period 1990-2000 in terms of ship registration, namely: (i) the rise of the second register (international register) and (ii) the establishment of new ship registers. As a resulted they proposed a different classification system for Flag States, which reflects safety and countries' maritime traditions. The countries identified as a 'nationality of control' for one or more records in the dataset are classified according to Alderton and Winchester's (2002) system.

Category	Country
Emerging Maritime Nations (EMN)	Angola; Bangladesh; Bulgaria; China; Chinese Taipei; Croatia; Ecuador; Egypt; Georgia; India; Indonesia; Iran; Israel; Korea; Kuwait; Latvia; Libya; Malaysia; Morocco; Nigeria; Pakistan; Paraguay; Peru; Poland; Qatar; Romania; Samoa; Saudi Arabia; Slovenia; Thailand; Turkey; UAE; Vietnam
International Registers	Hong Kong; Isle of Man; Philippines; Singapore; Ukraine
New Open Registers*	Gibraltar; Myanmar
Old Open Registers	Bahamas; Bermuda; Cyprus; Malta; Panama
Traditional Maritime Nations (TMN)	Argentina; Australia; Austria; Belgium; Brazil; Canada; Chile; Denmark; Finland; France; Germany; Greece; Iceland; Italy; Japan; Mexico; Netherlands; Norway; Portugal; Russia; South Africa; Spain; Sweden Switzerland; UK; USA; Venezuela
Unknown	Czech Republic; Irish Republic; Jersey; Monaco; Montenegro

*New Open Registers are those Flag States that were classified as ship registers by the International Transport Federation (ITF) between 1990-2000.

Table B-4.2.3. Nationality of Control Classification – Economic Development Status

Appendix B-5. Major Shipping Crises (1987- 2016)

1. Summary of the four major shipping crises in the period 1987-2016

1.1. The early 90s crisis

The tanker freight indices increased significantly from previous years in all tanker sizes with very large crude carriers (VLCC) and ultra large crude carriers (ULCC) reaching the highest rates in ‘at least 15 years’ (UNCTAD, 1990,p.45). This is partially due to the fact that the beginning of the Gulf War resulted in the closure of the Dortyol pipeline while at the same time the available tonnage was artificially limited as speculators seized the opportunity and stored oil in tankers (Stopford, 2009, p.149). As a result of the war, product shipments from Kuwait and Iraq related cargo trades were lost. These developments had an impact on various shipping segments but mostly disrupted the trade pattern of crude and oil products (UNCTAD, 1991) leading to a sudden drop in freight rates when the conflict ended. In 1991 dry bulk freight rates recovered from the weak 1990 levels. The unexpected high freight rates in 1991 are attributed to the ‘artificially restrained demand’, a result from the completion of the Desert Storm operation, and to an ‘abnormal set of circumstances largely unrelated to the fundamentals of supply and demand’ (OECD, 1991, p.105), such as the age of the fleet being blamed for the frequent incidents at the time. As a consequence, there was an unjustified optimistic sentiment which led to a lot of activity in the sale and purchase market and the orders of new tonnage and ultimately led to the collapse of rates in early 1992. Container vessels’ earnings were not affected as gravely by the 90s crisis remaining relatively stable in comparison with the other two major segments.

1.2. The Asian crisis (1997- 1998)

The repercussions from the Asian crisis were felt within the shipping segments at the end of 1997. The crisis resulted in South-East Asian countries’ currency depreciation, which had a negative impact on the domestic demand for imports. The growth of seaborne trade slowed down with the Asian crisis, resulting in a negative year-on-year growth in 1998 (Figure). This, coupled with the delivery of excessive amount of new tonnage in 1996 and 1997 (38.2 and 36.8 million dwt respectively – Figure 3) had an adverse effect on freight rates (UNCTAD, 1998). In the tanker segment the effects of the crisis and the oversupply were also reinforced by consolidation in the petroleum business under the form of mergers between oil majors, which increased their market influence (UNCTAD, 1999). Despite the fact that freight rates in all major fragments plummeted in 1998, the crisis was short-lived and rates started recovering in late 1999.

1.3. ‘Dot.com’ crisis

As it has already been established, the deep sea trade patterns follow closely the world economy (Stopford, 2009). The so called ‘Dot.com’ crisis, also referred to as the internet bubble, was a result of the availability of free venture capital and the belief that investing in internet startups on the stock market will return high profits. The speculative behaviour led to a fast and unsustainable growth of stock markets. The ‘bubble’ burst in 2000 which led to a recession of the world economy. The ripples affected the shipping segments as well with the freight rates crushing down. The ramifications were the most severe within the tanker segment with VLCC/ULCC rates falling nearly 75% by the end of 2001 from their January levels (UNCTAD, 2002).

1.4. Credit crunch

Although the early 2000s were mostly marked by economic prosperity, growth of gross domestic product (GDP) in most developed countries was starting to slow down before the collapse of Lehman Brothers in September 2008 turned the financial turmoil into a global recession (UNCTAD, 2009a). According to a United Nations’ report, dedicated to the systemic failures that led to the global recession, there are many factors that contributed, however, the impact of unrestricted capital flows and ‘unlimited freedom to exploit any opportunity to realize short-term profits’ was highlighted as one of the reasons why the crisis originated in the Anglo-Saxon developed countries (UNCTAD, 2009b, p. 4). Despite the fact that by the end of 2009 the stock markets had recovered and the economy of many developed countries started growing again, the ‘recovery’ was not on a global level (UNCTAD, 2009c). With the financial crash in 2008, shipping markets also collapsed. The average bulk carrier earnings fell suddenly from 65,000 $/day to 5,000 $/day, which is below the operational costs of the bulker fleet. The crisis had a similar effect on every shipping segment and although there have been brief periods of recovery, the surplus of shipping capacity ordered during the shipping boom of 2003-2008 and delivered after the collapse of the financial markets, which has not been absorbed by slow-steaming and the very low levels of scrapping, has kept freight rates low.

Appendix B-6. Ship Risk Profile Calculator (Paris MoU)

				Profile			
				High Risk Ship (HRS)		Standard Risk Ship (SRS)	Low Risk Ship (LRS)
Generic Parameters				Criteria	Weighting points	Criteria	Criteria
1	Type of ship			Chemical tankship Gas Carrier Oil tankship Bulk carrier Passenger ship	2	neither a high risk nor a low risk ship	All types
2	Age of ship[1]			all types > 12 y	1		All ages
3a	Flag	BGW-list[2]		Black - VHR, HR, M to HR	2		White
				Black – MR	1		
3b		IMO-Audit[3]		-	-		Yes
4a	Recognized Organization	Performance[4]	H	-	-		High
			M	-	-		-
			L	Low	1		-
			VL	Very Low			-
4b		Organizations recognized by one or more Paris MoU Member States		-	-		Yes
5	Company	Performance[5]	H	-	-		High
			M	-	-		-
			L	Low	2		-
			VL	Very Low			-
Historic Parameters							
6	Number of def. recorded in each insp. within previous 36 months	Deficiencies		Not eligible	-		≤ 5 (and at least one inspection carried out in previous 36 months)
7	Number of Detention within previous 36 months	Detentions		≥ 2 detentions	1		No Detention

Appendix C. Interviews

Appendix C-1. Examples of Questions Used in the In-depth Interview Stage

Introductory Phase:

A. Name
B. Current Company and position/experience in years
C. Past organisation(s) and position/experience in years
D. Industry experience (years)
E. Date and Location

Examples of Questions:

1. **According to your industry experience, do you think that different owners employ different strategies related to buying and selling of vessels?**

2. **What are the most popular strategies in shipping related to buying and selling of vessels in your opinion?**
    - Short-term (asset play) or long-term?
    - What would you define as short term/long term – in terms of years?
    - Are there any specific characteristics or external factors you associate asset players/long-term players with?
    - What owner characteristics explain the different behaviour in your opinion?

3. **According to your experience what factors affect how long owners keep their ships for?**
    - In your experience does the behaviour of shipowners depend on factors such as nationality and/or company type?

4. **With regard to the companies you have worked for – how is the model for buying/selling ships different?**
    - Different how?
    - Which model has proven to be more successful?

5. **Have you noticed a change in the behaviour of shipowners with regard to buying and selling of vessels throughout your career? (If 'No' – What about the 2008 market collapse?)**
    - (*If Yes)* Do you think the change *(if the interviewee has identified such a change)* will have a permanent impact on ship buying/selling policies? (*If yes – in what way?)*
    - Or is it just temporary until the market recovers?

Appendix C-2. Questionnaire Design

Typical periods of vessel ownership in modern shipping: Interview Stage

What is the typical period of ownership in modern shipping? How does it vary by ship type/size, speed or shipbuilder? What about owner nationality and company type (private, public, financial, state) and size? Has the behaviour changed significantly over the last decade?

Research has been ongoing at Newcastle University on typical periods of ownership in shipping that aims at providing insight on ownership strategies employed by different types of ship-owning companies, the timing chosen for buying or selling a ship and to investigate what are the main factors that affect sale and purchase timing.

The study is based on the commercial history records of nearly 4 000 bulkers, tankers and container vessels of 30 000 dwt and above built between 1987 and 2007. The historical ship records were retrieved from IHS Fairplay's shipping directory – SeaWeb and the data on company type and size was kindly provided by Clarkson Research Services Limited (CRSL).

The project is in its validation stage, which involves interviews with industry representatives. The aim of the interviews is to capture the industry's view on the trends identified so far and the potential future changes associated with vessel buying and selling behaviour and periods of ownership in shipping.

If you are interested in participating in this stage of the project in exchange of summary of the results at completion, please provide the information below. This information is confidential and your identity will be concealed at all times.

Name	
Current Organisation	
Position	
Years at Current Organisation	
Past Organisations and Positions held	
Industry Experience (years)	
Date	

For more information: Ralitsa Mihaylova
Email: r.mihaylova@ncl.ac.uk; Tel. +44(0)7719108777

Below is a list of hypothesized factors that may or may not affect the decision to buy or sell. The list is not exhaustive so please add any missing factors in the empty cells marked with '*'. Thank you for your time!

1. Looking at the table below can you rate each sub-factor's impact on periods of ownership.

2. Looking at the same table, please circle and rank what you perceive to be the three sub-factors that have the greatest impact on periods of ownership (number 1 equals highest impact, 3 equals lowest impact).

3. Please rank what you perceive to be the order of impact of the three main factors – ship characteristics, company/owner characteristics, external factors (number 1 equals highest impact, 3 equals lowest impact).

		FIRST Owner					*SUBSEQUENT Owners*				
Main Factor	**Sub-factor**	*Not Sure*	*No Effect*	*Weak Effect*	*Medium Effect*	*Strong Effect*	*Not Sure*	*No Effect*	*Weak Effect*	*Medium Effect*	*Strong Effect*
Ship Characteristics	Type (Bulker, Tanker, Container)										
	Size (Handy, Panamax, etc)										
	Age										
	Fuel Consumption										
	Speed										
	Shipbuilder										
	Shipbuilder Country										
	*										
	*										
Company Characteristics	Type (Public, Private, State, Financial)										
	Nationality of Group Owner										
	Company Size										
	*										
	*										
External Factors	Freight Rates										
	Newbuilding Prices (NB)										
	Change in NB prices										
	2^{nd} hand prices										
	Change in 2^{nd} hand prices										
	Demolition prices										
	Bunkers price										
	Interest Rates										
	Economic Growth										
	Exchange Rate										
	Inflation										
	Oil price										
	*										
	*										

Appendix C-3. Copy of the Call for Volunteers for the Interview Stage – Spinnaker Global

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Typical periods of vessel ownership

24 September 2015

Back to blog

Vessel ownership patterns in shipping is a topic that most shipping professionals have an opinion on but for which there is little objective numerical data.

Questions such as what is the typical period of ownership in shipping and how does it vary by ship type, owner's nationality or the company's business type (private versus state, family owned versus public, etc) and how the established patterns of behaviour may have changed in the wake of the latest shipping crisis remain unanswered.

Research has been ongoing at Newcastle University on typical periods of ownership in shipping that aims at providing insight on ownership strategies employed by different types of ship-owning companies, the timing chosen for buying or selling a ship and to investigate what are the main factors that affect sale and purchase timing. Ownership periods are also important because they determine the potential payback period for any investment in the ship, for example retro-fit of carbon-reduction technology. The results to date question received wisdom in the industry and show, for example, that the average time to first sale is around 10 years with slight variation between ship types and that at least 20% of ships remain with the original owner for their full economic life.

The study is based on the commercial history records of nearly 4 000 bulkers, tankers and container vessels of 30 000 dwt and above built between 1987 and 2007. The historical ship records were retrieved from IHS Fairplay's shipping directory – SeaWeb and the data on company type and size was kindly provided by Clarkson Research Services Limited (CRSL).

The project is in its validation stage, which involves interviews with industry representatives such as shipowners, marine equipment manufacturers, S&P brokers, ship finance specialists and other marine service providers. The aim of the interviews is to capture the industry's view on the trends identified so far and the potential future changes associated with vessel buying and selling behaviour and periods of ownership in shipping.

I would like to invite those members of the shipping industry who find themselves interested in the outcome of this project to take part in the interview stage.

To take part in the interview stage and review the results, please contact Ralitsa Mihaylova (Newcastle University) at r.mihaylova@ncl.ac.uk.

Newcastle University

Enlarge Image

URL: https://spinnaker-global.com/blog/1417_24-09-2015_typical-periods-of-vessel-ownership