Cyprus University of Technology
Faculty of Management and Economics

Doctoral Dissertation

"Chartering and Financial performance in Shipping"

Mr. Andreas Kouspos

Limassol, 2nd of May 2022

CYPRUS UNIVERSITY OF TECHNOLOGY
FACULTY OF MANAGEMENT AND ECONOMICS
DEPARTMENT OF COMMERCE, FINANCE AND SHIPPING

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Approval Form

Doctoral Dissertation

"Chartering and Financial performance in Shipping"

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Cyprus University of Technology

Limassol, May 2022.

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Acknowledgements

A wonderful academic research voyage reached the end. I have started my PhD aiming to become an accomplished researcher and embark on an academic career. Now that the hard and difficult times have passed, I am left with a sense of fulfillment having reached the end of the tunnel for my PhD scientific investigation.

In January 2016, I joined the Department of Commerce, Finance, and Shipping of the Faculty of Economics and Management of Cyprus University of Technology. Actively involved in the research, I decided to undertake studies in the area of shipping finance. In a broad sense, this thesis includes studies in factors affecting the financial performance of shipping firms in the shipping industry, more precisely studies based on chartering policy, technical innovation, risk/uncertainty and financial performance in the shipping industry.

Firstly, I must thank my supervisors Prof. Photis Panayides and Dr. Dimitris Tsouknidis who believed and guided me throughout my PhD life in a way that helped me to improve my research skills and techniques. Both were always very eager to support and assist me when I was facing difficulties with my research, especially with the data collection and methodology.

Secondly, I feel very indebted to my parents, Anastasios and Aikaterini and my grand-mother Maria who were always next to me supporting and encouraging me psychologically. Particularly, I dedicate this thesis to my mother who was impatiently waiting for my PhD completion and graduation despite the fact that she never realized how challenging it is. Undoubtedly, the thesis is also dedicated to my father who is always next to me to advise me for any professional and personal difficulties I may find.

Thirdly, special thanks to my friends and colleagues from my department, Dr. Polina Ellina and Dr. Christophoros Andreou, among others, who were very important for my PhD life motivation. Thanks are due to all the professors from my department particularly to Prof. Panagiotis Theodossiou and Dr. Christos Savva. Special thanks to Prof. Panagiotis Theodossiou who was the first that believed in my skills for starting my PhD, despite the fact that our academic paths and interests have changed after the first two years at the University.

Lasltly, special thanks to my department's secretaries, Mrs. Demetra Christodoulidou and Mrs. Nantia Kyratzi for their help.

“If you don't get what you want, you suffer; if you get what you don't want, you suffer; even when you get exactly what you want, you still suffer because you can't hold on to it forever. Your mind is your predicament. It wants to be free of change. Free of pain, free of the obligations of life and death. But change is law and no amount of pretending will alter that reality.”

— Socrates

ABSTRACT

This dissertation includes essays in the topic of chartering, technical innovation in shipping, risk and return in shipping and shipping financial performance.

Chapter 1 investigates the relationship between chartering policy and financial performance of U.S. listed shipping firms using publicly available data from SEC's 20-F forms for U.S. listed shipping firms to construct a unique dataset of vessel chartering decisions. Also, firm-level data is used during the econometric modelling of panel data which are employed as a methodology for investigating this research gap. Results show that employing a long-term chartering strategy i.e., time charter with duration more than a year, shipping firms can achieve higher financial performance for the sample's period which is characterized as 'bearish'. The higher the deadweight tonnage chartered under time charter with duration more than 1 year, the higher the financial performance of shipping firms. Also, chartering capabilities are important for the shipping firm for making the best decision for chartering its ships as efficiently as possible at the right time. After the shipping crisis of May 2008, it seems that shipowners prefer to follow the path of safety by chartering their most of ships under long-term chartering contracts. Results are of interest to shipowners and ship lending authorities, mostly for improving financial performance and ensuring that loan settlement are being paid respectively.

Chapter 2 reviews the relationship between ship's technical innovation of U.S. & Oslo listed shipping firms with financial performance. Annual data for technical innovation for 21 shipping firms from 2013 to 2019 is collected from SEC 20F forms from Securities and exchange commission (Edgar) for U.S. listed shipping firms and firms' webpages for Oslo listed shipping firms. Data for technical innovation includes eco-type ship, ship's propulsion type and ice class type ships. Panel data regression modelling is applied showing that technically innovated ships have a positive robust relationship with shipping firms' financial performance. In line with the academic literature, innovation contributes to higher financial value for a firm. Among the three types of technical innovation, eco-type contributes to higher financial performance of shipping firms. This can be seen as an attempt of shipping firms to embrace corporate social responsibility (CSR) techniques which is

positively seen by shipping investors in the market. Going ‘green’ can positively affect firm’s financial performance because shipping investors seems to embrace these green practices.

Chapter 3 examines the relationship between chartering policy and financial performance of U.S. listed shipping firms trading in the dry bulk and tanker shipping segments of the industry. We collect data for dry and tanker firms listed in U.S. stock exchanges, NYSE and NASDAQ from SEC 20F forms from the Securities and exchange commission (Edgar). These sub-segments in the shipping market have different business cycles which are formed by the demand and supply for transporting various commodity types worldwide. Panel data regression modelling is applied resulting that chartering policy in both segments differs and as a result there is a different impact on the financial performance for each shipping segment. We also compute volatilities/risks of freight rates for spot and time charter markets for assessing uncertainty in each market. Results show that employing a higher percentage of ships under time chartering strategy with duration more than a year in the dry segment has a higher impact on financial performance compared to tanker shipping segment. In contrast, employing a higher percentage of the fleet in the spot market in the tanker shipping segment compared to dry segment has a higher impact on shipping firms’ financial performance. Results are useful for the risk averse investors who can diversify risks by investing in dry bulk shipping firms trading most of their fleet under time chartering and in tanker shipping firms employing most of their fleet under voyage charter.

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List of Abbreviations

AFRA	Aframax
BB	Bareboat
CAPE	Capesize
CAPEX	Capital expenditure
CAPM	Capital asset pricing model
CC	Chartering capabilities
CIK	Central index key
COA	Contract of affreightment
CP	Chartering policy
CSR	Corporate social responsibility
DEA	Data Envelopment Analysis
DMU	Decision making unit
DWT	Deadweight tonnage
EDGAR	Electronic Data Gathering, Analysis, and Retrieval system
HFO	Heavy Fuel Oil
ISIN	International Securities Identification Number
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
MDO	Marine diesel oil
MVBV	Market to book value assets
MVE	Market value of equity
NASDAQ	National Association of Securities Dealers Automated Quotations
NYSE	New York stock exchange
RBV	Resource based view
ROA	Return on assets
SEC	Securities and exchange commission
SIC	Standard industrial classification
TA	Total assets
TC_LONG	Time charter long

TC_SHORT	Time charter short
TFDE	Tri-fuel diesel electric
U.S.	United states
VAR	Vector autoregressive
VIF	Variance inflation factor
VLCC	Very large crude carrier

Introduction

«Ναῦς », the ancient Greek word of ship used by the ancient Greeks for describing a water floating vehicle that transporting cargo and/or passengers from one place to another. Shipping has a long history throughout the centuries aiming at carrying cargo and/or passengers all around the world. Throughout the history of the world, the industry contributed to the wellbeing of the global societies, the development and welfare of the countries and to colonization of people to different areas of the world (Stopford, 2008). Historical facts witnessed that nations such as Germany, England and China among others contributed to the global development of the modern shipping industry by introducing innovative methods of finance i.e. the German KG system (Drobetz and Tegtmeier, 2013), the construction of modern ships from Chinese shipyards (Jiang and Lauridsen, 2012) and the English maritime law that governs global shipping transactions (Hill, 2017). Transportation by sea forms the leading mode of transportation worldwide, carrying over 80% of the global trade in volume terms (UNCTAD, 2021). World transportation is generated through the use of multiple ships after the negotiation, agreement and charterparty signing between charterers and shipowners in the shipping industry (Panayides, 2016). The shipping industry is separated into various segments such as dry, tanker, gas, and container (Tsouknidis, 2016; Kavussanos, 2003). Within these segments various purpose-built ships are deployed for transporting either packed or unpacked cargoes (Branch, 2007).

Shipping companies can be separated into private (family-owned) or public (listed in a stock exchange). Each company has its own fleet of vessels for carrying cargoes all over the world. Dry and wet packed cargoes are transported by containers whereas unpacked cargoes (bulk) are transported by dry, gas, or tanker ships (Stopford, 2008). Dry ships can be categorized into Handysize (20000-33999 dwt), Handymax (34000-53999 dwt), Supramax (54000-59999 dwt), Panamax (60000-99999 dwt), Capesize (100000-199999 dwt) and Very large bulk carrier (>200000 dwt). Sizes of tanker ships are Handymax (50000 dwt), Panamax (50000-74999 dwt), Aframax (75000-119999 dwt), Suezmax (120000-19999 dwt), Very large crude carrier (180000-320000 dwt) and Ultra Large Crude carriers (>320000 dwt). Container ship types vary from early containerships (500-800 TEUs), fully cellular (1000-2500 TEUs), Panamax (3000-4000 TEUs), Post-Panamax I (4000-6000 TEUs), Post Panamax II (6000-8500), New-panamax (8500-12,500 TEUs), Very large container ship

(12500-18000 TEUs) and Ultra large container ship (18000-25000 TEUs). The last category is the liquefied petroleum gas ships (LPG) and liquefied natural gas (LNG) vessels.

This thesis presents three essays that represent, timely, topical, and original inter-relationships in the commercial shipping industry. In such a volatile and uncertain shipping freight market (Tsouknidis, 2016; Drobetz et al., 2012b), shipping companies are directly affected by the fluctuations of freight rates that are determined by the interaction of demand and supply for transporting cargoes (Stopford, 2008). Shipowners are responsible for making business decisions such as choosing multiple chartering strategies for their fleet and as a result this may affect the financial condition and survival of the shipping firm in the short- and long-term. Thus, it is of utmost important to make the correct business decisions that can assist the shipping firms to increase their financial performance.

Chapter 1 titled "Investigating the relationship between Chartering Policy and Financial Performance of U.S. Listed Shipping Firms" focuses on the examination of the relationship between chartering policy and financial performance for U.S. listed shipping firms. Utilizing hand collected data for the chartering agreements of each ship for U.S. listed shipping firms, we form the chartering policy of each firm for each year. Chartering policy is the mixture of multiple charterparties for each firm's fleet for each year and shows the risk appetite and future expectations of the shipowner about the freight market. Chartering agreements are comprised of long-term chartering contracts (time charter or bareboat) and short-term agreements (voyage charter). Chartering agreements for each ship/firm/year are collected from SEC 20F forms from the Securities and exchange commission (Edgar). We also use data envelopment analysis (DEA) for capturing chartering capabilities of each firm throughout the sample period. We then apply Panel data regression modelling for assessing the impact of chartering policy on the shipping firms' financial performance from 2010 to 2018. The results show that employing a long-term chartering strategy i.e., time charter with duration more than a year, shipping firms can achieve higher financial performance for the sample's period which is characterized as 'bearish'. Also, chartering capabilities are important for the shipping firm for making the best decision for chartering its ships as efficiently as possible at the right time.

In Chapter 2 – “The relationship between technical innovation and financial performance: The case of U.S. and Oslo listed shipping firms” a thorough analysis was performed to assess how a ship’s technical innovation can create financial value for the shipping firm. Data for technical innovation for 21 shipping firms from 2013 to 2019 is collected from SEC 20F forms from Securities and Exchange Commission (Edgar) from U.S. listed shipping firms and firms’ webpages for Oslo listed shipping firms. Data for technical innovation is collected for eco-type ship, ship’s propulsion type and ice class type ships. Panel data regression modelling is applied for estimating any possible relationship between ship’s technical innovation and firm’s financial performance. Results show that shipping firms started investing in technically innovated ships since 2013 and this has a positive robust relationship with firms’ technical innovation. This may be attributed to the fact that after the world shipping crisis of May 2008, shipowners have been investing in technically innovated ships for tackling the on-going crisis as technically innovated ships are considered more attractive to the charterers because they have fewer operating expenses and efficient fuel consumption. The study finds that among the three types of technical innovation, eco-type technical innovation contributes to better financial performance of shipping firms.

In Chapter 3 – “Chartering policy and financial performance: The case of U.S. listed shipping firms trading in tanker and dry shipping sector” we collect data for dry bulk and tanker firms listed in U.S. stock exchanges, NYSE and NASDAQ from SEC 20F forms from the Securities and Exchange Commission (Edgar). Segmentation effect appears because the decision to hire a ship for carrying a specific cargo is influenced by four factors: 1. type of the commodity transported, 2. the cargo parcel size, 3. the ship’s route and 4. the loading/unloading port facilities. These sub-segments in the shipping market have different business cycles which are formed by the supply and demand for transporting various commodity types worldwide forming different chartering policy for each segment. Panel data regression modelling is applied resulting that in both segments, the chartering policy is different, thus affecting differently the financial performance of shipping firms in each segment. Volatilities of freight rates have been estimated showing that the dry bulk shipping segment exhibits higher variation in volatilities of time chartering than the tanker market but lower volatilities in the spot chartering market. Investing in shipping firms that employ a higher percentage of ships under a time chartering strategy with duration more than a year in the dry bulk shipping segment and under a voyage charter in the tanker market, risk averse investors can achieve higher financial performance by diversifying the volatilities of the shipping freight markets.

Conclusively, this dissertation employs panel data models for investigating three different academic gaps of the literature in the specific areas of chartering, innovation and of risk and return in the maritime and shipping finance related literature. The results of the analyses are useful for the shipowners, bankers, and risk averse investors because they can realize the importance of chartering policy and the strategy the ship is chartered for the purpose of earnings stability, loan settlement and risk diversification. Determinants of financial performance are multiple such as the leverage, market value of equity, market to book value of assets, financial capacity, operating leverage, freight, and volatility of freight rates and share prices among others. Generally, the results introduce two new variables in the extant literature, viz., chartering policy and ship's technical innovation. Results show that during bearish shipping freight markets shipowners will do better to employ their fleet under a time charter with duration more than a year as they can stabilize their earnings in the volatile and uncertain freight market. Moreover, by investing in a technically innovated ship such as an eco-type ship, shipping firms can achieve higher financial performance since this type of ships can be chartered with a freight premium in the shipping freight market during low freight market conditions. One possible limitation of the study that is acknowledged, is the small sample of investigation; however, the samples could not be increased more as the information which is available can be found only in SEC 20F fillings. The information was also partly hand-collected which reflects both the originality as well as the challenges posed in conducting this type of research. Further research can be done on chartering policy and financial performance of shipping firms based on each type of ship in other shipping segments. Furthermore, a good research path is to assess the relationship of chartering policy on shipping firms' stock prices.

Chapter 1 Investigating the relationship between Chartering Policy and Financial Performance of U.S. Listed Shipping Firms

1.1 Introduction

Transportation by sea forms the leading mode of transportation worldwide, carrying over 80% of the global trade in volume terms (UNCTAD, 2021). A large part of sea transportation is facilitated by the U.S. listed shipping companies, which are the largest in terms of capitalization globally (Drobetz et al., 2013a). One of the most important business decisions for a shipping firm is its chartering policy, i.e. deciding on the mix of different freight charter contracts under which its fleet of vessels will operate.[1] Operating within the notoriously risky global shipping industry exposes market participants to risky business decisions (Alexandridis et al., 2018b). The ability of a shipping company to generate income through chartering its vessels efficiently affects in a direct way its financial performance.

The freight market is the market in which transportation services are bought and sold by charterers and shipowners respectively with the main trading product to be the ship as without her service no cargo can be transported through sea (Stopford, 2008). The negotiations and agreements conclude in the signing of charterparties i.e., freight charter contracts (Panayides, 2016). These negotiations between the shipowner and charterer are facilitated by the shipbroker who is a specialist broker for bringing both parties for discussions and if possible, for agreement (Stopford, 2008). Chartering agreements are often classified by their time length into short-term and long-term ones (Rogers et al., 2016). Short-term chartering contracts are considered riskier as freight rates in the voyage rates (spot) market exhibit overall larger fluctuations (Kavussanos, 1996), incorporating (i) that the shipowner pays the voyage costs, which include the large and volatile bunkering cost for the voyage and (ii) the re-employment risk of the vessel, i.e. whether the shipowner will be able to charter again the vessel at an attractive freight rate after the initial voyage contract expires. By contrast, long-term time-charter contracts entail lower risk as freight rates agreed exhibit overall lower fluctuations, incorporating (i) that the shipowner does not pay the voyage costs, which are rolled over to the charterer and (ii) the certainty for the employment of the vessel

[1] Panayides (2016) defines chartering as the hiring of a ship or part of a ship for the purpose of transporting cargo by sea.

over a larger period of time according to the time length of the charter agreement, e.g., 6 months, 1 year, 3 years, 5 years, etc. Another type of chartering contract is the bareboat which differs a lot from the voyage and time charter. Bareboat charter is another type of long-term chartering contract which is signed between the two parties if the charterer wishes to fully operate the ship but without owning it; thus being responsible for all the costs of vessel except capital costs (Panayides, 2016). In this context, choosing a specific chartering policy reveals for a shipping firm: (i) its future expectations regarding the freight rate market and (ii) its risk appetite, since longer-term charter contracts generate stable revenue for a longer time period and exhibit considerably less volatility over time (see for e.g. Kavussanos, 1996).[2]

Even though the choices for length of freight contracts are the same in all shipping segments i.e., short or long-term chartering duration, the type of charterparties signed between the charterer and shipowner differs (BIMCO, 2021). Shipowners who trade in the dry bulk shipping market can sign time charterparties such as New York Produce Exchange (NYPE 93) and; Baltic and International Marine Council (BALTIME 1939 (amended 2001)) and voyage charterparties such as Gencon 94, Graincon among others. In the tanker shipping segment, charterparties such as Tankervoy 87 is signed for voyage charters and BPTIME3 for time charters among others. Other charterparties can be chosen for gas tankers such as ASBAGASVOY 2020, LNGVOY for voyage charter.

This paper is closely related with two strands of the literature. First, a number of studies have focused on the term structure of the dry-bulk shipping freight markets and provide explicit tests of the validity of the expectations theory in the ocean freight markets (Vanags and Hale, 1989; Veenstra, 1999; Kavussanos and Alizadeh, 2002). The existence of a time-varying risk premium helps in explaining any persistent profit opportunity in the freight market due to the unique characteristics of the shipping service, being non-storable and non-tradable, as these characteristics violate the arbitrage pricing relationship. Adland, and Cullinane (2005) consider theoretically the sources of risk of different chartering decisions in an effort to explain the observed cyclical predictable component of freight rates to a time-varying risk premium (see also, Alizadeh et al. 2007). Such sources of risk for the

[2] Chartering policy is the act of shipping company to charter its fleet of ships using different freight contracts with different durations. Chartering policy may be formed by choosing either one type of freight contracts i.e., voyage charter contracts or multiple freight contracts i.e., voyage charter and time charter contracts.

volatility in spot and time-charter freight rates involve the liquidity risk and the default risk inherent in a time-charter contract (Adland and Jia, 2008a), i.e. the risk premium attributable to charter default risk is positive and increasing in the spot freight rate level and period charter duration. Effectively, a shipowner entering a period charter eliminates his exposure to the fluctuations of spot freight rates, but at the cost of the prevailing spot freight rates. Therefore, the inability to terminate or sell the period charter at will, if the time-charter market moves against his position, creates liquidity risk. At the same time, if the spot market moves against his position in the time-charter market (increase), he will have an incentive to default or renegotiate the terms of the contract.

Second, a number of studies have focused on the potential determinants of financial performance of shipping firms, such as for example their capital structure (Drobetz et al., 2013a; Merika et al., 2015; Adland et al., 2017b), their corporate governance mechanisms (Syriopoulos and Tsatsaronis, 2011; Andreou et al., 2014) and their ownership structure (Tsionas et al., 2012; Tsouknidis, 2019; Drobetz et al., 2019). However, to the best of our knowledge there has not been any study investigating empirically the relationship between the chartering policy and the financial performance of shipping firms. In this paper, we address this gap in the extant literature by utilizing the publicly available U.S. Securities and Exchange Commission (SEC) 20F filing forms, which are mandatory to be disclosed by all U.S. listed firms, to construct a unique and hand-collected dataset at the vessel-level. Specifically, we record the freight charter contract for 8,733 vessels owned by 27 U.S. listed shipping firms, listed in NYSE and NASDAQ, over the period 2010-2018.

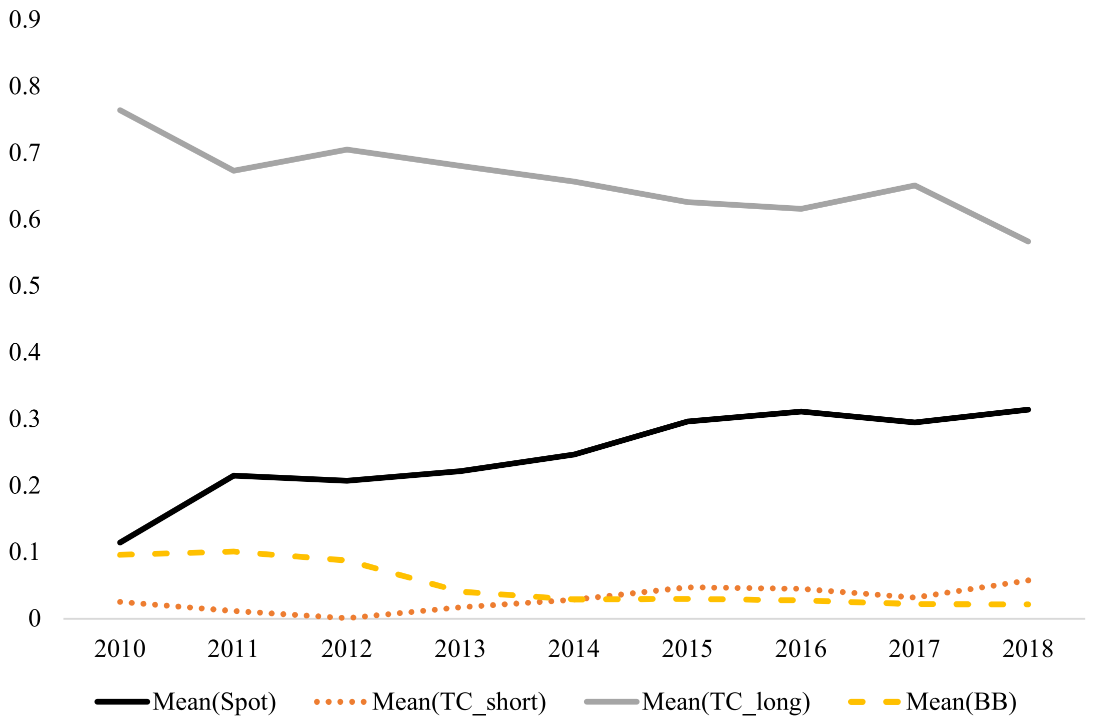
The investigation of the relationship between chartering policy and financial performance has important implications for various stakeholders in the shipping and financial markets such as shipowners, charterers, banks, and investors. For instance, shipowners might benefit by chartering their vessels under long-term contracts during a bearish market in order to avoid the deterioration of their freight rate revenue. At the same time, ship-lending banks may feel safer regarding the repayment of a shipping bank loan when the ship operator has secured a time-charter contract at an attractive freight rate for the financed vessel. Investors can assess the risk of the chartering policy of a shipping firm by looking into the chartering contracts signed by the owners.

The most striking result of this study is that pursuing a long-term time-chartering policy (over one year) has a positive effect on the financial performance of shipping firms on average, during the time period from 2010 to 2018. This result is important as it shows that adopting a less risky time charter, rather than a riskier voyage charter chartering policy, leads to better financial performance on average for a sample of U.S. listed shipping firms. This result may be attributed to an extent to the fact that the sample period examined is characterized mainly through a bearish freight rate market where supply of tonnage was on average higher than the demand of tonnage.[3]

Figure 1.1 shows that the U.S. listed shipping firms charter most of their vessels under long-term chartering contracts during the period 2010 to 2018; while Figure 1.2 shows that there is considerable variation over time regarding the chartering strategies followed within firms and across years. These patterns may be attributed to the effect of the pronounced shipping crisis that followed the global financial crisis after September 2008. Thus, it may be argued that during this turbulent period, shipping firms chose "safety" by "locking" into stable freight revenue for long time periods by chartering their vessels under long-term time-charter contracts. This more conservative chartering policy is a way of hedging against the excess freight rate volatility and uncertainty prevailing in the shipping market.

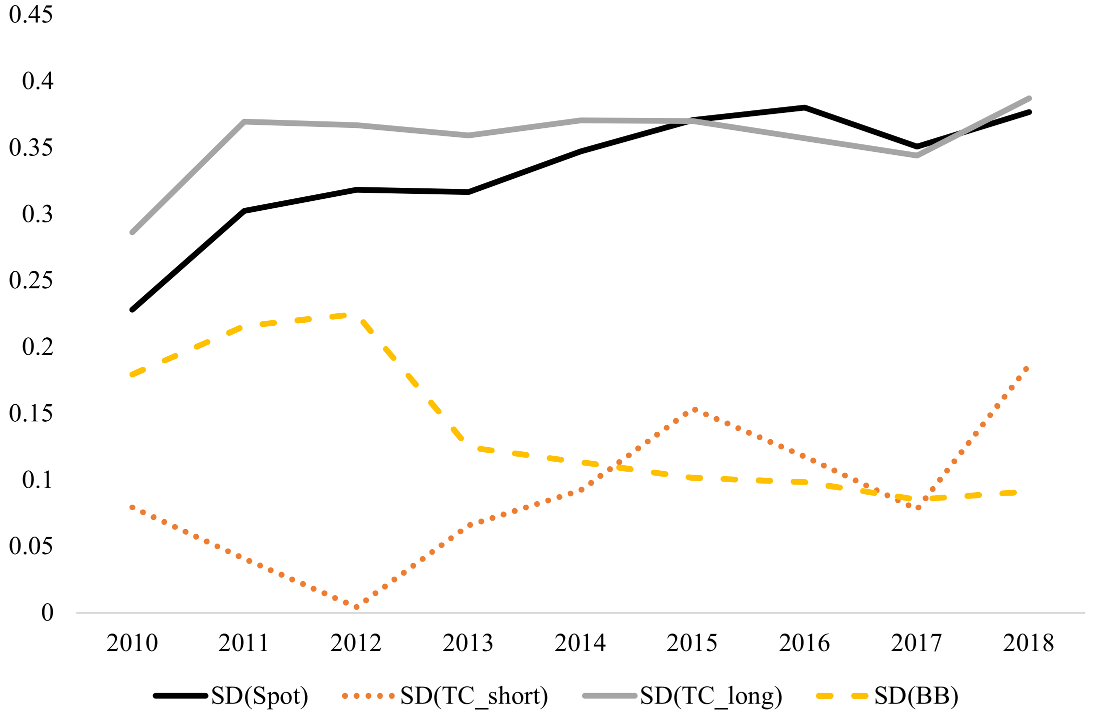
[3] An alternative way to stabilize freight revenue is the use of freight derivatives, such as Forward Freight Agreements and Freight Options (Kavussanos and Visvikis, 2006). However, information through the SEC 20F forms on the use of such products is limited and non-consistent across the U.S. listed shipping firms. Having incorporated such information in the analysis of this paper might have weakened the strength of the reported results. For a thorough discussion of this issue, see Adland and Jia (2017) and Adland and Alizadeh (2018).

Figure 1:1 Mean ratios for the four chartering policies examined within firms and across years: Sample period 2010 - 2018



Note: This figure shows the mean values of the ratios measuring the four chartering policies examined in this paper at the firm-level, i.e. *spot, tc_short, tc_long* and *bb,* over the period 2010 to 2018. *Spot* is the ratio of the vessels' deadweight tonnage chartered under spot chartering strategy over the fleet's total deadweight tonnage. *Tc_short* is the ratio of the vessels' deadweight tonnage chartered under time-charter contracts with duration less than one year over fleet's total deadweight tonnage. *Tc_long* is the ratio of the vessels' deadweight tonnage chartered under time-charter contracts with duration of one or more years over the fleet's total deadweight tonnage. *Bb* is the ratio of the vessels' deadweight tonnage chartered under bareboat chartering contracts over the fleet's total deadweight tonnage.

Figure 1:2 Standard Deviations (SD) of the ratios of the four chartering policies examined within firms and across years: Sample period 2010 - 2018



Note: This figure shows the standard deviations of the ratios measuring the four chartering policies examined in this paper at the firm-level, i.e. *spot, tc_short, tc_long* and *bb,* over the period 2010 to 2018. See also notes in Figure 1.1

The rest of this paper is organized as follows. Section 1.2 discusses the extant literature and develops the research hypotheses examined. Section 1.3 outlines the methodology adopted and dataset, while Section 1.4 describes the empirical results of the study and section 1.5 provides the ensuing discussion. Finally, Section 1.6 concludes the paper.

1.2 Literature review and research hypotheses:

1.2.1 The risk-return relationship in financial and shipping markets

The relationship between risk and return is a well investigated issue in the general finance literature (Conrad and Plotkin, 1968; Fiegenbaum, 1990; Xing and Howe, 2003). A large part of the extant literature on this issue builds on the mean-variance framework and develops formal asset pricing models such as the Capital Asset Pricing Model (CAPM) (Sharpe, 1964; Mossin, 1966) building on the idea that an investor will require an expected return proportional to the beta (systematic risk) of an asset. A number of studies have been devoted on investigating the validity of asset pricing models in the shipping industry. Kavussanos and Marcoulis (1997a) and Kavussanos et al. (2003) estimate the CAPM on shipping stocks and report lower betas than the market average. In a similar setting, Grammenos and Marcoulis (1996) adopt the methodology of Fama and McBeth and report overall low betas for shipping stocks. More recently, Drobetz et al. (2016) find evidence for high levels of systematic risk in shipping stocks when compared with benchmark sectors of the average firm in the S&P 500 index, which match the fundamental risk characteristics of the industry, i.e. high financial and operating leverage. Financial theory suggests that higher systematic risk leads to higher expected returns and this relation usually leads to lower returns for riskier investments in bear markets.

Apart from the aforementioned studies which explore the validity of specific asset pricing models utilizing firm-level data for listed shipping companies, the risk-return relationship in the shipping finance literature has received considerable attention, as shipowners often face multi-million-dollar decisions that relate to chartering, operation and sale and purchase of vessels. These decisions are considerably risky given the fact that shipping freight rates exhibit a number of stylized facts, such as their pronounced cyclicality (Stopford, 2008), distinct seasonality (Kavussanos and Alizadeh, 2001) and excess volatility (Kavussanos, 1996), which is characterized by pronounced volatility spillovers (Tsouknidis, 2016).[4] However, the traditional mean-variance analysis has not always proven able to explain the risk-return relationship in shipping freight markets (Makrominas, 2018). For

[4] For a full review of the stylized facts of shipping freight rates and relevant discussion, see Alexandridis et al. (2018).

instance, Theodossiou et al. (2020) reveal the existence of a positive skewness premium in shipping freight rates, suggesting that on average shipping investors are willing to accept lower expected returns for the opportunity to earn high pay-offs in the future. Based on the discussion above we develop the following testable hypothesis:

Hypothesis 1: *Ceteris paribus and during bear markets, operating a higher percentage of the fleet under a time charter rather than a voyage charter contract leads to higher return and vice versa.*

1.2.2 Chartering policy as firms' capability

Choosing the optimal mix of freight charter contracts for a fleet of vessels may also be viewed as a shipping firm's capability based on the resource-based-view (RBV) theory. Specifically, the RBV theory argues that even though resources are available to all firms, each firm utilizes resources in a different manner (Ethiraj et al., 2005). In this context, the concept of "chartering capabilities" may be viewed as a measure of the "unique" ability of a shipping firm to charter its vessels efficiently. Capabilities are conceived as the efficiency with which a firm employs a given set of resources (inputs) at its disposal to achieve certain objectives (outputs) (Dutta et al., 2005). In our context, shipping firms deploy assets and capital expenditure to achieve higher revenues. The shipping firm's resources may be measured by the firm's assets (vessels) and capital expenditures. Following this rationale, the ability of firm to efficiently deploy its resources (total assets) in the charter market may be viewed as the shipping firm's chartering capability, which is eventually reflected upon its financial performance.

Our measure of chartering capabilities is based on the RBV theory supporting that "the type, magnitude and nature of a firm's resources and capabilities are important determinants of its profitability" (Amit and Schoemaker, 1993). Thus, shipping firms which use their resources (total assets) more efficiently (capital expenditures), will be characterized as being more capable in achieving higher revenue (output). This view is supported by Grant (1991) and Teece et al. (1997) who explain that capabilities are useful because they use resources in a way that helps firms to perform better than others. Fawcett et al. (1997) argue that a firm may gain competitive advantage if it can consistently differentiate its activities from the competitors. Essentially, to differentiate themselves, firms need to improve competencies and capabilities that will eventually enhance their financial performance. Capabilities allow firms to perform value-creating tasks effectively and are rooted in everyday organizational processes and routines that are not imitable (Grewal and Slotegraaf, 2007) and are considered to be determinants of competitive advantage (Day, 1994). Based on the discussion above we develop the following testable hypothesis:

Hypothesis 2: *Ceteris paribus, the higher the shipping firms' chartering capabilities, the higher the financial performance of shipping firms and vice versa.*

1.3 Methodology

The dataset examined in this paper consists of both time series and cross-sectional observations, forming an unbalanced panel dataset. Thus, we rely on panel data estimators, which take into account the possibility of unobserved heterogeneity among the firms included in the sample. Eq. (1.1) describes a generic panel data model that allows for fixed (firm-specific and time-specific) and random effects. The following generic panel data regression model is used to investigate the relationship between firm performance and chartering policy of U.S. listed shipping firms:

$$y_{it} = a_i + \alpha_t + \sum_{k=1}^{K} \beta_k z_{kit} + \gamma Log(Clarksea)_t + u_i + \varepsilon_{it} \, ; \qquad (1.1)$$

$$\varepsilon_{it} \sim i.i.d.(0, \sigma_\varepsilon^2), E(u_i) = 0, E(u_i^2) = \sigma_u^2, E(\varepsilon_{it} u_j) = 0, for \ \forall \ i,t,j; E(u_i u_j) = 0, for \ i \neq j$$

where y_{it} denotes firm performance as measured by firm's return on assets (*ROA*); *i*=1, 2,…, n identifies the firm; t=1, 2,…,T denotes the time period (year); a_i and α_t are constant terms, which allow for the possibility of (constant) heterogeneous behavior between the firms (a_i) and over time periods (α_t), respectively; β_k measures the effect that the k^{th} explanatory variable has on *ROA*; z_{kit} is a matrix of *K* variables which are firm-specific; γ measures the effect on *ROA* of the natural logarithm of the freight rates index *Clarksea,* which is industry-specific; u_i stands for the between-firms errors and is introduced in the model in order to allow for the possibility that firm-specific constant terms are randomly distributed across individual firms and ε_{it} is a white noise error term and stands for the within-firm errors following a distribution with mean zero and variance σ_ε^2. A consequence of the above is that both the u_i and ε_{it} are orthogonal with the regressors in the model; that is, $E(u_{it} z_{kit}) = 0$ and $E(\varepsilon_{it} z_{kit}) = 0$.

The Hausman (1978) test statistic can be used to select between fixed-effects and random-effects specifications by testing the null hypothesis that H_0: $E(u_{it}z_{kit}) = 0$ vs. H_1: $E(u_{it}z_{kit}) \neq 0$. The null hypothesis (H_0) of the Hausman test is that the random effects model is not rejected, while if H_0 is rejected then the fixed effects model is appropriate. In order to mitigate to an extent the effect of possible endogeneity among the variables used in the estimation, i.e. reverse causality between our dependent and independent variables, we include time constant fixed effects and a set of control variables (on this see, Roberts and Whited (2013) and Coles et al. (2012). Kavussanos and Tsouknidis (2016; 2014) provide a full exposition of a panel data regression framework. All variables entering Eq. (1.1), along with their precise definitions and sources, are presented next and summarized in Table 1.1.

1.3.1 Measuring chartering policy

In order to measure the chartering policy (*CP)* we first classify vessel charter contracts (j) into four categories: (i) voyage agreements (*spot)*, (ii) time-charter agreements with a maturity of less than one year (*tc_short)*, (iii) time-charter agreements with a maturity equal to or longer than one year (*tc_long)* and (iv) bareboat agreements (*bb)*. Then, for each firm and year combination in the sample we compute the following measures of chartering policy:

$$Spot_{it} = \frac{\sum_{j=1}^{J} DWT_{spot}}{\sum_{j=1}^{J} DWT_{TTL}}$$

$$TC\_short_{it} = \frac{\sum_{j=1}^{J} DWT_{TC < 1\, year}}{\sum_{j=1}^{J} DWT_{TTL}}$$

Eq. (1.2)

$$TC\_long_{it} = \frac{\sum_{j=1}^{J} DWT_{TC \geq 1\, year}}{\sum_{j=1}^{J} DWT_{TTL}}$$

$$BB_{it} = \frac{\sum_{j=1}^{J} DWT_{BB}}{\sum_{j=1}^{J} DWT_{TTL}}$$

Where, $j=1,\ldots, J$ denotes the vessel charter contract, $i=1, \ldots, n$ identifies the firm, and $t=1,\ldots,T$ represents the time period (year). DWT_{Spot}, $DWT_{TC < 1\ year}$, $DWT_{TC \geq 1\ year}$, DWT_{BB}, are the dead-weight tonnage of the vessels chartered under the four different chartering strategies, i.e. *Spot*, *TC_short*, *TC_long* and *BB*, respectively. DWT_{TTL} is the total deadweight tonnage of the fleet for each shipping firm for each year. In the panel data regression models estimated later in the paper we include the following four variables of chartering policy (one at a time): *spot, tc_short, tc_long* and *bb.*

1.3.2 Measuring chartering capabilities through Data Envelopment Analysis (DEA)

As discussed earlier in the paper, chartering capabilities may be viewed as the abilities of the shipping firm to charter its inputs (total assets and capital expenditures) generating revenue as output. The ability of a decision-making unit (*DMU*), i.e., a firm, to convert its inputs into outputs is widely measured using the mathematical programming method Data Envelopment Analysis (*DEA*). *DEA* has been extensively used for measuring operational and marketing capabilities. For example, Nath et al. (2010) used a sample of 186 logistics retailers in the UK and measured their marketing and operational capabilities using DEA with tangible assets as input and cost of sales as output. Similarly, Ahmed et al. (2014) used *DEA* to measure marketing and operational capabilities of 532 firms in 166 industries using fixed assets as input and revenue as output. According to Thanassoulis (1993) *DEA* is not affected by multicollinearity issues among the input-output variables used for its estimation.

In this paper, we apply DEA analysis to measure the chartering capabilities of shipping firms as the following fractional programming problem:

$$\max h_X = \frac{\sum_{r=1}^{s} Ur\, Yrk}{\sum_{i=1}^{m} Vi\, Xik} = \frac{U_1 Y_{1_k} + U_2 Y_k + \cdots + U_S Y_{S_k}}{V_1 X_{1_k} + V_2 X_k + \cdots + V_m X_k} \quad (1.3)$$

$$\text{Subject to} \quad \frac{\sum_{r=1}^{s} Ur\, Yrj}{\sum_{i=1}^{m} Vi\, Xij} \leq 1 \ (j=1,.., n)$$

$$V_1, V_2, \ldots, V_i \geq 0$$

$$U_1, U_2, \ldots, U_r \geq 0.$$

In Eq. (1.2) the weights V_i and U_r are estimated in a way to maximize the h_X ratio of the specific Decision-Making Unit DMU_k (firm). The constraints, which are equal to the number of firms, allow the weights to only take values between 0 and 1, while at least one value must be higher than zero. The process of estimating Eq. (1.2) is the following: for a Decision-Making Unit (DMU_k) select a set of weights (V_i, U_r) to maximize efficiency. Then, the same weights are used to the rest of the firms to calculate their efficiency. All firms must always have at least one positive value as input and output no missing values are allowed.[5] Out of this process, all firms are classified as efficient (value of 1) or inefficient (any other value).

In our setting, we use the following variables as inputs: (i) total assets (*TA*) (ii) capital expenditure (*CAPEX*) and output: (iii) Revenue. *TA* is the sum of fixed assets, current assets and other non-current assets; *CAPEX* is the amount spent for the construction of new vessels and expenditures ensuring that vessels comply with international regulatory standards.[6] *REVENUE* measures how efficiently a shipping firm utilized its resources. The *DEA* process yields the variable Chartering Capabilities (*CC*) for each firm and year combination examined. All the results of DEA are included in Table A.1.1 and A1.2 of Appendix I.

1.3.3 Control variables

Several studies in the general finance literature (for example, Brammer and Millington (2008) and Wintoki et al. (2012) and in the shipping finance literature i.e., Drobetz et al. (2019, 2013a) and Tsouknidis (2019) suggest that firm's financial performance may be associated with a number of other characteristics, rather than the ones of primary interest in each study and use a number of control variables to account for these characteristics. Therefore, in line with the extant literature on the determinants of firm's financial performance, we are guided by prior research and economic rationale to include the following control variables in Eq. (1) in order to account for the possibility that they can influence firm performance simultaneously with the chartering policy of the shipping firm. (1) The

[5] In mathematics, we can refer to this semi-positive assumption as: $x_j \geq 0$, $y_j \geq 0$, $x_j \neq 0$, $y_j \neq 0$ j=1,…,n.

[6] Total assets and capital expenditure have also been used in DEA applications in the shipping markets by Panayides et al., (2011) and Bang et al., (2012).

chartering capabilities *(CC)* measure the ability of the firm to transform inputs into outputs in an efficient way. (2) The natural logarithm of the average age of the vessels (fleet) of each firm measured in years *(Log(Agev))*, is used to capture whether vessels' average age exerts an effect on firm's financial performance. (3) The natural logarithm of the average size of the vessels (fleet) measured in dead-weight-tonnage *(Log(Avdwt))*, is used to capture whether vessels' average size exerts an effect on firm's financial performance. (4) The natural logarithm of the age of the firm measured in years *(Log(Agef))*, is included to capture whether older firms exhibit better performance as a result of their more experienced management. The founding date of each firm examined is collected through its official website and cross-checked through its publicly disclosed financial statements in NYSE or NASDAQ stock exchanges. (5) The leverage ratio *(Lev)*, defined as the firm's long-term debt over total assets. This control variable is included as higher levels of debt are typically associated with higher financial performance (Jensen, 1986). (6) The operating leverage ratio *(OpLev)* measured as the operating expenses of the firm over the book value of its assets. Higher levels of operating leverage may be associated with higher financial performance in an industry with high operational risk such as the shipping industry. (7) The natural logarithm of the market value of equity expressed in $ millions *(Log(MVE))*; as increased market value of equity may be associated with higher firm performance (Buzzell and Gale, 1975). (8) The ratio of market-to-book value *(MVBV),* defined as the market value of equity over the book value of assets, often used as a measure of firm's growth opportunities. A higher MVBV ratio implies that investors expect management to create more value from a given set of assets, thus affecting *ROA* positively. (9) The natural logarithm of the ClarkSea freight rates index *Log(ClarkSea),* defined as the weighted average index of vessel earnings measured in $/day in the main sectors of commercial vessels, weighted by the fleet size of the respective vessel type. This variable accounts for the fact that shipping firms might exhibit better performance as a result of high prevailing freight rates. The Shipping Intelligence Network (SIN) of Clarksons (2021) computes vessel earnings used to construct the Clarksea index as the net total revenue for each route using daily freight rates minus: (i) bunker costs, computed as the average bunker price across several representative regional bunker ports, (ii) port fees, adjusted for different currency exchange quotations and total commissions due to the port operator. The result is divided by the number of voyage days, to provide the earnings per day for each vessel type. This calculation is adopted by Clarksons SIN in order to orthogonalize freight rates to possible changes on bunker fuel cost and / or operating costs that may affect the nominal freight rate the ship earns. More details of the calculations freight rates and their constituent parameters and assumptions are set out in Annexes 1 – 4 of the Clarksons (2021) "Sources & Methods for the Shipping Intelligence Weekly". (10) The volatility of the Clarksea freight rates index (*VolClarkSea),* defined as the annualized volatility (standard deviation) of the ClarkSea's monthly changes using a one-year rolling window. Higher volatility of freight rates may be associated with higher firm performance. (11) The volatility of the stock returns (*Retstd),* defined as the annualized volatility (standard deviation) of the firms' weekly stock returns using a one-year rolling window. Higher volatility of stock returns is generally associated with higher firm performance (Wintoki et al., 2012).

1.3.4 Data Description

The initial sample of U.S. listed shipping firms includes 49 firms constructed by multiple sources, such as Thomson Reuters Eikon, Lloyds List and Bloomberg. However, out of this population of U.S. listed shipping companies, sample firms were selected based on the following criteria: (i) generating the majority (over 60%) of their income from shipping transportation activities based on information retrieved from their websites (ii) having available data to construct the chartering policy variable through their publicly available SEC 20-F forms and (iii) having available data to collect the control variables through Compustat, Thomson Reuters Eikon and Worldscope databases. The initial population of U.S. Listed shipping firms we utilize and the criteria we apply to select our sample follow earlier studies, such as Kavussanos and Tsouknidis (2014), Drobetz et al. (2016) and (Tsouknidis, 2019). All firms have a standard industrial code (SIC) of 4400 (Water Transportation) or the sub-code 4410/4412 (Deep Sea Foreign Transportation of Freight). The SIC 4400 is a parent directory and has the following description (URL accessed on 18th August 2020, https://siccode.com/sic-code/44/water-transportation): "This major group includes establishments engaged in freight and passenger transportation on the open seas or inland waters, and establishments furnishing such incidental services as lighterage, towing, and canal operation. This major group also includes excursion boats, sight-seeing boats, and water taxis.", while the SIC 4412 is a sub-directory and has the following description (URL accessed on 18th August 2020, https://siccode.com/sic-code/4412/deep-sea-foreign-transportation-freight): “Establishments primarily engaged in operating vessels for the transportation of freight on the deep seas between the United States and foreign ports. Establishments operating vessels for the transportation of freight which travel to foreign ports and also to non-contiguous territories are classified in this industry.” After applying these restrictions, the surviving sample was reduced to 27 listed shipping firms in NYSE and NASDAQ stock exchanges.[7,8] Data collected comprise annual observations over a nine-year time period 2010 to 2018, for a total of 243 firm-year observations.[9] However, due to the existence of missing values for some of the variables entering the panel data regressions presented later in the paper, the final number of observations entering each specification may be lower than the initial sample of 243 firm-year observations. Each firm–year combination uniquely determines observations and firms are allowed to enter or exit this unbalanced panel data set. Since we use yearly data, we do not capture changes in chartering policy within a year. Furthermore, we do not include Contracts of Affreightment (COA’s) in our analysis as they are limited in the sample of vessels examined.

Table 1.1 lists and describes all variables used in this paper and their sources. *ROA* is the dependent variable, defined as the ratio of operating income before depreciation and provisions over total assets.[10] The main independent variable of interest is the chartering policy (*CP*). To construct the chartering policy (CP) variable, we record the type of charter contract for each vessel/firm/year, over the period 2010 to 2018, for a total of 8,733 vessel-year observations which are later aggregated to 243 firm-year observations as discussed earlier in the paper. Wherever possible, we fill-in gaps in the data and validate already collected data through the 20-F forms, by reading the financial statements disclosed in the websites of the shipping firms. We use the central index key (CIK) to match the firm-level aggregated data with financial data from the Compustat, Thomson Reuters Eikon and

[7] The full list of shipping firms examined in this study may be found in Table A1.3 of the Appendix II.
[8] For dry-bulk shipping companies an alternative to a “normal” fixed-rate time charter contract may be an index-linked time charter based on the average freight rate assessments of the 5TC routes published by the Baltic Exchange. This type of contract is effectively the equivalent of operating in the spot (voyage) market. Only three dry-bulk shipping companies report vessels operating under such chartering contracts. Therefore, we exclude these vessels from our analysis to preserve the purity of “normal” time-charter contracts.
[9] Prior to 2010 there is scarce availability of data to construct the chartering policy variable as the number of firms drops to one-digit numbers.
[10] We use *ROA* as the dependent variable and market-to-book ratio (Tobin’s Q) as a control variable throughout the paper, as the latter forms a proxy for growth opportunities (Tsouknidis, 2019).

Worldscope databases. CIK is a ten-digit numeric identifier given to an individual, company, or foreign government by the United States Securities and Exchange Commission. We use CIK to identify firms' filings across databases including EDGAR.

Table 1-1: List of the variables used in Equations (1.1) and (1.2)

Type of variable	Description	Source (item)
Dependent	*ROA*: is the ratio of operating income before depreciation and provisions (oibdp) divided by total assets (at).	Compustat (oibdp/at)
Independent	*Chartering Policy (CP)* is measured by the following four variables for each firm and year in the sample: *Spot:* is the total deadweight tonnage of ships chartered under spot (voyage) chartering contracts over the fleet's total deadweight tonnage. *Tc_short:* is the total deadweight tonnage of ships chartered under time chartering contracts with duration less than one year over the fleet's total deadweight tonnage. *Tc_long:* is the total deadweight tonnage of ships chartered under time chartering contracts with duration equal/over one year over the fleet's total deadweight tonnage. *BB:* is the total deadweight tonnage of ships chartered under bareboat chartering contracts over the fleet's total deadweight tonnage.	SEC 20F Form
	CC measures the ability of a shipping firm to charter its vessels in the chartering market by exploiting its resources (ships). It is computed through the DEA using the variables: Total assets *(TA)*, Capital expenditure (*CAPEX*) and *REVENUE*.	Compustat (at) Compustat (capx) Compustat (sale)
Controls	*Log(Agev)* is the natural logarithm of the average age of the fleet measured in years.	SEC 20F Form
	Log(Avdwt) is the natural logarithm of the average size of the fleete measured in deadweight tonnage (dwt).	SEC 20F Form
	Log(Agef) is the natural logarithm of the years since the firm has been founded. The founding date of each firm is obtained through its official website and cross-checked through its publicly disclosed financial statements.	SEC 20F Form and websites of firms and stock exchanges
	Lev is the ratio of the firm's long-term debt (dltt) over total assets (at).	Compustat (dltt/at)
	OpLev is the ratio of operating expenses total (WC01249) over total assets (at)	Worldscope and Compustat (at)
	Log(MVE) is the natural logarithm of the market value of equity (mkvalt).	Compustat (mkvalt)
	MVBV is the ratio of market to book value, computed as market value of equity (mkvalt) divided by book value of common equity (ceq).	Compustat (mkvalt/ceq)
	Log(ClarkSea): The weighted average index of earnings in the main sectors of commercial vessels, weighted by fleet size of the respective vessel type.	Clarksons SIN
	Vol(ClarkSea) is the annualized volatility (standard deviation) of the ClarkSea's last twelve monthly returns with a rolling window of one year.	Clarksons SIN

	Retstd is the annualized volatility (standard deviation) of the firms' last 52 weekly stock returns (RI) with a rolling window of one year.	Thomson Reuters Eikon

Note: This table lists the variables used to estimate Equation (1.1) and (1.2) along with their short description. The column "Source (Item)" presents the source of each variable and the specific database item(s) in the parentheses. RI is the return index of the stock price.

Table 1.2 provides descriptive statistics for the variables examined in this paper. The mean value of the dependent variable *ROA* is equal to 6.50%; while its standard deviation is equal to 11.34%, exhibiting enough variation over the firms and period examined. *Spot* and *tc_long* ratios exhibit the highest mean values across the four ratios measuring chartering policies (the other two being *tc_short* and *bb*), which are equal to 0.25 and 0.66, respectively; while their standard deviations show that they exhibit enough variation over the firms and years examined equal to 0.34 and 0.36, respectively. Total assets (*TA*), capital expenditure (*Capex*) and *Revenue* have mean and standard deviation of 1899.37, 200.87, 298.97 and 1783.01, 305.30 339.80 respectively. average veesels' age (*Agev*) is 8.54 years with average deadweight (*Avdwt*) to be 105,970 tons. Firm age (*agef*) is 12.86 years. Leverage mean is 50.54%. mean and standard deviation of *oplev* is 13.78% and 7.73% respectively. Mean value of market value of equity *MVE* is $817.06 mn. *MVBV* mean is 1.01. *Clarksea* index has an average value of $11.815 per day. It also has a high standard deviation of $1979.55. volatility of clarksea index (*volclarksea*) and share price (*retsd*) are 0.36 and 2.24% respectively. .The statistics of the control variables mentioned above are of similar magnitude to the ones reported by earlier studies using U.S. listed shipping firms, such as for example, Kavussanos and Tsouknidis (2014) and Tsouknidis (2019). The Shapiro and Wilk (1965) test statistic rejects the null hypothesis that a variable follows the normal distribution across the variables examined. Next, Table 1.3 presents the Pearson correlations' matrix table across the variables entering Eq. (1). As observed, the pair-wise correlations do not exhibit high values, for example over 0.6, indicating that multicollinearity is not present across the independent variables used.

Table 1-2: Descriptive statistics for the variables entering Equations (1) and (2): Sample period 2010 to 2018

Variable	Mean	Median	Standard Deviation	Min	Max	Skewness	Kurtosis	S&W Test [p-value]
ROA (%)	6.50	6.67	11.34	-114.75	99.96	-2.63	76.03	10.66 [0.000]
Spot ratio	0.25	0.05	0.34	0.00	1.00	1.15	2.88	6.57 [0.000]
TC_short ratio	0.03	0.00	0.10	0.00	0.79	4.50	24.91	9.45[0.000]
TC_long ratio	0.66	0.80	0.36	0.00	1.00	-0.64	1.94	5.48 [0.000]
BB ratio	0.05	0.00	0.15	0.00	1.00	3.84	18.64	9.65 [0.000]
CC	0.51	0.46	0.26	0.03	1.00	0.48	2.17	4.50 [0.000]
TA ($mln)	1899.37	1286.94	1783.01	3.26	10,371.76	1.82	7.51	7.80 [0.000]
Capex ($mln)	200.87	95.56	305.30	0.00	2,299.90	3.01	15.17	9.51 [0.000]
Revenue ($mln)	298.97	197.25	339.80	2.01	3,518.58	4.73	39.58	9.58 [0.000]
Agev (years)	8.54	8.41	3.91	1.00	25.00	0.70	4.37	3.95 [0.000]
Avdwt (dwt)	105,970	92,309	59,263	9,140	312,105	1.07	4.01	6.03 [0.000]
Agef (years)	12.86	10	9.88	1.00	46.00	1.73	5.47	8.24 [0.000]
Lev (%)	50.54	50.33	17.06	0.00	93.08	0.69	3.11	3.27 [0.000]
OpLev (%)	13.78	11.99	7.73	2.00	49.92	1.88	7.92	7.63 [0.000]
MVE ($ mln.)	817.06	457.64	1652.99	0.52	17,596.03	6.74	58.60	10.75 [0.000]
MVBV ratio	1.01	0.68	1.78	0.00	24.43	10.49	135.55	10.95 [0.000]
ClarkSea ($/day)	11,815.31	11,742.89	1,979.55	9,440.66	15,491.31	0.57	2.17	5.64 [0.000]
VolClarksea	0.36	0.37	0.06	0.26	0.47	0.16	2.33	3.79 [0.000]
Retstd (%)	2.24	0.74	2.74	0.00	10.47	1.31	3.45	8.67 [0.000]

Note: Descriptive statistics for the variables entering Equations (1.1) and (1.2): Sample period 2010 to 2018

Table 1-3: Pearson correlation matrix (Chapter 1)

Variables	ROA	CC	Agev	Avdwt	Agef	Lev	OpLev	MVE	MVBV	ClarkSea	VolClarkSea	Retstd
ROA	1.0000											
CC	0.1561*	1.0000										
Agev	-0.0783	0.2493*	1.0000									
Avdwt	0.1088	-0.0413	-0.0827	1.0000								
Agef	0.075	-0.0985	0.0937	0.1757*	1.0000							
Lev	0.2430*	0.0014	-0.0522	0.0048	0.2528*	1.0000						
OpLev	-0.2158*	0.3086*	0.1978*	0.1007	0.1361*	-0.1312*	1.0000					
MVE	0.2086*	-0.2233*	0.004	0.3787*	0.2301*	0.0435	-0.3243*	1.000				
MVBV	0.1022	0.118	0.1472*	0.0853	-0.0669	0.0816	-0.0261	0.2069*	1.000			
ClarkSea	0.0842	0.1916*	-0.0495	-0.0218	-0.1430*	0.0349	-0.1327*	0.1171	0.0736	1.000		
VolClarkSea	-0.1284	-0.2756*	0.0064	0.0293	0.2579*	-0.0542	0.08	-0.0064	-0.0615	-0.4959*	1.000	
Retstd	0.0724	0.0048	0.0511	-0.0424	0.0539	0.2311*	-0.086	-0.0395	-0.0035	0.0014	-0.0417	1.000

Note: This table presents the Pearson pair-wise linear correlations for all the variables included in Eq. (1.1). As a rule of thumb, no pair-wise correlation is higher than 0.6 indicating no multicollinearity issues. * denotes statistical significance at the 5% confidence level.

1.4 Empirical results

Table 1.4 reports the results of estimating Eq. (1) in four different model specifications M1 to M4. Each model specification includes one out of the four chartering policy variables as discussed earlier in the paper, i.e. *spot*, *tc_short*, *tc_long* and *bb*. The Hausman (1978) test favors a fixed effects over a random effects model and for this reason we include firm, shipping segment and time fixed effects in all four specifications. The values of the Adjusted R^2 ranges between 59.76% and 68.86%, indicating that the independent variables included in the model explain a high proportion of the variance observed in the variable financial performance (*ROA*). The Variance Inflation Factor (VIF) values range between 1.34 and 1.42, suggesting no evidence of multicollinearity among the independent variables. VIF coefficients for each explanatory variable are computed through the following formula: $VIF = \frac{1}{1-R_i^2}$, where R_i^2 is the coefficient of determination of an auxiliary regression in which the dependent variable is the independent variable under scrutiny for multicollinearity in the original equation, while the independent variables in this auxiliary regression are the rest of the independent variables of the original model (for details see Gujarati and Porter, 2008). As a rule of thumb, variables with VIF values greater than 10 indicate high collinearity, i.e. that the variable could be considered as a linear combination of other independent variables.

The most striking result across M1 to M4 is that short-term chartering policies, i.e. *spot* and *tc_short*, exhibit negative and statistically significant coefficients, i.e. -1.028 (t-stat = -1.95) and -2.090 (t-stat = -2.81), respectively. Furthermore, the variable *tc_long* has a positive and highly statistically significant coefficient of 1.217 (t-stat = 3.29), suggesting a positive relationship between a long-term time-chartering strategy and financial performance. *Spot* is statistically significant in 10% confidence interval and *tc_short* and *tc_long* are statistically significant in 1% confidence interval. These results confirm Hypothesis 1 and show that long-term chartering contracts, i.e., time charter contracts with time horizon of more than one year, enhance firms' financial performance. However, this result is not presented for bareboat chartering as the coefficient is not statistically significant at any reasonable significance level. Bareboat chartering typically refers to an even larger time-horizon rather than the typical long-term chartering agreements of 1 to 5 years maximum. Overall, these results reveal that a longer-term chartering strategy leads to higher financial performance during bear shipping freight rate markets.

Next, the variable chartering capabilities *(CC)*, exhibits a positive and statistically significant coefficient at the 5% significance level across M1 to M4 specifications. This result supports Hypothesis 2 stating that the higher the chartering capabilities of a shipping firm, the higher will be its financial performance, ceteris paribus. Regarding the rest of the variables, *MVBV* is positive and highly significant at the 1% significance level in all M1 to M4 model specifications, which is in line with evidence in Drobetz et al. (2013) and Tsouknidis (2019). Next, the *Log(ClarkSea)* and *VolClarkSea* variables, capturing the state of the shipping freight rate market, are also positive and significant across all models estimated, suggesting a strong positive relationship between freight rates and shipping firms' financial performance, in line with conventional wisdom. The rest of the control variables do not exhibit statistical significance at any reasonable significance level. We next follow the testing procedure of Petersen (2009) and choose to compute clustered adjusted standard errors at the firm level across M1 to M4 (Table 1.5).

Table 1-4: Panel data regressions of the logarithm of firm financial performance Log (ROA) on chartering policy and controls

Variables	M1	M2	M3	M4	Standardized coefficients
Constant	-35.899* (-1.86)	-35.019* (-1.92)	-40.662** (-2.18)	-33.867* (-1.78)	-
Spot	-1.028* (-1.95)	-	-	-	-0.362
TC_short	-	-2.090*** (-2.81)	-	-	-0.246
TC_long	-	-	1.217*** (3.29)	-	0.448
BB	-	-	-	0.378 (0.38)	0.064
CC	1.913** (2.55)	1.747** (2.33)	1.811** (2.49)	1.917** (2.49)	-
Log(Avagev)	0.125 (0.50)	0.208 (0.66)	0.315 (1.18)	0.087 (0.21)	-
Log(Avdwt)	0.102 (0.21)	-0.019 (-0.06)	0.230 (0.51)	-0.006 (-0.01)	-
Log(Agef)	0.082 (0.30)	-0.157 (-0.50)	-0.032 (-0.12)	0.028 (0.09)	-
Lev	-0.003 (-0.63)	-0.001 (-0.05)	0.001 (0.18)	-0.003 (-0.51)	-

OpLev	-0.036 (-0.85)	-0.034 (-1.00)	-0.032 (-0.85)	-0.043 (-1.04)	-
Log(MVE)	0.086 (0.97)	0.010 (0.09)	0.116 (1.26)	0.027 (0.23)	-
MVBV	0.142*** (5.09)	0.127*** (5.72)	0.127*** (4.96)	0.141*** (5.27)	-
Log(ClarkSea)	3.291* (1.89)	3.358** (2.12)	3.461** (2.13)	3.232* (1.89)	-
VolClarkSea	13.424** (2.45)	13.232** (2.50)	13.802*** (2.65)	12.204** (2.18)	-
Retstd	0.026 (1.30)	0.021 (1.19)	0.026 (1.35)	0.021 (1.12)	-
Observations (firm-year)	195	195	195	195	-
Adjusted R^2	59.88%	59.76%	61.64%	68.86%	-
F-stat **[p-value]**	19.89 [0.0000]	8.27 [0.0000]	13.44 [0.0000]	10.15 [0.0000]	-
Hausman Test (fe vs. re) **[p-value]**	51.38 [0.0000]	22.83 [0.0292]	25.83 [0.0184]	54.54 [0.0000]	-
Mean VIF	1.34	1.34	1.40	1.42	-
Firm fixed effects	Yes	Yes	Yes	Yes	-
Shipping segment fixed effects	Yes	Yes	Yes	Yes	-
Time fixed effects	Yes	Yes	Yes	Yes	-

Notes: This table presents the results of the estimated panel data regressions between firm performance (ROA), chartering policy (spot, tc_short, tc_long, bb) and control variables following the econometric model described in Eq (1.1). The coefficients of firm, shipping segment and time dummies are supressed. F-stat, tests the joint significance of the estimated coefficients. The Hausman (1978) test statistic is utilized in the fixed effects OLS estimates to select between the fixed and random-effects specifications. T-statistics and p-values are reported in (.) and [.], respectively. Statistical significance of the estimated coefficients is denoted with *, ** and *** for 10%, 5% and 1% significance levels, respectively. We follow the recommendations of Petersen (2009) and compute clustered adjusted standard errors at the firm level. As a rule of thumb, Mean VIF values below 10 indicate the absence of multicollinearity.

Table 1-5: Panel data regressions of the logarithm of firm financial performance Log (ROA) on chartering policy and controls using cluster adjusted standard errors.

Variables	M1	M2	M3	M4	Standardized coefficients
Constant	-1.0514 (-0.25)	1.3630 (0.35)	-4.7317 (-1.08)	1.0471 (0.21)	-
Spot	-1.1179 ** (-2.10)	-	-	-	-0.362
TC_short	-	-1.8681*** (-2.68)	-	-	-0.246
TC_long	-	-	1.2400 *** (2.82)	-	0.448
BB	-	-	-	0.3285 (0.37)	0.064
CC	1.6672**	1.5302 *	1.5788 **	1.6740 **	-

	(2.22)	(1.92)	(2.09)	(2.49)	
Observations (firm-year)	243	243	243	243	-
Adjusted R^2	60.39%	59.20%	61.94%	57.16%	-
F-stat [p-value]	8.34 [0.0000]	8.68 [0.0000]	7.27 [0.0000]	7.74 [0.0000]	-
Hausman Test (fe vs. re) [p-value]	51.38 [0.0000]	22.83 [0.0292]	25.83 [0.0184]	54.54 [0.0000]	-
Mean VIF	1.34	1.34	1.40	1.42	-
Firm fixed effects	Yes	Yes	Yes	Yes	-
Shipping segment fixed effects	Yes	Yes	Yes	Yes	-
Time fixed effects	Yes	Yes	Yes	Yes	-

Note: This table presents the results of the estimated panel data regressions between firm performance (ROA), chartering policy (spot, tc_short, tc_long, bb) and control variables following the econometric model described in Eq (1.1) and applying Petersen (2009) cluster adjusted standard errors. The coefficients of firm, shipping segment and time dummies are suppressed. F-stat, tests the joint significance of the estimated coefficients.

Finally, we estimate and report the standardized coefficients for the chartering policy variables of interest. These assess the relative importance of the 4 different chartering strategies on shipping firms' financial performance. Standardized coefficients are estimated by standardizing the variables *spot, tc_short*, *tc_long*, and *bb* to have mean of 0 and standard deviation of 1. The following formula is used: $b_i^* = b_j \frac{\sigma_{x_j}}{\sigma_y}$. b_j is the estimated coefficient, b_i^* is the standardized coefficient, and σ_{x_j} is the standard deviation of the i_{th} explanatory variable. σ_y is the standard deviation of the dependent variable (return on assets). The mean of each variable is subtracted from its values and then the result is divided by the standard deviation of each variable. Then a regression is estimated with the standardized values and the coefficients of the regression are the standardized coefficients. Therefore, this formula describes how many standard deviations the return on assets will change for one standard deviation change in the predictor variable. Specifically, the standardized coefficient of the variable *spot* takes the value of -0.362, for the *tc_short* takes the value of -0.246, for the *tc_long* takes the value of 0.448 and for the *BB* the value of 0.064. Therefore, the standardized coefficients estimated suggest that the *tc_long* variable is the most important one for determining financial performance in terms of relative importance, followed by the variable *spot*.

1.4.1 Robustness tests

In order to ensure that the results of this paper are free from choices in the estimation process we conduct the following robustness tests: (i) we measure the ratios for the four types of chartering policies (*Spot, TC_short, TC_long* and *BB*) using the number of vessels instead of the deadweight tonnage capacity (dwt) (Table 1.6). In order to measure the chartering policy (*CP)* we first classify vessel charter contracts (j) into four categories: (i) voyage agreements (*spot)*, (ii) time-charter agreements with a maturity of less than one year (*tc_short)*, (iii) time-charter agreements with a maturity equal to or longer than one year (*tc_long)* and (iv) bareboat agreements (*bb)*. Then, for each firm and year combination in the sample we compute the following measures of chartering policy:

$$Spot_{it} = \frac{\sum_{j=1}^{J} NoShips_{spot}}{\sum_{j=1}^{J} NoShips_{TTL}}$$

$$TC\_short_{it} = \frac{\sum_{j=1}^{J} NoShips_{TC\,<\,1\,year}}{\sum_{j=1}^{J} NoShips_{TTL}}$$

Eq. (1.4)

$$TC\_long_{it} = \frac{\sum_{j=1}^{J} NoShips_{TC\,\geq 1\,year}}{\sum_{j=1}^{J} NoShips_{TTL}}$$

$$BB_{it} = \frac{\sum_{j=1}^{J} NoShips_{BB}}{\sum_{j=1}^{J} NoShips_{TTL}}$$

Where, j=1,…, J denotes the vessel charter contract, i=1, …., n identifies the firm, and t=1,…..,T represents the time period (year). $NoShips_{spot}$, $NoShips_{TC<1\,year}$, $NoShips_{TC\,\geq\,1\,year}$, $NoShips_{BB}$, are the number of the vessels chartered under the four different chartering strategies, i.e. *Spot*, *TC_short*, *TC_long* and *BB*, respectively. $NoShips_{TTL}$is the total number of ships in the fleet for each shipping firm for each year. In the panel data regression models estimated later in the paper we include the following four variables of chartering policy (one at a time): *spot, tc_short, tc_long* and *bb*; (ii) we use the ClarkSea sectoral indices for dry-bulk (Table 1.7), tanker (Table 1.8) and LNG (Table 1.9) vessels instead of the aggregate ClarkSea index. *Earn_bulk* is the average bulk sector earnings, *earn_tankers* is the average tanker sector earnings and *earn-lng* is the average earnings for LNG ships; (iii) we omit the variable of chartering capabilities (cc) (Table 1.10); (iv) we include the average bunker prices across four benchmark ports, namely Singapore, Houston, Gibraltar and Rotterdam (Table 1.11); (v) In this test, we run the panel data regression using random effects model (Table 1.12). It seems that a fixed-effects model fits better the model compared to the random effects model. In all cases, the results obtained are qualitatively the same.

Table 1-6: Panel data regressions of the logarithm of firm financial performance Log (ROA) on chartering policy (per number of ships) and controls

Variables	M1	M2	M3	M4
Constant	-37.9789 * (-1.84)	-36.6390 * (-2.01)	-38.8246 ** (-2.08)	-34.5414 * (-1.83)
Spot_vessels	-0.7287 (-1.54)	-	-	-
TC_short_vessels	-	-2.2669 ** (-2.36)	-	-
TC_long_vessels	-	-	1.2772 *** (3.63)	-
BB_vessels	-	-	-	0.1753 (0.18)
CC	1.8921 ** (2.53)	1.7126 ** (2.29)	1.7285 ** (2.43)	1.9222 ** (2.51)
Log(Avagev)	0.1181 (0.44)	0.2064 (0.66)	0.3300 (1.26)	0.1116 (0.27)
Log(Avdwt)	-0.0336 (-0.07)	-0.0314 (-0.10)	0.0694 (0.16)	0.0330 (0.08)
Log(Agef)	0.0342 (0.12)	-0.1018 (-0.35)	-0.0415 (-0.15)	0.0244 (0.08)
Lev	-0.0027 (-0.44)	-0.0007 (-0.09)	0.0011 (0.17)	-0.0028 (-0.41)
OpLev	-0.0394 (-0.93)	-0.0350 (-1.02)	-0.0326 (-0.83)	-0.0437 (-1.05)
Log(MVE)	0.0821 (0.90)	0.0124 (0.12)	0.1376 (1.53)	0.0341 (0.28)
MVBV	0.1396 *** (5.01)	0.1278 *** (5.79)	0.1271 *** (4.92)	0.1387 *** (5.18)
Log(ClarkSea)	3.3597 * (1.92)	3.5422 ** (2.24)	3.4584 ** (2.11)	3.2469 * (1.91)
VolClarkSea	13.4191 ** (2.42)	3.5422 ** (2.24)	13.8848 ** (2.64)	12.0765 ** (2.17)

Retstd	0.0240 (1.18)	0.0225 (1.22)	0.0237 (1.21)	0.0219 (1.11)
Observations (firm-year)	195	195	195	195
Adjusted R^2	59.13%	60.18%	62.02%	57.23%
F-stat **[p-value]**	-	-	-	-
Hausman Test (fe vs. re)	48.81	49.65	64.52	62.80
[p-value]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
Mean VIF	9.43	9.07	9.43	9.28
Firm fixed effects	Yes	Yes	Yes	Yes
Shipping segment fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes

Note: This table presents the results of the estimated panel data regressions between firm performance (ROA), chartering policy (spot, tc_short, tc_long, bb) using number of ships instead of deadweight tonnage and control variables following the econometric model described in Eq (1.1). The coefficients of firm, shipping segment and time dummies are supressed. F-stat, tests the joint significance of the estimated coefficients. The Hausman (1978) test statistic is utilized in the fixed effects OLS estimates to select between the fixed and random-effects specifications. T-statistics and p-values are reported in (.) and [.], respectively. Statistical significance of the estimated coefficients is denoted with *, ** and *** for 10%, 5% and 1% significance levels, respectively. We follow the recommendations of Petersen (2009) and compute clustered adjusted standard errors at the firm level. As a rule of thumb, Mean VIF values below 10 indicate the absence of multicollinearity.

Table 1-7: Panel data regressions of the logarithm of firm financial performance Log (ROA) on chartering policy and controls using bulkers' earnings instead of clarksea index

Variables	M1	M2	M3	M4
Constant	-32.6115 (-1.56)	-31.6146 (-1.59)	-38.4318 * (-1.88)	-30.1701 (-1.48)
Spot_vessels	-1.1179 ** (-2.37)	-	-	-
TC_short_vessels	-	-1.8681 ** (-2.66)	-	-
TC_long_vessels	-	-	1.2400 *** (3.36)	-
BB_vessels	-	-	-	0.3285 (0.36)
Earn_bulkers	2.6647 ** (1.62)	2.7124 ** (1.79)	2.9019 ** (1.88)	2.5809 ** (1.63)
Observations (firm-year)	195	195	195	195
Firm fixed effects	Yes	Yes	Yes	Yes
Shipping segment fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes

Note: This table presents the results of the estimated panel data regressions between firm performance (ROA), chartering policy (spot, tc_short, tc_long, bb) using number of ships instead of deadweight tonnage and control variables following the econometric model described in Eq (1.1) and replacing clarksea index with earn_bulkers.

Table 1-8: Panel data regressions of the logarithm of firm financial performance Log (ROA) on chartering policy and controls using tankers' earnings instead of clarksea index

Variables	M1	M2	M3	M4
Constant	-461.2113 (-1.62)	-467.8949 * (-1.77)	-505.1789 * (-1.88)	-445.2882 (-1.62)
Spot_vessels	-1.1179 ** (-2.37)	-	-	-
TC_short_vessels	-	-1.8681 ** (-2.66)	-	-
TC_long_vessels	-	-	1.2400 *** (3.36)	-
BB_vessels	-	-	-	0.3286 (0.36)
Earn_tankers	2.6647 (1.62)	2.7124 * (1.79)	2.9019 * (1.88)	2.5809 ** (1.63)
Observations (firm-year)	195	195	195	195
Firm fixed effects	Yes	Yes	Yes	Yes
Shipping segment fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes

Note: This table presents the results of the estimated panel data regressions between firm performance (ROA), chartering policy (spot, tc_short, tc_long, bb) using number of ships instead of deadweight tonnage and control variables following the econometric model described in Eq (1.1). Clarksea index is replaced with earn_tankers.

Table 1-9: Panel data regressions of the logarithm of firm financial performance Log (ROA) on chartering policy and controls using lng' earnings instead of clarksea index

Variables	M1	M2	M3	M4
Constant	-61.2183 (-1.60)	-60.7340 (-1.77)	-69.5847 * (-1.89)	-57.8770 (-1.56)
Spot_vessels	-1.1179 ** (-2.37)	-	-	-
TC_short_vessels	-	-1.8681 ** (-2.66)	-	-
TC_long_vessels	-	-	1.2400 *** (3.36)	-
BB_vessels	-	-	-	0.3286 (0.36)
Earn_lng	2.6647 (1.62)	2.7124 * (1.79)	2.9019 * (1.88)	2.5809 ** (1.63)
Observations (firm-year)	195	195	195	195
Firm fixed effects	Yes	Yes	Yes	Yes
Shipping segment fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes

Note: This table presents the results of the estimated panel data regressions between firm performance (ROA), chartering policy (spot, tc_short, tc_long, bb) using number of ships instead of deadweight tonnage and control variables following the econometric model described in Eq (1.1). Clarksea index is replaced with earn_lng.

Table 1-10: Panel data regressions of the logarithm of firm financial performance Log (ROA) on chartering policy and controls omitting *CC*

Variables	M1	M2	M3	M4
Constant	12.5604 (0.77)	3.6206 (0.25)	4.5300 (0.31)	14.6479 (0.88)
Spot	-1.0332 * (-1.72)	-	-	-
TC_short	-	-1.6604 (-1.56)	-	-
TC_long	-	-	1.3174 *** (3.03)	-
BB	-	-	-	0.3582 (0.72)
Log(Avagev)	0.1315 (0.47)	0.0697 (0.60)	0.3358 (1.15)	0.0962 (0.82)
Log(Avdwt)	-0.0118 (-0.02)	0.0910 (0.64)	0.1382 (0.25)	-0.1183 (-0.21)
Log(Agef)	-0.2207 (-0.57)	-0.0364 (-0.33)	-0.3233 (-0.87)	-0.2763 (-0.63)
Lev	-0.0018 (-0.28)	0.0153 *** (4.89)	0.0034 (0.53)	-0.0014 (-0.20)
OpLev	-0.0060 (-0.14)	-0.0314 (-1.61)	-0.0025 (-0.07)	-0.0124 (-0.32)
Log(MVE)	0.1276 (1.19)	0.0832 * (1.71)	0.1611 (1.51)	0.0697 (0.53)
MVBV	0.1219 *** (4.38)	0.0001 (0.01)	0.1076 *** (4.08)	0.1198 *** (4.30)
Log(ClarkSea)	-1.0510 (-0.68)	-0.3065 (-0.22)	-0.6131 (-0.46)	-1.1172 (0.72)
VolClarkSea	-1.3559 (-0.30)	-2.1387 (-0.48)	0.0169 (0.00)	-2.6248 (-0.53)
Retstd	0.0195 (0.85)	-0.0062 (-0.31)	0.0203 (0.97)	0.0147 (0.67)
Observations (firm-year)	195	195	195	195
Adjusted R^2	52.88%	26.72%	55.40%	50.25%
Mean VIF	8.74	5.90	8.69	8.88
Firm fixed effects	Yes	No	Yes	Yes
Shipping segment fixed effects	Yes	No	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes

Note: Notes: This table presents the results of the estimated panel data regressions between firm performance (ROA), chartering policy (spot, tc_short, tc_long, bb) and control variables following the econometric model described in Eq (1.1). The coefficients of firm, shipping segment and time dummies are supressed. F-stat, tests the joint significance of the estimated coefficients. The Hausman (1978) test statistic is utilized in the fixed effects OLS estimates to select between the fixed and random-effects specifications. T-statistics and p-values are reported in (.) and [.], respectively. Statistical significance of the estimated coefficients is denoted with *, ** and *** for 10%, 5% and 1% significance levels, respectively. This table shows the results of the regressions for the 4 models omitting chartering capabilities.

Table 1-11: Panel data regressions of the logarithm of firm financial performance Log (ROA) on chartering policy and controls

Variables	M1	M2	M3	M4
Constant	-0.5201 (-0.09)	1.9471 (-2.01)	-3.6978 (-0.67)	1.1962 * (0.17)
Spot_vessels	-1.0287 ** (-2.05)	-	-	-
TC_short_vessels	-	-2.0902 *** (-3.00)	-	-
TC_long_vessels	-	-	1.2177 *** (3.15)	-
BB_vessels	-	-	-	0.3785 (0.36)

Note: This table shows the chartering strategies coefficients and significance for the 4 regression models including average bunker' prices.

Table 1-12: Panel data regressions of the logarithm of firm financial performance Log (ROA) on chartering policy and controls using random effects model

Variables	M1	M2	M3	M4
Constant	-2.4985 (-0.36)	-2.4781 (-0.35)	-4,4973 (-0.63)	0.0836 (0.01)
Spot	-0.6349 * (-1.89)	-	-	-
TC_short	-	-1.6387 ** (-2.15)	-	-
TC_long	-	-	0.6952 ** (2.30)	-
BB	-	-	-	0.2370 (0.33)
CC	0.9831 ** (2.49)	0.9143 ** (2.34)	0.8924 ** (2.25)	0.9896 ** (2.44)
Log(Avagev)	-0.0681 (-0.40)	-0.0146 (-0.08)	-0.0608 (0.37)	-0.0272 (-0.16)
Log(Avdwt)	0.7189 ** (2.39)	0.4676 (1.46)	0.6967 ** (2.51)	0.8120 * (1.83)
Log(Agef)	-0.0348 (-0.18)	-0.0817 (-0.39)	-0.0192 (-0.10)	-0.0460 (-0.24)
Lev	0.0151 ** (2.41)	0.0134 ** (1.98)	0.0183 *** (3.08)	0.0164 ** (2.49)
OpLev	-0.0402 ** (-2.51)	-0.0383 ** (-2.34)	-0.0408 *** (-2.64)	-0.0499 *** (3.23)
Log(MVE)	0.0722 (0.89)	0.0444 (0.51)	0.0668 (0.85)	0.0675 (0.82)
MVBV	-0.0013 (-0.03)	0.0187 (0.45)	-0.0111 (-0.28)	-0.0023 (-0.06)
Log(ClarkSea)	-0.4516 (-0.73)	-0.1493 (-0.24)	-0.2792 (-0.44)	-0.4835 (-0.77)
VolClarkSea	-1.5900	-1,2965	-1.7498	-1.7636

	(-0.90)	(-0.75)	(-0.99)	(-0.96)
Retstd	-0.0026	-0.0002	-0.0095	-0.0062
	(-0.08)	(-0.35)	(-0.63)	(-0.18)
Observations (firm-year)	195	195	195	195
Adjusted R^2	30.65%	29.57%	32.20%	29.60%

Note: Notes: This table presents the results of the estimated panel data regressions between firm performance (ROA), chartering policy (spot, tc_short, tc_long, bb) and control variables including random effects. T-statistics and p-values are reported in (.) and [.], respectively. Statistical significance of the estimated coefficients is denoted with *, ** and *** for 10%, 5% and 1% significance levels, respectively.

1.4.2 Further tests

Apart from the above robustness tests, we also identify the ships that are observed to be technically innovated in the sample and run the regression again to see which type of technical innovation and chartering contract can contribute to better financial performance. Innovation is defined in the general literature as the introduction of a new idea or product within the organization (Daft, 1978; Damanpour and Evan, 1984; Damanpour et al., 1989). Technical innovation is the introduction of a new product (Totterdell et al., 2002) and/or the modification of an existing product. Vessel-level data was collected through SEC 20F form and official webpages for constructing the variable innovation $(inndwtratio_{it})$ which is measured as a ratio (1) of the total deadweight of technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year (Eq. 1.5). Three types of innovation were identified and considered in the sample: ice class vessels, the eco-type vessels and ships' propulsion system type. *'ice class'* type ships 1A, 1B and 1C which are constructed according to Finnish-Swedish ice rules being capable of sailing on thick ice of 0.8mm, 0.6mm and 0.4mm respectively (DNV-GL, 2011). These vessels are specified by thick steel hull (to withstand the pressure of ice), stronger rudder, propeller and watertight bulkheads; heating fuel and ballast tanks and powerful engines (Riska, 2010; Liu and Kronbak, 2010; Solakivi et al., 2018). According to Greve (2003), '*propulsion'* is considered as innovation. Ship's propulsion is used to drive the ship's propelling shaft. Eco-type ships is a new generation of ships and are considered *'eco'* if is fuel efficient and create less pollution to the environment (Haider et al., 2013). Such type of ship offers less water resistance during sailing and less emissions in the environment (Ardmore Shipping, 2020). Eco-type ships are constructed for optimizing fuel efficiency

(Ardmore Shipping, 2020). Furthermore, according to Capital Product Partners (2020) eco-type vessels are new designs constructions which results in material bunker savings compared to older designs and bigger carrying capacity. “Such savings could result in a substantial reduction of bunker cost for charterers on a per unit basis” (Capital Product Partners, 2020).

$$inndwtratio_{it} = \frac{\sum_{f=1}^{F} Total\ deadweight\ of\ ships\ under\ innovation\ owned}{\sum_{f=1}^{F}\ Total\ deadweigh\ \ of\ ships\ owned\ in\ the\ fleet} \quad (1.5)$$

We run Hausman (1978) test to see which model we will follow. We use fixed effect model with time and fixed effects for *spot*, *tc_short* and *bb* but we use panel data regression with time-fixed effects for *tc_long*. Results show that a ship chartered under short-term time charter strategy and being technically innovated will have a positive impact on the financial performance of the shipping firm compared to the other chartering strategies. The interaction term *inndwtratio* with *tc_short* coefficient is statistically significant in 5% confidence interval with p-value equals to 0.045. We run the panel data regression for all models again using $inndwtratio_{it}$ as an interaction term as shown in Table 1.12. Probably, a ship chartered under a time charter strategy with less than one year duration and being technically innovated is a preferable ship to the charterers for transporting cargo all around the world. Any ship with technical innovation on propulsion, eco-efficiency or ice class will probably be a choice for the charterers that is being reflected in higher financial performance for the shipping firm.

Table 1-13: Panel data regressions of the logarithm of firm financial performance Log (ROA) on chartering policy and controls using inndwtratio as an interaction term.

Variables	M1	M2	M3	M4
Constant	-36.9053 ** (-1.93)	-28.5812 (-1.29)	-27.9709 (-1.26)	-32.1603 (-1.69)
Spot	-1.1482 * (-1.97)			
TC_short		-2.3341 ** (-2.12)		
TC_long			0.1279 (0.39)	
BB				0.5223 (0.52)
Interaction term: inndwtratio	0.7328 (0.75)	14.8332 ** (2.10)	-1.7191 (-1.15)	02.0276 (-1.07)
inndwtratio	-0.2087 (-0.20)	-0.0619 (-0.17)	0.9850 (1.51)	0.7463 (0.67)

CC	1.9597 **	1.4901	1.5618 *	1.9501 **
	(2.54)	(1.59)	(1.94)	(2.46)
Log(Avagev)	0.1061	-0.1196	-0.1561	0.0356
	(0.41)	(-0.97)	(-1.36)	(0.09)
Log(Avdwt)	0.0279	0.0711	0.0528	-0.0819
	(0.05)	(0.36)	(0.27)	(-0.16)
Log(Agef)	0.1760	-0.0551	-0.0387	-0.0405
	(0.56)	(-0.54)	(-0.28)	(-0.13)
Lev	-0.0033	0.0111 ***	0.0118 ***	-0.0053
	(-0.68)	(3.54)	(3.26)	(-0.81)
OpLev	-0.0383	-0.0339	-0.0428	-0.0404
	(-0.92)	(-1.36)	(-1.43)	(-1.99)
Log(MVE)	0.0773	0.1436 ***	0.1635 ***	0.0137
	(0.77)	(2.31)	(3.06)	(0.11)
MVBV	0.1400 ***	-0.0019	0.0125	0.1453 ***
	(4.25)	(-0.11)	(0.62)	(4.45)
Log(ClarkSea)	3.4845 *	2.6941	2.6031	3.1978 *
	(1.93)	(1.31)	(1.24)	(1.84)
VolClarkSea	13.4066 **	9.1578	9.6588	11.8335 *
	(2.50)	(1.19)	(1.35)	(2.02)
Retstd	0.0293	0.0015	0.0022	0.0276
	(1.32)	(0.10)	(0.12)	(1.29)
Observations (firm-year)	189	189	189	189
Adjusted R^2	60.43%	35.53%	32.69 %	58.04%
Firm fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes

Notes: This table presents the results of the estimated panel data regressions between firm performance (ROA), chartering policy (spot, tc_short, tc_long, bb) and control variables including technical innovation following the econometric model described in Eq (1.1). The coefficients of firm, shipping segment and time dummies are supressed. F-stat, tests the joint significance of the estimated coefficients. The Hausman (1978) test statistic is utilized in the fixed effects OLS estimates to select between the fixed and random-effects specifications. T-statistics and p-values are reported in (.) and [.], respectively. Statistical significance of the estimated coefficients is denoted with *, ** and *** for 10%, 5% and 1% significance levels, respectively.

1.5 Discussion of the results

The results of this study have important implications regarding the operating decisions of shipping companies, especially during periods of low freight rates and tight liquidity. Furthermore, the results may be attributed to certain possible explanations. The great uncertainty induced in the shipping freight market after the peak of the global financial crisis in September 2008, may have resulted into increasing the level of risk aversion among shipowners and charterers. This effect might have been exacerbated further, if one considers the inherent characteristics of the shipping markets, such as their highly leveraged capital structure, enabled by borrowing large amounts of capital mainly through banks and shipping bond issues. The ongoing financial crisis after 2007 affected the shipping industry as well since it is a well-known fact that the shipping cycle follows the world economic cycle, activity in the cargo sea transportation fell too much due to the oversupply of tonnage resulting in the low freight market conditions. Another important development in the global economy, affecting directly the shipping markets, was the pronounced increase of oil price after 2010 and drop after 2014, which translated into very high bunker price volatility. By chartering a vessel in the spot market, the shipowner is exposed to bunker costs, while under a time-charter agreement these costs are the responsibility of the charterer. Probably, shipowners made these conservative decisions for avoiding the market uncertainty, the risk of firm's collapse and to ensure future stability of earnings.

The results reported in this study also have several important implications for the financing of shipping investments**.** The results reveal that a chartering policy of the shipping firm that desires to charter its vessels signing longer period time-charter contracts results in higher financial performance during a period of low freight rates. This strategy can be also thought of as a minimization of losses (costs) strategy. In other words, operating a higher percentage of the fleet under time chartering seems to be an efficient way of maximizing financial performance in bear freight markets. Furthermore, the results reveal that firms with higher chartering capabilities can achieve higher financial performance. This can be explained by the fact that shipping companies that are listed on stock exchanges are large and reputable, thus employing highly skilled personnel among other chartering capabilities attributes. Being capable of studying the market and make decisions at the right time can have a positive impact on the financial performance of the U.S. listed shipping firms.

Chartering capability also exhibits a positive effect on shipping firms' financial performance. Theoretically, the positive effect shows that some of the shipping companies board of directors may have higher shipping knowledge and chartering capability for chartering the shipping firm's fleet as efficiently as possible thus, achieving higher financial performance. However, there are shipping companies that practically prefer chartering their ships either in the spot market or in the time charter market. This can be explained by the fact that such type of shipping firms probably has their trustworthy clients, and this may make them feel secure that either voyage or time charter they will charter their ships following the specific chartering policy. Moreover, it would be clearer if we know what type of cargo these shipping firms choose to transport as each cargo and shipping segment follows its own business cycle.

1.6 Conclusion

1.6.1 Major findings

The contributions of this paper to the literature (Kavussanos and Alizadeh, 2002; Tsouknidis, 2019; Adland, Roar; Cullinane, 2005; Adland and Cullinane, 2005; Adland and Jia, 2008) are the following: First, it investigates empirically for the first time the relationship between the chartering policy and the financial performance of U.S. listed shipping firms. Previous studies mentioned before relating to the term structure of freight contracts, freight rate premiums and determinants of financial performance. Second, it examines a unique and hand-collected vessel-level dataset constructed by public sources complemented by financial data from standard sources. The results of this study reveal a robust positive relationship between the time length of the chartering contracts, under which the vessels operate, and the financial performance of U.S. listed shipping companies, during the period 2010 to 2018. This period is characterized by relatively low freight rates, tight liquidity and increased uncertainty in the shipping freight markets.

1.6.2 Limitations and further study

One major limitation is the small sample of investigation however the full sample could not be increased more as there are missing information for the chartering policy for many firms. Also, another reason of the small sample size is the restrictions explained before that we apply for conducting this study. Although the sample is small, qualitative inferences were reached contributing to the existing literature. Further study may be done in the chartering policy for each specific ship in the different shipping segments of the industry using private data for long-time horizon. Additionally, it would be interesting to assess the relationship between chartering policy and financial performance of U.S. Listed shipping firms considering the Covid-19 pandemic and the recent Ukraine crisis. By using event study, important inferences may be drawn for this relationship. Lastly, as many shipping firms were gone under crash risk after the world financial crisis of May 2008, for instance Scorpio tankers share price was around 120$ on 2010 and in 3 years’ time fall around 40$, then is of outmost importance to investigate the relationship between chartering policy and shipping firms' crash risk.

1.6.3 Practical implications

These results stimulate the interest of shipowners and portfolio managers in terms of allocating and managing funds in the shipping industry, according to the chartering strategy adopted and the chartering capabilities developed by shipping firms. It has been shown that pursuing a long-term chartering strategy with duration more than a year shipowners and shipping investors can achieve higher financial performance. Shipowners can charter more of their fleet under time chartering contracts with duration more than a year and as a result higher financial performance can be achieved during bearish shipping markets. Shipping investors should invest in shipping companies that have higher proportion of their fleet time chartered with duration more a year. Time chartering allow shipowners not to paying the bunkers costs and to stabilize the firm's cash inflows for long time period. Furthermore, shipping banks can realize that shipping firms that prefer chartering their ships under time charter with duration more than a year, they stabilize their earnings thus being capable to repay the loan settlements in the long-term.

Chapter 2 The relationship between technical innovation and financial performance: The case of U.S. and Oslo listed shipping firms

2.1 Introduction

Innovation is defined in the general literature as the introduction of a new idea or product within the organization (Daft, 1978; Damanpour and Evan, 1984; Damanpour et al., 1989). Shipping is characterized by on-going innovation epitomized by the introduction and diffusion of new ideas and investment in new technologies. For example, shipping digitalization i.e., PortCDM (Haraldson, 2015; Michaelides et al., 2019) and autonomous ships (Ahvenjärvi, 2017) are some of the most important types of innovation that will shape the future. Apart from these, innovations can be identified in vessels innovative services such as ice class type ships, propulsion, and fuel efficiency. One of the most technologically innovated ship is HMM Algeciras which was built in 2020 able to carry 23,964 TEUs (Hound, 2020). The ship offers innovation services such as optimized hull design and a highly efficient engine that gives a better propulsion during the voyage in the sea.

Damanpour (1991) mentions that innovation can be classified into administrative and technical innovations. Technical innovation is the introduction of a new product (Totterdell et al., 2002) and/or the modification of an existing product. Technical innovations are noticed on ships in the shipping industry which are for example, an ice class type ship which can navigate through ice; an eco-ship which has technical characteristics such as fuel-efficient engine or more efficient hull than inefficient ships resulting in less fuel consumption and reduced bunkers' costs for transporting cargo. Such type of technical innovations provides a better and more qualitative ship's service to the charterers for sea transportation. Shipowner, as a decision-maker faces the dilemma of investing in technically innovated ships or optimize an existing fleet (Haider et al., 2013) with the ultimate aim to increase profitability. Such a dilemma entails some portion of risk because the shipowner should sacrifice a huge capital investment now for a future exchange of ship's technical innovation expecting to achieve competitive advantage and higher financial performance. However, this investment cannot ensure profits to the shipowner since the state of the economy and shipping freight markets are totally uncertain, volatile and unpredictable (Notteboom and Lam, 2014; Ishizaka et al., 2018; Lim et al., 2019; Tsouknidis, 2016). Investment in ships with technical innovations may be financially profitable (Bigliardi, 2013; Damanpour and Evan, 1984, Simpson et al., 2006) or a failure (Jenssen and Randøy, 2006; Schilling and Hill, 1998a, Simpson et al., 2006). Successful ship's technical innovations will be reflected in the shipping firm's financial performance when charterers are willing to pay higher freight rate for chartering such types of ships. According to Clarksons (2021), earnings for eco-ships and non-eco ships differ and this feature makes our research even more interesting. For example, eco-ships earn slightly higher earnings than non-eco ships (Clarksons, 2021), \$58643/day and \$52681/day respectively for Suezmax tankers.

A large part of the firm's sales is generated from new or newly improved products (Schilling and Hill, 1998b) i.e., a shipping firm invests in a new technically innovated vessel, which in turn create competitive advantage (Schumpeterian et al., 1982a;Laursen and Salter, 2006) and economic growth (Geroski and Machin, 1992). In the general academic literature, it has been found that innovation positively affects firm performance (Bierly and Chakrabarti, 2009; Thornhill, 2006; Weerawardena et al., 2006; Damanpour and Evan, 1984). Research on innovation and financial performance has not received much attention in the shipping finance literature. Greve (2003) shows that an innovation launch is begun when shipbuilding firms are noticed to have low performance. Jenssen and Randøy (2006) investigates the relationship between innovation and business performance in the shipping industry using interview questionnaires for Norwegian firms. Authors, found a positive relationship between business performance and innovation. Panayides (2006) points out the effect of innovativeness on logistics service providers' performance mentioning that innovativeness also increases performance. More recently, research related to innovation has also been undertaken by Haider et al. (2013) and Adland et al. (2017) on eco-ships and fuel-efficiency respectively. Despite there are many studies in innovation in the shipping industry, there is not an empirical investigation of the relationship between ship's technical innovation and financial performance. To fill this gap in the literature, this study uses a sample of 21 listed shipping firms (dry, tankers and container shipping firms) for evaluating if a technically innovated fleet can create financial value for the shipping firm. Firm level data was downloaded from thomson reuters and vessel level data was gathered from SEC 20F filings from SEC (securities and exchange commission) for the U.S firms whereas data for Oslo listed firms from firms' webpages.[11]

This research contributes to the existing literature in two ways: First, the results show that technically innovated ships create financial value for listed shipping firms because charterers are eager to charter this type of ships with a freight rate premium. Increasing the deadweight tonnage of the shipping firms' technically innovated fleet leads to higher financial performance during the sample period which is observed with low freight rates and tight liquidity. This may be attributed to the shipowners' attitude towards 'risk taking', namely, shipowners invest in technically innovated ships for negotiating better chartering agreements during bearish economic conditions. This result is in line with other authors that support that during low performance market (bearish market), managers are more prone to take risks with the expectation to increase financial performance (Kahneman and Tversky, 1979; Bromiley, 2017, 1991).

Secondly, utilizing a unique data set including firm- and vessel-level data for U.S. and Oslo listed shipping firms, we reveal that eco-innovated ships are a significant determinant of listed shipping firms' financial performance compared to the propulsion and ice-class innovation types. During market economic crisis, many companies decide to go 'green', for example, shipping firms in our sample invest in eco-innovated ships for increasing their financial performance and provide a chartered eco-type vessel to their clients. In the academic literature, many authors support that 'green' activities have a positive impact on financial performance (Przychodzen and Przychodzen, 2015; Lee and Min, 2015). Green management might best be defined as the act of a corporation to perform environmentally conscious practices (Dwyer et al., 2009). This can be attributed to the notion of firms to embrace corporate social responsibility in which green activities plays a key role (Dwyer and Lamond, 2008; Lamond, 2007) for gaining competitive advantage with the protection of natural resources (Dwyer and Lamond, 2008) and increasing financial performance (Margolis et al., 2007; Pava and Krausz, 1996; Preston and O'Bannon, 2016). The results of this study signify

[11] Securities and Exchange Commission (SEC) is an independent agency of U.S. aiming to protect investors, securities markets and proper allocation of capital. Part of our shipping companies' data is collected from SEC whereas the remaining, Oslo listed shipping firms' data is collected from firm's webpages.

important implications for shipping companies and bankers. Practically, results can assist shipowners to realize if an investment in a technically innovated ship worth during bearish shipping markets. Bankers can also understand that technically innovated ships can attract higher chartering freight rates thus, a collateralized innovated ship is safer.

The rest of this paper is organized as follows. Section 2.2 discusses the extant literature and develops the research hypotheses examined. Section 2.3 outlines the dataset adopted, while Section 2.4 describes the methodology and Section 2.5 explains the empirical results of the study. Section 2. provides the ensuing discussion. Finally, Section 2.7 concludes the paper.

2.2 Literature review

In the following text, literature review on shipping innovation, energy efficiency and ice-class type ships are developed.

2.2.1 Shipping innovation

At the micro-economic environment, financial performance of shipping firms have many determinants such as leverage (Drobetz et al., 2013a), CEO duality (Syriopoulos and Tsatsaronis, 2012), corporate social responsibility (Drobetz et al., 2013b), ownership, firm's size (Merika et al., 2015) among others. However, in the shipping finance literature has not been investigated yet whether ship's technical innovation can create financial value for the shipping firm. For example, a fuel-efficient ship is a type of technical innovation. It has been found by (Adland et al., 2017a) that during bearish shipping market conditions fuel-efficient ships receive a freight premium to be chartered whereas in normal and boom market conditions not. Jenssen and Randøy (2002) were the first to explore whether organizational and inter-organizational variables promote innovation in the shipping industry by using the methodology of interviews. Authors collect 63 interviews from Norwegian shipping companies and show that a strategy for new products/services directly affect the actual service/product innovation in the shipping industry. Extending their study in 2002, Jenssen and Randøy (2006) identify a positive relationship between innovation and firm performance in the shipping industry after interviewing 46 Norwegian shipping firms. Even though they reach significant results, their study is limited only in Norway and lacks sample's time variation. Similarly, other authors support the view that firms engage in innovation should expect higher financial performance (Bierly and Chakrabarti, 2009; Brown and Eisenhardt, 1995; Caves and Ghemawat, 1992; Damanpour, 1991). Therefore, if a charterer commits to pay a freight premium to the owner for chartering a technically innovated ship, then, we suppose that financial value can be created for the shipping firm increasing shipping firm's financial performance. Recent research in shipping innovation show that diversifying the fleet into LNG carriers result in better financial performance and operational efficiency (Lim and Lim, 2020). Authors use a sample of 34 LNG companies from 1986 to 2017 with data downloaded from Clarksons shipping intelligence.

2.2.2 Energy efficient ships

Kollamthodi et al. (2008) support the view that fuel-efficient ships receive higher freight rates by the charterers for a specific fixture. One example of fuel-efficient ships are eco-ships which "incorporate many of the latest technological improvements, such as electronically controlled engines, more efficient hull forms matched with energy efficient propellers, and decreased water resistance" (Ardmore Shipping, 2020). This type of ships is considered technically innovated (Haider et al., 2013) and can also achieve propulsion efficiency by using efficient and technology advanced propeller. Haider et al. (2013) investigate the existence of a two-tier market for eco-ships. Using structure questionnaires, they interview different representatives of the shipping industry i.e a shipowner, a shipbroker, a charterer and a class society surveyor. Results show that fuel efficiency matters during low performance market conditions compared to high freight earnings market conditions and; a two-tier market was created by the on-going shipping crisis after May 2008 including two market segments: fuel efficient and inefficient vessels. The authors also stress out the importance of fuel oil, explaining that higher fuel oil price will obviously drive to a two-tier market.

Adland et al. (2017) assess empirically whether there exists a freight rate premium for energy-efficient dry bulk ships using a sample of 9136-time charter fixtures for bulk carriers above 40,000 dwt between January 2001 and January 2016.[12] Results show that the

[12] Dwt is the deadweight tonnage of a ship

willingness of charterers to pay for energy efficient ships vary according to the shipping freight cycle. During 2008-2012 fuel efficient vessels attract a freight rate premium whereas, fuel saving is reflected in higher TC rates for Panamax and Capesize vessels for normal freight market conditions other than 2003-2008 period. Agnolucci et al. (2014) investigate the extent to which fuel savings related to energy efficient ships are captured by the shipowners through higher charter rates resulting that some of the financial savings accrue to shipowners. Adland et al. (2018) investigate the impact of periodic hull cleaning on oil tankers' energy efficiency using real fleet performance and weather data from 2012 to 2016. Drydocking hull cleaning has been found to contribute to less fuel consumption compared to underwater hull cleaning. Furthermore, quality has been investigated as a determinant of freight rates (Köhn and Thanopoulou, 2011; Tamvakis and Thanopoulou, 2000; Tamvakis and Thanopoulou, 2000). Results show no statistical significance between older and younger vessels. Even though many studies exist for capturing freight rate premiums, no study has linked fleet's technical innovation with shipping firm's financial performance at the micro level.

2.2.3 Ice class ships

Literature review on ice-class type ships has not received much attention by the academics. Ice-class type ships trade in the Arctic ocean which has attracted the research of academics the last 10 years due to the on-going ice melting and global warming conditions (Theocharis et al., 2018; Lasserre, 2014). Baltic sea area, Estonia, Norway and Finland countries for example, are characterized by harsh environmental conditions i.e. low temperature and salinity. Löptien and Axell (2014) describes that the property of ice can be described by ice concentration, thickness and ridge density which shows year-to-year variations (Comiso, 2012). Bad weather conditions such as darkness, ice concentration, fog and size of waves (Solesvik and Borch, 2015) require the use of ice class type ships. Anecdotal evidence considers ice class ships innovated because of their capability to navigate on ice transporting oil products, iron ore, coal and gas (Humpert, 2014). These vessels are specified by thick steel hull (to withstand the pressure of ice), stronger rudder, propeller and watertight bulkheads; heating fuel and ballast tanks and powerful engines (Riska, 2010; Liu and Kronbak, 2010; Solakivi et al., 2018). These specifications make their capital and fuel consumption costs higher than an open water ship (Solakivi et al., 2018; Bourbonnais and Lasserre, 2015; Erikstad and Ehlers, 2012).

Including in a shipping firm's fleet ice class type ships can offer competitive advantage for the firm in the market because these ships are few in a global level servicing specific shipping routes (IMO, 2020). Due to their rare existence and unique innovative service, ice class ships differentiate its services from other ships creating commercial advantage for the shipping firm. Trading the ice class ships in the arctic ocean, shipping firm's revenue may be positively affected in the long term. While the arctic ocean is described by unpredictability, bad weather and sailing conditions (Solesvik and Borch, 2015), these characteristics can deteriorate the ship voyage thus, these technical innovated ships assist in safer navigation.

2.2.4 Research theory and hypotheses development

Performance is considered as an important indicator of a business' success if it contributes to better firm's financial situation and competitive advantage (Zhu et al., 2016). Many studies have proven the relationship between innovation and business performance (Deshpandé et al., 1993; Bayus et al., 2003; Cohen and Levinthal, 1989; Kostopoulos et al., 2011). Innovation is risky and expensive at the same time (Simpson et al., 2006). Being risky for a firm's economic conditions, it means that both negative and positive consequences may arise after an innovation launch. Many authors have proved the existence of a positive relationship between innovation and performance (Bierly and Chakrabarti, 2009; Brown and Eisenhardt, 1995; Caves and Ghemawat, 1992; Damanpour, 1991; Damanpour et al., 1989; Damanpour and Evan, 1984; Schulz and Jobe, 2001; Thornhill, 2006). Furthermore, Jenssen and Randøy (2002) identified a positive relationship between innovation and firm performance in the shipping industry. Ship's technical innovation offers services such as easy and efficient navigation through ice, fuel-efficiency for the charterer who may wish to charter a ship under a time charter (bunkers cost is the responsibility of charterer), eco-friendly activities i.e., Therefore, such a type of ship has more possibilities to attract higher freight rates than a non-technically innovated ship.

Therefore, we form the following hypothesis:

Hypothesis 1: *Ceteris paribus, the higher the total deadweight tonnage of technically innovated ships in the fleet, the higher the financial performance of the shipping firm.*

Based on our sample, we observe three types of technical innovation in the SEC 20F filings for U.S. listed shipping firms and in the webpages for Oslo listed shipping firms: eco-type, propulsion and ice class type ships. Among these three, eco-type ships are noticed to offer more technical characteristics compared to ice-class and propulsion types of innovation. For example, eco-ships are fuel efficient ships that "incorporate many of the latest technological improvements, such as electronically controlled engines, more efficient hull forms matched with energy efficient propellers, and decreased water resistance" (Ardmore Shipping, 2020).[13] This type of ships is considered technically innovated (Haider et al., 2013) and can also achieve propulsion efficiency by using efficient and technology advanced propeller. Haider et al. (2013) report that eco-type ships offer fuel efficiency that matters during low performance market conditions compared to boom periods of the shipping cycle. Eco-type ships are new designs constructions that "have improved propulsion efficiency and decreased water resistance (Ardmore Shipping, 2020) which results in material bunker savings compared to older designs and bigger carrying capacity. "Such savings could result in a substantial reduction of bunker cost for charterers on a per unit basis" (Capital Product Partners, 2020). Furthermore, Pyxis Tankers (2020) state that eco-type ships consume less bunkers than older vessels thus, this type of ships is more desirable for the charterers. Haider et al. (2013) and Adland et al. (2017) explain that during peak times fuel efficient ships are not seen to receive any freight rate premium. In contrast, during normal and low market conditions, ship's fuel efficiency is priced higher than inefficient ships. In contrast, ice class type ships offer only one technical innovated service: navigating on ice conditions. However, despite their hull construction is thicker and engine is powerful compared to eco-type ships, they have high capital and fuel consumption costs (Solakivi et al., 2018; Bourbonnais and

[13] According to Clarksons (2021) earnings for eco-ships and non-eco ships differ and this feature makes our research even more interesting to investigate if technical innovation is related to higher financial performance. For example, eco-ships earn slightly higher earnings than non-eco ships according to Clarksons (2021), $58643/day and $52681/day respectively for Suezmax tankers. This small amount of revenue difference results in huge number of profits for a company that has many technically innovated ships in its fleet.

Lasserre, 2015; Erikstad and Ehlers, 2012). Furthermore, innovated propulsion ship types are observed to have innovated ship propulsion systems that consume low fuel during navigation however, they are not considered as eco-ships in their prospectuses.

Therefore, we form the following hypothesis:

Hypothesis 2: *Ceteris paribus, eco-type ships have a higher impact on shipping firms' financial performance than ice class and propulsion innovated ships during low freight shipping market conditions.*

2.3 Data and variables description

2.3.1 Sample of listed shipping firms

U.S. and Norwegian listed shipping firms from NYSE, Nasdaq and Oslo stock exchanges were chosen upon the following conditions: (i) at least their 60% of revenue should be generated from shipping transportation activities (ii) technical innovation ratio is constructed by having available data gathered from SEC 20F forms of U.S.[14] Securities and Exchange Commission (SEC) and Oslo listed shipping firms' webpages and finally (iii) downloading available data for each firm through thomson reuters. All U.S. listed shipping firms in the dataset have standard industrial code (SIC) of 4400 (water transportation) or the sub-code 4410/4412 (Deep Sea foreign transportation of freight). The SIC 4400 is a parent directory and is described as (URL accessed on 24th October 2020, https://siccode.com/sic-code/44/water-transportation): "This major group includes establishments engaged in freight and passenger transportation on the open seas or inland waters, and establishments furnishing such incidental services as lighterage, towing, and canal operation. This major group also includes excursion boats, sight-seeing boats, and water taxis.", while the SIC 4412 is a sub-directory and is described as (URL accessed on 24th October 2020, https://siccode.com/sic-code/4412/deep-sea-foreign-transportation-freight): "Establishments primarily engaged in operating vessels for the transportation of freight on the deep seas between the United States and foreign ports. Establishments operating vessels for the transportation of freight which travel to foreign ports and to non-contiguous territories are classified in this industry. Central index key (CIK) is used to match the U.S. listed shipping firms' data of each shipping firm

[14] These criteria are based upon previous studies such as (Tsouknidis, 2019) and (Drobetz et al., 2013a).

with the data in thomson reuters.[15] Oslo listed shipping firms' firm level data and thomson reuters data were matched with ticker.[16] Finally, these 21 firms (Table A1) are observed to own vessels that are technically innovated. The sample period covered in this study ranges between 2013 to 2019 to form an unbalanced panel data set.[17] A bearish shipping market is observed during this period with volatile freight rates in the market compared to the high freight earnings level prior to 2008 where the average ClarkSea index was (Figure 2.1):[18]

Figure 2:1 Weekly ClarkSea index $/day

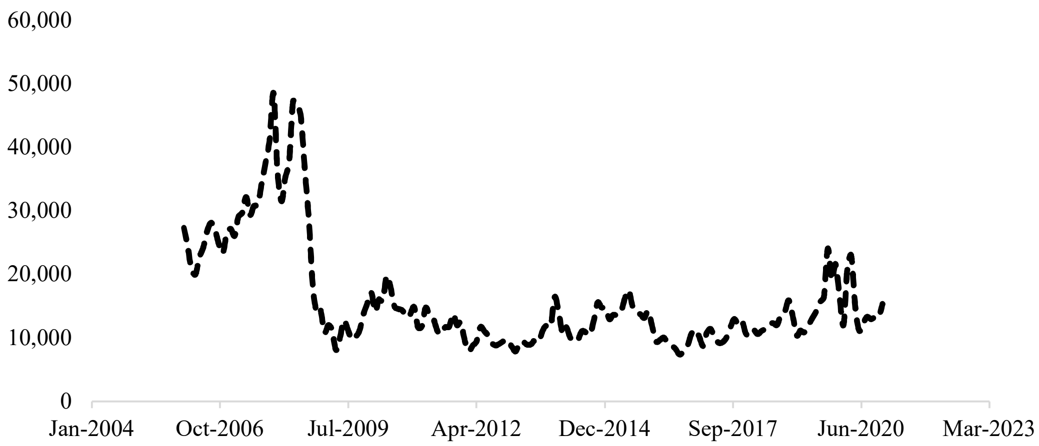


Figure 2.1: shows the average ClarkSea index from January 2006 to December 2020. ClarkSea index is the weighted average index of vessel earnings measured in $/day in the main sectors of commercial vessels, weighted by the fleet size of the respective vessel type.

[15] Central index key is the identifier of each U.S. listed shipping firm and is formed by ten-digit numbers provided for each shipping firm by Securities and exchange commission.

[16] Ticker is a multiple numeric or letter identifier for a shipping company listed in Oslo stock exchange. We use ticker to match the vessel level data of the listed Oslo shipping firm with the firm level data for each company in the Thomson reuters database.

[17] Panel data model allows firms to enter and exit the dataset. Our sample includes the maximum number of shipping firms available for investigating the relationship between technical innovation and financial performance in the shipping industry. Research on technical innovation in shipping firms was undertaken in the stock exchanges of U.S., Oslo, Hong Kong, London and Singapore reaching the final sample of 21 shipping firms forming a panel data period of seven years. Thus, the sample cannot increase more due to data unavailability. The small sample is a major limitation of the study however, important results can be extracted from the specific research. Other similar study which includes low number of shipping firms in its sample is Panayides et al. (2011).

[18] Bearish market is defined as the market which is observed by price declines at least 20% decline of shares' prices.

The sample used in this study contains 4122 total annual observations for dry and wet ships for the 21 listed shipping firms between 2013 and 2019.[19] From the total observations, the frequency of types on technical innovations on ships such as ice class ships, eco-type ships and propulsion are 502, 628 and 301 respectively. Also, interesting is that the sample is observed with 1369 unique vessels from which 200, 261 and 101 have type of technical innovation of ice-class ships, eco-ships and propulsion respectively.[20]

2.3.2 Measuring financial performance

To see whether technically innovated ships in a shipping firm's fleet create financial value for the firm, we use financial performance as the dependent variable. Financial performance is measured by applying the financial ratio of ROA, defined as the operating profit before depreciation and provisions divided by total assets. The relationship between financial performance and innovation in shipping has been studied through interviews (Jenssen and Randøy, 2006). In this study, we apply ROA as the dependent variable.

2.3.3 Measuring Innovation and defining types of innovation

2.3.3.1 Measuring innovation

Panayides (2006) measures innovation with the frequency of introduction new processes, products or services in the marketplace and new ideas seeking by the firm. Greve (2003) uses research and development costs to capture innovation for shipbuilding firms. In this study, vessel-level data was collected through SEC 20F forms and official webpages for constructing the variable innovation $(inndwtratio_{it})$ which is measured as a ratio (1) of the total deadweight of technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year.[21] Three types of innovation were identified and considered in the sample: ice class vessels, the eco-type vessels and ships' propulsion system type which are explained in the following text.

[19] All firms used in this study are found in Table A2.1 in the Appendix III.
[20] Only 14 ships are observed to be identified with eco-type and propulsion innovated at the same time.
[21] Fleet is the ships owned by a shipping firm measured in number or deadweight tonnage.

$$inndwtratio_{it} = \frac{\sum_{f=1}^{F} Total\ deadweight\ of\ ships\ under\ innovation\ owned}{\sum_{f=1}^{F} Total\ deadweight\ of\ ships\ owned\ in\ the\ fleet} \quad (2.1)$$

2.3.3.2 Ice class ships

First type is *'ice class'* type ships 1A, 1B and 1C which are constructed according to Finnish-Swedish ice rules being capable of sailing on thick ice of 0.8mm, 0.6mm and 0.4mm respectively (DNV-GL, 2011). These vessels are specified by thick steel hull (to withstand the pressure of ice), stronger rudder, propeller and watertight bulkheads; heating fuel and ballast tanks and powerful engines (Riska, 2010; Liu and Kronbak, 2010; Solakivi et al., 2018).

2.3.3.3 Ship's propulsion

According to Greve (2003), '*propulsion'* is considered as innovation. Ship's propulsion is used to drive the ship's propelling shaft. The sample includes different types of propulsion system such as mechanical or electrical. Among them, innovation is considered the last types of propulsion system invented in the market. Innovated propulsion systems are the following: TFDE and X-DF propulsion system. TFDE stands for tri-fuel diesel electric propulsion and is technically innovated compared to steam propulsion generating lower maintenance costs than diesel engine propulsion system (steam turbines) which uses diesel, coal, nuclear power or fuel oil as fuel. TFDE necessities the use of two small electrical motors which gives the benefit of less weight and space for cargo carrying. The TFDE propulsion does not need cylinder oil, lube oil, scavenge space waste oil production, starting air pipelines and compressors. No use of HFO or MDO purifiers resulting in lower maintenance costs. A second type of propulsion system is the X-DF technology which "is based on the lean-burn principle (Otto cycle), in which fuel and air are premixed and burned at a high air-to-fuel ratio, a concept widely used on medium-speed and high-speed dual fuel engines" (WINGD, 2018). Some of their benefits include low investment costs for the Fuel Gas Supply System (FGSS), low electrical power consumption and low maintenance costs.

2.3.3.4 Eco-innovated ships

Thirdly, the last category of ship's innovation is *'eco-type'* ships. Throughout the collection of data, carefulness was given to avoid biased collection of data for this type of innovation. In more detail, ships which installed scrubbers are not considered eco-type.[22] Eco-type ships is a new generation of ships and are considered *'eco'* if is fuel efficient and create less pollution to the environment (Haider et al., 2013).[23] Such type of ship offers less water resistance during sailing and less emissions in the environment (Ardmore Shipping, 2020). Eco-type ships are constructed for optimizing fuel efficiency (Ardmore Shipping, 2020). Furthermore, according to Capital Product Partners (2020) eco-type vessels are new designs constructions which results in material bunker savings compared to older designs and bigger carrying capacity. "Such savings could result in a substantial reduction of bunker cost for charterers on a per unit basis" (Capital Product Partners, 2020).[24]

2.3.4 Definition of variables

Definition of variables is shown in Table 2.1. For capturing financial performance of shipping firms, we use *ROA* as the dependent variable which is the ratio of operating income before depreciation and provisions divided by total assets. The variables of interest are: 1. *inndwtratio* which is the ratio of the total deadweight of technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year. 2. *Icedwtratio* is ice class type technical innovation measured as a ratio of the total deadweight of ice-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year. 3. *Ecodwtratio* is eco-class type technical innovation measured as a ratio of the total deadweight of eco-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year. 4. *Propdwtratio* is propulsion-class type technical innovation measured as a ratio of the total deadweight of eco-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year.

[22] Scrubbers are used by ships for limiting air pollution by removing sulfur oxides from the ship's engine and boiler exhaust gases. This regulation came into force on 1st January 2020 by IMO. The limit of sulfur is 0.50% globally.
[23] For avoiding biasness during the collection of data for eco-type ships we thoroughly research to see whether each vessel for each year for each shipping firm is clearly referred to as 'eco-type'.
[24] For each year from 2013 to 2019, we identify each ship for each shipping firm owns that is *'eco'* type. For example, in the SEC Form 20F of Tsakos energy navigation with cik 0001166663 we see that the ship with the name *ULYSSES* is referred as ECO VLCC design.

In order to ensure that the model is precise as much as possible we use control variables.[25] These variables are found to be determinants of financial performance of shipping firms in the literature. *Mvbv* is the ratio of market to book value of equity. Naceur and Goaied (2002) showed that market to book value of equity is positively related to profitability. *Lev* is the total debt to shareholders' equity. Jensen (1986) showed that higher debt is associated with higher profitability. *Oplev* is the ratio of operating expenses to sales (Drobetz et al., 2013a). *Fincap* is the financial capacity of the firm which is measured as net cash flow from operating activities (net cash receipts and disbursements resulting from the operations of the company) divided by the net sales of the company (gross sales and other operating revenue less discounts, returns and allowances). *Annualvol* is the annualized volatility of weekly stock prices. *Avdwt* is the average deadweight of each shipping firm's fleet per year. Firm's age, *agef* is measured the number of years since the firm has been established and is measured as the natural logarithm of this number (Lee et al., 2014).[26] *Mve* is the market value of equity for each shipping firm. *Avage* is the average age of each shipping firm's fleet per year. *lfreight* is the natural logarithm of the ClarkSea freight rates index, defined as the weighted average index of vessel earnings measured in $/day in the main sectors of commercial vessels, weighted by the fleet size of the respective vessel type.[27] This variable is used since financial performance of shipping firms may be greater based on the prevailing freight market conditions.

Table 2-1: Definition of variables used in equation (2.2)

Type of variable	Description	Source (item)
Dependent	*Roa*: is the ratio of operating income before depreciation and provisions divided by total assets	Thomson Reuters (WC08326)

[25] For being careful with the presence of endogeneity during our model estimation of panel data we use control variables. The use of control variables and time fixed effects avoid possible reverse causality on the model Coles et al. (2012); Lee et al. (2014); Roberts and Whited (2013).
[26] The establishment date of each firm is founded in each shipping firm's webpage and double-checked through its financial statements.
[27] ClarkSea freight rate earnings are computed by Clarksons Shipping Intelligence Network (SIN) by collecting the daily freight rate earnings from each shipping route less: 1. port fees, adjusted for different currency exchange quotations and total commissions, 2. cost of bunkers. Then, the result is divided by the voyage days to calculate earnings per day for each ship type. More information can be found in Annexes 1 – 4 of the Clarksons (2020) "Sources & Methods for the Shipping Intelligence Weekly".

Variables of interest	*Inndwtratio*: is innovation measured as a ratio of the total deadweight of technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year.	SEC-20F
	Icedwtratio is ice class type technical innovation measured as a ratio of the total deadweight of ice-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year.	SEC-20F
	Ecodwtratio is eco-class type technical innovation measured as a ratio of the total deadweight of eco-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year.	SEC-20F
	Propdwtratio is propulsion-class type technical innovation measured as a ratio of the total deadweight of eco-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year.	SEC-20F
Controls	*Mvbv*: is the ratio of market to book value of equity	Thomson Reuters (MTBV)
	Oplev: is the ratio of operating expenses (WC01249) to total book value of assets (WC02999)	Thomson Reuters
	Lev: is the ratio of debt to shareholder's equity	Thomson reuters (WC08231)
	Fincap: is the financial capacity of the firm (DWFC) Net Cash Flow – Operating Activities	Thomson Reuters (DWFC/WC01001)

	represent the net cash receipts and disbursements resulting from the operations of the company. It is the sum of Funds from Operations, Funds From/Used for Other Operating Activities and Extraordinary Items. WC01001 is the net sales of the company which represents gross sales and other operating revenue less discounts, returns and allowances.	
	lfreight is the natural logarithm of the ClarkSea freight rates index, defined as the weighted average index of vessel earnings measured in $/day in the main sectors of commercial vessels, weighted by the fleet size of the respective vessel type.	Clarksons (SIN)
	Annualvol: is the annualized volatility of weekly firms' stock prices.	Thomson Reuters (RI)
	Avage: is the average age of each shipping firm's fleet per year	SEC-20F
	Mve is the market value of equity for each shipping firm.	Thomson Reuters (MV)
	Agef: is the firm's total years since it has been established	Firms' webpages
	Avdwt: is the average deadweight of each shipping firm's fleet per year	SEC-20F

Note: This table shows the definitions of variables used to estimate equation (1) and their sources. *Roa* is the ratio of operating income before depreciation and provisions divided by total assets. *Inndwtratio* is technical innovation measured as a ratio of the total deadweight of technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year. *MVBV* is the ratio of market to book value of equity. *Oplev* is the ratio of operating expenses (WC01249) to total book value of assets (WC02999). *Lev* is the ratio of debt to shareholder's equity. *Annualvol* is the annualized volatility of weekly firms' stock prices. *Avage* is the average age of each shipping firm's fleet per year. *Avdwt* is the average deadweight of each shipping firm's fleet per. *Fincap* is the financial capability of the firm which is measured as net cash flow from operating activities (net cash receipts and disbursements resulting from the operations of the company) divided by the net sales of the company (gross sales and other operating revenue less discounts, returns and allowances). *Mve* is the market value of equity for each shipping firm. *Agef* is the firm's total years since it has been established. *lfreight* is the natural logarithm of the ClarkSea freight rates index, defined as the weighted average index of vessel earnings measured in $/day in the main sectors of commercial vessels, weighted by the fleet size of the respective ship type. *Icedwtratio* is ice class type technical innovation measured as a ratio of the total deadweight of ice-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year. *Ecodwtratio* is eco-class type technical innovation measured as a ratio of the total deadweight of eco-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year. *Propdwtratio* is propulsion-class type technical innovation measured as a ratio of the total deadweight of eco-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year.

2.3.5 Descriptive statistics

A description of variables used in model (2.2) are presented below. Variables are chosen for explaining the financial performance of shipping firms and mostly to see whether technical innovation creates financial value for the shipping firms. Data includes firm and vessel level data captured from thomson reuters, official webpages and securities and exchange commission. Descriptive statistics are provided in table 2.2.

Table 2-2: Descriptive statistics of the variables in equation 2.2 for the sample period 2013-2019

Variable	Mean	Median	Standard Deviation	Min	Max	Skewness	Kurtosis	S&W Test [p-value]	Fisher-type ADF [p-value]
Roa (%)	1.314	2.360	6.563	-32.500	10.710	-2.652	13.407	24.560 [0.0000]	111.344 [0.0000]
Inndwtratio (%)	0.393	0.392	0.332	0.000	1.000	0.305	1.804	4.272 [0.0005]	134.3780 [0.0000]
Icedwtratio (%)	0.083	0	0.324	0	0.846	2.625	8.827	31.542 [0.0000]	90.8299 [0.0000]
Ecodwtratio (%)	0.215	0	0.324	0	1	1.340	3.441	9.454 [0.0000]	9.4477 [1.0000]
Propdwtratio (%)	0.095	0	0.218	0	1	2.269	7.076	18.896 [0.0000]	35.9376 [0.6537]
Mvbv ratio (%)	0.760	0.660	0.479	0.130	2.230	1.294	4.572	11.098 [0.0000]	58.592 [0.0314]
Oplev (%)	0.161	0.127	0.127	0.001	0.646	2.256	8.277	28.174 [0.0000]	52.539 [0.0885]
Lev (%)	50.225	50.880	13.528	6.02	74.500	-0.699	3.784	3.859 [0.0011]	166.858 [0.0000]
Clarksea ($/day)	12015.74	11742.89	1963.758	9440.656	15082.29	0.3783	1.7645	4.073 [0.0000]	41.0006 [0.4264]
Fincap (%)	29.775	29.781	21.627	-20.025	77.653	-0.047	2.619	0.887 [0.6069]	85.4157 [0.0008]
Annualvol (%)	5.377	5.765	3.431	0.442	12.172	0.116	1.735	7.381 [0.0000]	156.929 [0.0000]
Avage (years)	6.329	6.392	3.123	0	13.567	0.130	2.656	1.744 [0.1047]	36.0703 [0.6478]
Avdwt (dwt)	111909	100424	73353	9140	309661	0.805	3.015	7.753 [0.0000]	91.158 [0.0000]
Agef (years)	19.371	12.000	23.876	0	100	2.417	7.734	47.728 [0.0000]	1.7605 [1.000]
Mve ($mln.)	58336	41014	56656.08	0	298734	1.8088	6.9059	19.405 [0.0000]	81.5315 [0.0001]

Note: This table describes the variables with their relevant mean, median, standard deviation, minimum (min), maximum (max), skewness and kurtosis accordingly. Also, it presents data regarding unit roots and normality tests. The sample consists of 21 shipping firms listed on NYSE, Nasdaq and Oslo from the end of fiscal years 2013 to 2019. *ROA* is the ratio of operating income before depreciation and provisions divided by total assets. *Inndwtratio* is technical innovation measured as a ratio of the total deadweight of technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year. *Icedwtratio* is ice class type technical innovation measured as a ratio of the total deadweight of ice-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year. *Ecodwtratio* is eco-class type technical innovation measured as a ratio of the total deadweight of eco-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year. *Propdwtratio* is propulsion-class type technical innovation measured as a ratio of the total deadweight of eco-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year. *Mvbv* is the ratio of market to book value of equity *LEV* is the ratio of debt to shareholder's equity. *Annualvol* is the annualized volatility of weekly firms' stock prices. *OPLEV* is the ratio of operating expenses (WC01249) to total book value of assets (WC02999). *Avage* is the average age of each shipping firm's fleet per year. *Avdwt* is the average deadweight of each shipping firm's fleet per year. *Mve* is the market value of equity for each shipping firm. We then run Shapiro and Wilk (1965) test for normality and Fisher-type ADF Unit root test. *Agef* is the firm's total years since it has been established. *Fincap* is the financial capacity of the firm which is measured as net cash flow from operating activities (net cash receipts and disbursements resulting from the operations of the company) divided by the net sales of the company (gross sales and other operating revenue less discounts, returns and allowances). *lfreight* is the natural logarithm of the ClarkSea freight rates index, defined as the weighted average index of vessel earnings measured in $/day in the main sectors of commercial vessels, weighted by the fleet size of the corresponding ship type.

Before entering the variables in the equation (2.2) for running the panel data regression, we estimate the Pearson correlation matrix among the variables for avoiding any multicollinearity issues. Table 2.3 describes the Pearson correlation matrix and their corresponding values. The table indicates that high multicollinearity exists between *inndwtratio* and *ecodwtratio* in our model estimation, but this is not a model estimation issue since these variables are never used together in the panel data regression estimation. As a rule of thumb, any variables with linear correlation more than 60% are excluded from the regression estimation.

Table 2-3: Pearson correlation matrix (Chapter 2)

Variables	*roa*	*inndwtratio*	*icedwtratio*	*ecodwtratio*	*propdwtratio*	*lavage*	*lavdwt*	*fincap*	*lfreight*	*mvbv*	*oplev*	*lev*	*lmve*	*annualvol*	*agef*
roa	1.000														
inndwtratio	0.162	1.000													
icedwtratio	0.146	0.299*	1.000												
ecodwtratio	-0.050	0.661*	-0.203*	1.000											
propdwtratio	0.175*	0.261*	-0.180*	-0.291*	1.000										
lavage	0.055	-0.423*	-0.105	-0.351*	-0.023	1.000									
lavdwt	0.085	0.033	0.106	-0.130	0.144	-0.007	1.000								
fincap	0.352*	-0.001	0.288*	-0.358*	0.239*	0.187*	0.063	1.000							
lfreight	0.026	0.103	-0.037	0.110	0.030	0.065	0.019	-0.147	1.000						
mvbv	0.289*	0.135	0.053	-0.207*	0.453*	-0.074	0.239*	0.387*	-0.014	1.000					
oplev	-0.105	-0.237*	-0.195*	0.080	-0.291*	0.339*	-0.175*	-0.158	0.042	-0.290*	1.000				
lev	0.105	0.474*	0.033	0.250*	0.318*	-0.240*	0.162	-0.040	0.117	0.136	-0.004	1.000			
lmve	0.228*	-0.028	0.084	-0.256*	0.249*	0.111	0.380*	0.265*	0.022	0.522*	-0.328*	-0.066	1.000		
annualvol	0.200*	0.277*	0.114	-0.054	0.383*	-0.091	-0.032	0.076	0.065	0.248*	-0.274*	0.146	0.005	1.000	
agef	-0.103	-0.066	-0.164	0.128	-0.133	-0.215*	0.040	-0.318*	0.019	-0.175*	0.039	0.216*	0.043	-0.389*	1.000

Note: this table shows the linear relationship between the variables used in the model (1). Variables with correlation values more than 60% are excluded from the model. *** *p<0.01*, ** *p<0.05*, * *p<0.1*

2.4 Methodology

2.4.1 Panel data modelling

Collecting vessel-level data for technical innovation for 21 shipping firms we employ the following generic panel data regression model for investigating if ships' technical innovation is related to higher shipping firm's financial performance. Cross sectional time-series data, also known as panel data, is used to capture the behavior of 21 shipping entities over a time horizon of seven years (2013-2019). One advantage of panel data series is the account of heterogeneity between the shipping entities over time using control variables in the model.

The following generic panel data model is established:

$$y_{it} = \rho + \alpha_t + \sum_{\psi=1}^{\Psi} \varphi_{\psi i}\, \chi_{\psi it} + u_{it} + e_{it} \quad (2.2)$$

$$e_{it} \sim i.i.d.(0, \sigma^2), E(u_i) = 0, E(u_i^2) = \sigma_u^2,\ E(e_{it,} u_j) = 0,\ E(u_i, u_j)=0,\ if\ i \neq j$$

i refers to firms and t refers to fiscal years. y_{it} denotes the return on assets of each shipping firm i = 1,2,3…n; t = 1, 2, 3 …T defines the time frame for the data period in which annual observations are used. $\chi_{\psi it}$ is a matrix of ψ independent variables which are specific for each firm included in the sample; $\varphi_{\psi i}$ is the coefficient of the matrix of independent variables. e_{it} is a white noise error term with standard deviation and mean of σ^2 and 0 respectively. ρ is the constant of the panel data model and accounts for perfect collinearity of the sample data. u_{it} is the between entities error. Furthermore, the heterogeneous influence is measured by defining constant for time in the panel data model α_t. Finally, u_{it} *and* e_{it} are orthogonal.

For the reasons of choosing the most appropriate model, we follow the standard procedure for choosing the appropriate panel data model which is described below.[28] We firstly employ Hausman (1978) test for testing the null hypothesis H_0: $\mathrm{E}(X_{\psi it} U_i) = 0$ and H_1: $\mathrm{E}(X_{\psi it} U_i) \neq 0$ ensuring that a mis-specified model is avoided. Also, Breusch and Pagan (1980) Lagrange multiplier (LM) test is used to enhance our choice for the most appropriate model avoiding heteroskedasticity. Breusch and Pagan (1980) Lagrange multiplier (LM) test

[28] The standard procedure has been followed by (Kavussanos and Tsouknidis, 2014).

statistic tests two hypotheses, $H_0: \sigma_{u^2} = 0$ versus $H_1: \sigma_{u^2} \neq 0$. Except from these tests, all the variables were checked for normality using the Shapiro and Wilk (1965) test which tests that the sample follow a normal distribution. Finally, variance inflation factor (VIF) is computed for heteroskedasticity issues in the model of panel data regression. Coefficients of VIF for each independent variable is computed using the following formula $VIF = \frac{1}{1-R_i^2}$. R_i^2 is the coefficient of determination of a regression and shows of how close the data fit to the regression line. VIF result of more than 10 indicate high collinearity namely, there is a linear combination among the variables in the model.

2.5 Empirical estimations

This paper shows the positive impact of shipping firm's fleet technical innovation on shipping firms' financial performance. Our research is in line with past research of Jenssen and Randøy (2006) that found a positive relationship between innovation and performance in shipping industry. Even though our sample is small (21 shipping firms), significant result can be extracted. Table 2.4 describes the panel data regression results using *roa* as dependent variable and several control variables. Major variable of interest is *inndwtratio*.

Table 2-4: Panel data regressions of the roa on innovation and controls

Variables	M1	M2	M3	M4
Constant	-22.2251 (-0.64)	-34.9710 (-1.11)	-22.7482 (-0.69)	-38.4197 (-1.20)
inndwtratio	2.5826 * (2.04)	-	-	-
ecodwtratio	-	-	2.9926 ** (2.36)	-
icedwtratio	-	0.7287 (0.40)	-	-
propdwtratio	-	-		-2.1312 (-1.38)
Control variables				
mvbv	-0.1612 (-0.15)	0.2148 (0.22)	-0.0670 (-0.06)	0.4127 (0.42)
oplev	5.9648 (1.45)	4.8729 (1.12)	5.0627 (1.32)	4.4091 (1.11)
lev	0.0578 (1.00)	0.0771 (1.39)	0.0701 (1.30)	0.0870 (1.56)
lfreight	0.0149 (0.00)	1.4729 (0.43)	-0.1516 (-0.04)	1.6883 (0.48)
fincap	9.8592 *** (4.09)	9.4646 *** (3.71)	11.0978 *** (4.60)	9.9874 *** (4.13)
lmve	1.4646 ** (2.09)	1.3518 ** (2.03)	1.5897 ** (2.20)	1.4255 ** (2.05)
annualvol	0.2845 ** (2.35)	0.3206 ** (2.41)	0.3376 ** (2.71)	0.3578 ** (2.74)
Observations	147	147	147	147
Cluster errors	Yes	Yes	Yes	Yes
VIF	1.76	1.70	1.74	1.77
Time fixed effects	Yes	Yes	Yes	Yes
Adjusted R^2	25.48%	24.46%	25.93%	24.74%
F-stat	11.09 [0.0000]	9.66 [0.0000]	32.27 [0.0000]	10.31 [0.0000]

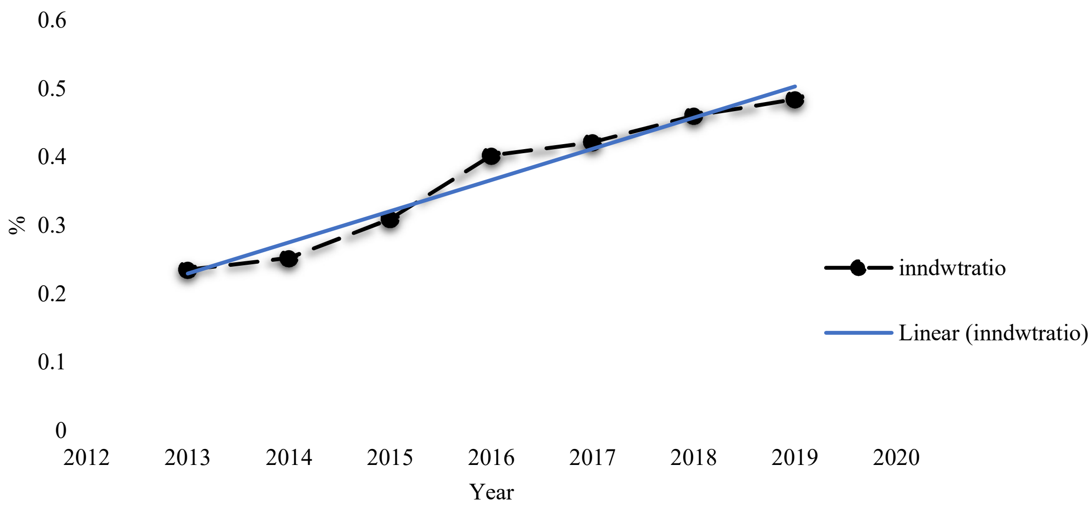
Note: this table shows the panel data regression for M1-M4 with cluster standard errors and the dependent variable of *roa* for equation (1). *Inndwtratio* captures the ratio of the total deadweight of innovated vessels for each year for each firm over the total deadweight of ships for each shipping firm's fleet. *Icedwtratio* is ice class type technical innovation measured as a ratio of the total deadweight of ice-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year. *Ecodwtratio* is eco-class type technical innovation measured as a ratio of the total deadweight of eco-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year. *Propdwtratio* is propulsion-class type technical innovation measured as a ratio of the total deadweight of eco-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year. Hausman (1978) test statistic and Breusch-Pagan test (1980) are computed resulting in a Fixed effect OLS regression model with cluster standard errors. T-statistics and p-values are reported in (.) and [.] respectively. ***, **, * denote significance at the 1%, 5% and 10% significance levels, respectively.

Following the standard procedure for choosing the most appropriate model, we conclude that a time fixed effects model is ideal. Most importantly, a pooled OLS regression with time fixed effects and cluster standard errors is used. Lee et al. (2014) supports that time fixed effects should be applied otherwise the model estimation and results would be biased. For the four models, Hausman (1978) test prove that a random effect model should be used with the results for M1, 2, 3 and 4 to be 4.48, 11.08, 10.86 and 10.74 respectively. Their respective p-values are 0.8778, 0.2705, 0.2855 and 0.2940. Then, we run Breusch and Pagan (1980) reaching the conclusion that a pooled OLS regression with time fixed effects is ideal for our sample. Fixed effect model in panel data are widely used in shipping (see for example, (Kavussanos and Tsouknidis, 2016, 2014; Tsouknidis, 2019). For all models 1, 2, 3 and 4, adjusted R^2 takes the value of 25.48%, 24.46%, 25.93% and 24.74% respectively. Variance inflation factor (VIF) is below 2 for all the models showing the absence of multicollinearity in the independent variables used to estimate the time fixed effects model.[29] The measurement used for measuring financial performance in this paper *roa* has been found to be positively related to vessel's technical innovation. *Inndwtratio* is positively and statistically significant in 10% significance level with coefficient and p-value equal to 2.5826 and 0.057 respectively. This result supports hypothesis 1 meaning that increasing the technical innovated ships in the fleet, a shipping firm can achieve higher financial performance during low freight market conditions. Furthermore, *fincap* has a positive coefficient of 9.8590 implying that a positive relationship exists between financial capacity and financial performance. This coefficient is statistically significant in 1% significance level. This result is in line with Przychodzen and Przychodzen (2015). Also, results show the positive relationship between *roa* and *mve* and *annualvol* respectively with p-values equal to 0.050 and 0.029 for model 1. *Mve* has been found to be positively related to *roa* in Tsouknidis (2019). Figure 2.2 shows the increase in technical innovation based on deadweight for the 21 shipping firms of the sample from 2013

[29] VIF values equals to 1.76 and 2.11 showing the absence of multicollinearity in the panel data regressions. Due to space unavailability VIF for independent variables are not included but they are available upon request.

to 2019. It clearly shows that shipping firms have launched technical innovations on ships for tackling the on-going shipping crisis. An approximate positive increase of 30% exist on technical innovated ship for 2013 and 2019.

Figure 2:2 Fleet's technically innovated ships based on dwt between 2013-2019



Note: this figure shows the average % of technically innovated ships including in all the shipping firms for each year in the sample measured by inndwtratio. Inndwtratio captures the ratio of the total deadweight of innovated vessels for each year for each firm over the total deadweight of ships for each shipping firm's fleet.

Among the three innovation types identified and used in the model, *ecodwtratio* is the only one that has a strong robust positive effect on shipping firms' financial performance being statistically significant in 5% level. This result contributes to the existing literature by identifying one innovation type that improves shipping firms' financial performance during low freight market conditions. Eco-ships are characterized by efficient propellers, technologically controlled engines, and improved propulsion efficiency. Additionally, they are fuel efficient thus, the robust positive relationship with *roa* is in line with Adland et al. (2017) results who conclude that the willingness to pay a premium for energy efficiency is closely related to the freight market cycle uncovering that during normal freight market conditions and after the shipping crisis for the period 2008-2012 dry bulk ships were chartered with a freight rate premium. For the boom period between 2003-2008, a freight rate premium was payable for fuel inefficient ships. During 2013 and 2019, we noticed many shipping firms to invest in eco-type ships for attracting charterers thus, positively affecting their financial performance for tackling the on-going shipping crisis and tight freight market liquidity.

2.5.1 Robust estimations

We also apply fifth robustness tests for ensuring that our data are not driven from endogeneity or biasedness. Firstly, we include in the panel data regression three extra variables that are determinants of shipping firms' financial performance: *avage*, *avdwt* and *agef* which are defined in Table 2.5. Average age of ships is important because older ships are not identified with the most recent technical innovations. Average deadweight of each shipping firm's fleet is important to capture any variation between firms' tonnage capacity. Firm's age is included to capture whether older firms exhibit better performance because of their more experienced management. By including these three variables *inndwtratio* remains positive and statistically significant coefficient in 10% significance level and p-value equal to 3.8713 (t-stat = 2.02) and 0.056 respectively. Furthermore, *ecodwtratio* remains statistically significant in 10% level with p-value equals to 0.050. *Icedwtratio* and *propdwtratio* have not any statistical influence on *roa*.

Secondly, a panel data regression was run using the following innovation measurement:

$$INN_{it} = \frac{\sum_{f=1}^{F} Total\ number\ of\ ships\ under\ technica\ \ innovation\ owned}{\sum_{f=1}^{F}\ Total\ number\ of\ ship\ \ \ owned\ in\ the\ fleet} \quad (2.3).$$

Four variables used for robustness test: *innratio*, *ecoratio*, *iceratio* and *propratio*. *Innratio* is innovation measured as a ratio of the number of technically innovated ships each firm possesses in its fleet for each year divided by the total number of technically innovated ships the firm owns for each year. *Ecoratio* is eco-type innovation measured as a ratio of the number of eco-type technically innovated ships each firm possesses in its fleet for each year divided by the total number of eco-type technically innovated ships the firm owns for each year. *Iceratio* is innovation measured as a ratio of the number of ice class type technically innovated ships each firm possesses in its fleet for each year divided by the total number of ice-class type technically innovated ships the firm owns for each year. *Propratio* is innovation measured as a ratio of the number of propulsion type technically innovated ships each firm possesses in its fleet for each year divided by the total number of propulsion type technically innovated ships the firm owns for each year. *Innratio* and *ecoratio* are found to be statistically significant in 10% and 5% confidence interval with p-values equal to 0.063 and 0.038 as shown in table 2.6.

Thirdly, we estimate the regression models for a third time considering any possible sectors effect. Results remain the same with *inndwtratio* and *ecodwtratio* to be statistically significant in 10% and 5% levels with p-values to be 0.063 and 0.038 respectively (Table 2.7). Fourthly, we run a robust regression of Eq (2.2) for the four-model specifications with robust standard errors as shown in Table 2.8. *Inndwtratio*, *fincap* and *lmve* are statistically significant in 10%, 1% and 5% confidence interval. *Inndwtratio* has a p-value of 0.093 and t-statistic of 1.69. Moreover, *ecodwtratio* has a parameter of 2.6890 and is statistically significant in 10% confidence interval with p-value equals to 0.077.

Fifthly, the standard errors of the OLS regression need to be unbiased meaning that the error terms should be independent and identically distributed. This is one of the OLS assumptions that should not be violated. According to Petersen (2009) time-fixed effects in panel data modelling may cause the standard errors to move downwards for factors that change over time. This issue will cause the panel data regression results to be spurious and inconsistent. As a remedy, we run the panel data models M(2)-M(4) in Eq(2) for each type of ship's technical innovation using cluster-adjusted standard errors of Petersen (2009). *Ecodwtratio* and *propdwtratio* appear to be statistically significant in 10%nand 5% confidence interval with p-value equal to 0.079 and 0.038 respectively (Table 2.9). Finally, as a sixth remedy we run random-effects panel data regression (Table 2.10). In all cases except the random-effects panel data regression, results are qualitatively the same. Random-efects model does not fit on this type of data as Hausman test favors a fixed-effect model.

Table 2-5: Panel data regressions of the roa on innovation and controls

Variables	M1	M2	M3	M4
Constant	-7.2981 (-0.16)	-29.8502 (-0.63)	-7.3990 (-0.17)	-33.6922 (-0.83)
inndwtratio	3.8713 * (2.02)	-	-	-
ecodwtratio	-	-	4.1066 ** (2.03)	-

icedwtratio	-	1.2732 (0.68)	-	-
propdwtratio	-	-	-	-2.4995 (-1.47)
Control variables				
mvbv	0.5004 (0.34)	0.7735 (0.53)	0.5472 (0.38)	0.9413 (0.62)
lavage	1.2463 (0.52)	0.4894 (0.21)	1.3620 (0.60)	0.5008 (0.21)
lavdwt	-0.2540 (-0.47)	-0.4049 (-0.79)	0.0197 (0.04)	-0.4133 (-0.83)
lagef	0.7543 (0.87)	0.4994 (0.60)	0.7316 (0.92)	0.5116 (0.61)
oplev	4.2474 (0.96)	4.0831 (0.83)	2.6290 (0.60)	3.7363 (0.78)
lev	0.0540 (0.80)	0.0816 (1.10)	0.0737 (1.13)	0.0955 (1.23)
lfreight	-1.4305 (-0.28)	1.2445 (0.27)	-1.9831 (-0.40)	1.4621 (0.32)
fincap	9.6985 ** (2.68)	9.3361 ** (2.51)	11.6421 *** (3.57)	10.0920 *** (2.93)
lmve	1.1689 (1.16)	1.2478 (1.28)	1.2522 (1.23)	1.3416 (1.33)
annualvol	0.3075 ** (2.15)	0.3419 ** (2.24)	0.3682 ** (2.73)	0.3840 ** (2.62)
Observations	127	127	129	129
Cluster errors	Yes	Yes	Yes	Yes
VIF	1.96	1.87	1.94	1.91
Time fixed effects	Yes	Yes	Yes	Yes
Firm fixed effects	No	No	No	No
Hausman Test	4.48	11.08	10.86	10.74
[p-value]	[0.8778]	[0.2705]	[0.2855]	[0.2940]
Adjusted R^2	26.71%	24.95%	27.73%	25.27%
F-stat	9.44 [0.0000]	9.64 [0.0000]	27.19 [0.0000]	10.31 [0.0000]

Note: this table shows the panel data regression for M1-M4 with cluster standard errors and the dependent variable of *roa* for equation (1). *Inndwtratio* captures the ratio of the total deadweight of innovated vessels for each year for each firm over the total deadweight of ships for each shipping firm's fleet. *Icedwtratio* is ice class type technical innovation measured as a ratio of the total deadweight of ice-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year. *Ecodwtratio* is eco-class type technical innovation measured as a ratio of the total deadweight of eco-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year. *Propdwtratio* is propulsion-class type technical innovation measured as a ratio of the total deadweight of eco-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year. Hausman (1978) test statistic and Breusch-Pagan test (1980) are computed resulting in a Fixed effect OLS regression model with cluster standard errors. T-statistics and p-values are reported in (.) and [.] respectively. ***, **, * denote significance at the 1%, 5% and 10% significance levels, respectively.

Table 2-6: Panel data regressions replacing deadweight under innovation with number of ships under innovation

Variables	M1	M2	M3	M4
Constant	-9.0265 (-0.19)	-29.6567 (-0.70)	-8.0535 (-0.18)	-33.3471 (-0.82)
innratio	2.3688 * (1.97)	-	-	-
ecoratio	-	-	2.9831 ** (2.22)	-
iceratio	-	0.5109 (0.23)	-	-
propratio	-	-	-	-2.1864 (-1.37)
Control variables				
mvbv	0.6726 (0.45)	0.7723 (0.54)	0.6226 (0.43)	0.9605 (0.63)
lavage	1.2344 (0.50)	0.4981 (0.21)	1.3527 (0.60)	0.4952 (0.21)
lavdwt	-0.2164 (-0.39)	-0.4010 (-0.78)	0.0840 (0.18)	-0.4072 (-0.82)
lagef	0.7635 (0.86)	0.4992 (0.61)	0.7359 (0.91)	0.5140 (0.61)
oplev	4.5509 (1.03)	4.0658 (0.82)	2.9298 (0.67)	3.6631 (0.76)
lev	0.0629 (0.93)	0.0823 (1.11)	0.0801 (1.22)	0.0949 (1.23)
lfreight	-1.2924 (-0.24)	1.2161 (0.26)	-1.9881 (-0.40)	1.4290 (0.31)
fincap	9.2051 *** (2.45)	9.3401 *** (2.51)	11.2602 *** (3.45)	10.0783 *** (2.91)
lmve	1.1286 ** (1.13)	1.2457 * (1.29)	1.2243 * (1.23)	1.3350 * (1.33)
annualvol	0.3116 ** (2.14)	0.3437 ** (2.27)	0.3643 ** (2.70)	0.3845 ** (2.63)
Observations	127	127	127	127
Cluster errors	Yes	Yes	Yes	Yes
VIF	1.95	1.87	1.94	1.91
Time fixed effects	Yes	Yes	Yes	Yes
Firm fixed effects	No	No	No	No
Hausman Test	11.08	10.74	11.37	10.81
[p-value]	[0.2701]	[0.2940]	[0.2512]	[0.2892]

Adjusted R^2	26.48%	24.93%	27.73%	25.26%
F-stat	9.96 [0.0000]	12.82 [0.0000]	27.19 [0.0000]	10.31 [0.0000]

Note: this table shows the panel data regression for M1-M4 with cluster standard errors and the dependent variable of *roa* for equation (1). *Inndwtratio* captures the ratio of the total deadweight of innovated vessels for each year for each firm over the total deadweight of ships for each shipping firm's fleet. *Icedwtratio* is ice class type technical innovation measured as a ratio of the total deadweight of ice-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year. *Ecodwtratio* is eco-class type technical innovation measured as a ratio of the total deadweight of eco-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year. *Propdwtratio* is propulsion-class type technical innovation measured as a ratio of the total deadweight of eco-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year. Hausman (1978) test statistic and Breusch-Pagan test (1980) are computed resulting in a Fixed effect OLS regression model with cluster standard errors. T-statistics and p-values are reported in (.) and [.] respectively. ***, **, * denote significance at the 1%, 5% and 10% significance levels, respectively.

Table 2-7: Panel data regressions of the roa on innovation and controls using sector effects

Variables	M1	M2	M3	M4
Constant	-24.4857 (-0.71)	-21.0576 (-0.61)	-33.7821 (-1.04)	-37.5685 (-1.12)
inndwtratio	1.9599 * (1.75)	-	-	-
ecodwtratio	-	2.9906 ** (2.42)	-	-
icedwtratio	-	-	0.2014 (0.11)	-
propdwtratio	-	-	-	-1.6658 (-1.11)
Control variables				
mvbv	-0.4350 (-0.46)	-0.3138 (-0.31)	-0.2376 (-0.27)	-0.0297 (-0.03)
oplev	10.1366 (1.34)	8.2118 (1.15)	9.7424 (1.24)	8.8425 (1.17)
lev	0.0769 (1.20)	0.0822 (1.35)	0.0931 (1.51)	0.0990 (1.57)
lfreight	-0.0171 (-0.00)	-0.5304 (-0.14)	1.0003 (0.28)	1.3149 (0.35)
fincap	10.9976 *** (4.79)	12.0519 *** (5.67)	10.9862 *** (4.53)	11.1909 *** (4.97)

lmve	1.4958 * (1.98)	1.5907 * (2.07)	1.4079 * (1.98)	1.4513 * (1.99)
annualvol	0.2409 * (1.76)	0.2752 * (1.97)	0.2495 * (1.79)	0.2770 * (1.97)
Observations	129	129	129	129
Cluster errors	Yes	Yes	Yes	Yes
VIF	2.31	2.29	2.24	2.32
Time fixed effects	Yes	Yes	Yes	Yes
Firm fixed effects	No	No	No	No
Sector effects	Yes	Yes	Yes	Yes
Hausman Test	4.48	11.08	10.86	10.74
[p-value]	[0.8778]	[0.2705]	[0.2855]	[0.2940]
Adjusted R^2	26.06%	26.89%	26.44%	24.74%
F-stat	-	-	-	-

Note: this table shows the panel data regression for M1-M4 with cluster standard errors and the dependent variable of *roa* for equation (1). *Inndwtratio* captures the ratio of the total deadweight of innovated vessels for each year for each firm over the total deadweight of ships for each shipping firm's fleet. *Icedwtratio* is ice class type technical innovation measured as a ratio of the total deadweight of ice-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year. *Ecodwtratio* is eco-class type technical innovation measured as a ratio of the total deadweight of eco-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year. *Propdwtratio* is propulsion-class type technical innovation measured as a ratio of the total deadweight of eco-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year. Hausman (1978) test statistic and Breusch-Pagan test (1980) are computed resulting in a Fixed effect OLS regression model with cluster standard errors. T-statistics and p-values are reported in (.) and [.] respectively. ***, **, * denote significance at the 1%, 5% and 10% significance levels, respectively.

Table 2-8: Panel data regressions of the roa on innovation and controls using robust standard errors

Variables	M1	M2	M3	M4
Constant	-44.9725 (-1.28)	-46.7961 (-1.33)	-46.7329 (-1.33)	-47.9923 (-1.35)
inndwtratio	2.7513 * (1.69)	-	-	-
ecodwtratio	-	-	2.6890 * (1.78)	-
icedwtratio	-	1.7762 (1.45)	-	-
propdwtratio	-	-	-	-1.9039 (-1.21)
Control variables				
mvbv	0.3582 (0.36)	0.5867 (0.59)	0.4931 (0.49)	0.6839 (0.70)

oplev	6.4081 (1.49)	5.2986 (1.28)	5.3635 (1.32)	4.6096 (1.11)
lev	0.0521 (1.01)	0.0787 (1.65)	0.0678 (1.44)	0.0893 * (1.80)
lfreight	2.3468 (0.59)	2.6314 (0.66)	2.3495 (0.59)	2.6279 (0.66)
fincap	8.7760 *** (2.79)	8.1445 ** (2.52)	9.7166 *** (2.83)	8.7895 *** (2.71)
lmve	1.4285 ** (2.59)	1.3076 ** (2.46)	1.5153 *** (2.64)	1.3710 ** (2.47)
annualvol	0.2579 (1.50)	0.2946 (1.63)	0.3105 * (1.69)	0.3308 ** (1.84)
Observations	129	129	129	129
Robust standard errors	Yes	Yes	Yes	Yes
VIF	1.43	1.35	1.40	1.91
Time fixed effects	Yes	Yes	Yes	Yes
Adjusted R^2	20.81%	19.76%	20.81%	19.79%
F-stat	7.70 [0.0000]	9.06 [0.0000]	7.97 [0.0000]	8.55 [0.0000]

Note: this table shows the panel data regression for M1-M4 with cluster standard errors and the dependent variable of *roa* for equation (1). *Inndwtratio* captures the ratio of the total deadweight of innovated vessels for each year for each firm over the total deadweight of ships for each shipping firm's fleet. *Icedwtratio* is ice class type technical innovation measured as a ratio of the total deadweight of ice-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year. *Ecodwtratio* is eco-class type technical innovation measured as a ratio of the total deadweight of eco-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year. *Propdwtratio* is propulsion-class type technical innovation measured as a ratio of the total deadweight of eco-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year. Hausman (1978) test statistic and Breusch-Pagan test (1980) are computed resulting in a Fixed effect OLS regression model with cluster standard errors. T-statistics and p-values are reported in (.) and [.] respectively. ***, **, * denote significance at the 1%, 5% and 10% significance levels, respectively.

Table 2-9: Panel data regressions of the roa on innovation and controls with cluster adjusted standard errors

Variables	M1	M2	M3	M4
Constant	-22.08 *** (-2.66)	-21.36 ** (-2.55)	-24.14 *** (-3.28)	-22.82 (-2.65)
inndwtratio	2.5826 (1.26)	-	-	-
ecodwtratio	-	-	2.9926 * (0.079)	-
icedwtratio	-	0.7287 (0.45)	-	-
propdwtratio	-	-	-	-2.1312 ** (-2.09)
Observations	129	129	129	129
Cluster adjusted errors	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes
Adjusted R^2	25.48%	24.46%	25.93%	24.74%
F-stat	5.21 [0.0000]	5.65 [0.0000]	5.29 [0.0000]	5.30 [0.0000]

Note: this table shows the panel data regression for M1-M4 with cluster standard errors and the dependent variable of *roa* for equation (1). *Inndwtratio* captures the ratio of the total deadweight of innovated vessels for each year for each firm over the total deadweight of ships for each shipping firm's fleet. *Icedwtratio* is ice class type technical innovation measured as a ratio of the total deadweight of ice-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year. *Ecodwtratio* is eco-class type technical innovation measured as a ratio of the total deadweight of eco-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year. *Propdwtratio* is propulsion-class type technical innovation measured as a ratio of the total deadweight of eco-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year. Hausman (1978) test statistic and Breusch-Pagan test (1980) are computed resulting in a Fixed effect OLS regression model with cluster standard errors. T-statistics and p-values are reported in (.) and [.] respectively. ***, **, * denote significance at the 1%, 5% and 10% significance levels, respectively.

Table 2-10: Panel data regression using random-effects model

Variables	M1	M2	M3	M4
Constant	-22.2251 (-0.43)	-22.7482 (-0.44)	-34.9710 (0.67)	-38.4197 (-0.74)
inndwtratio	2.5826 (1.28)	-	-	-
ecodwtratio	-	2.9926 * (1.53)	-	-

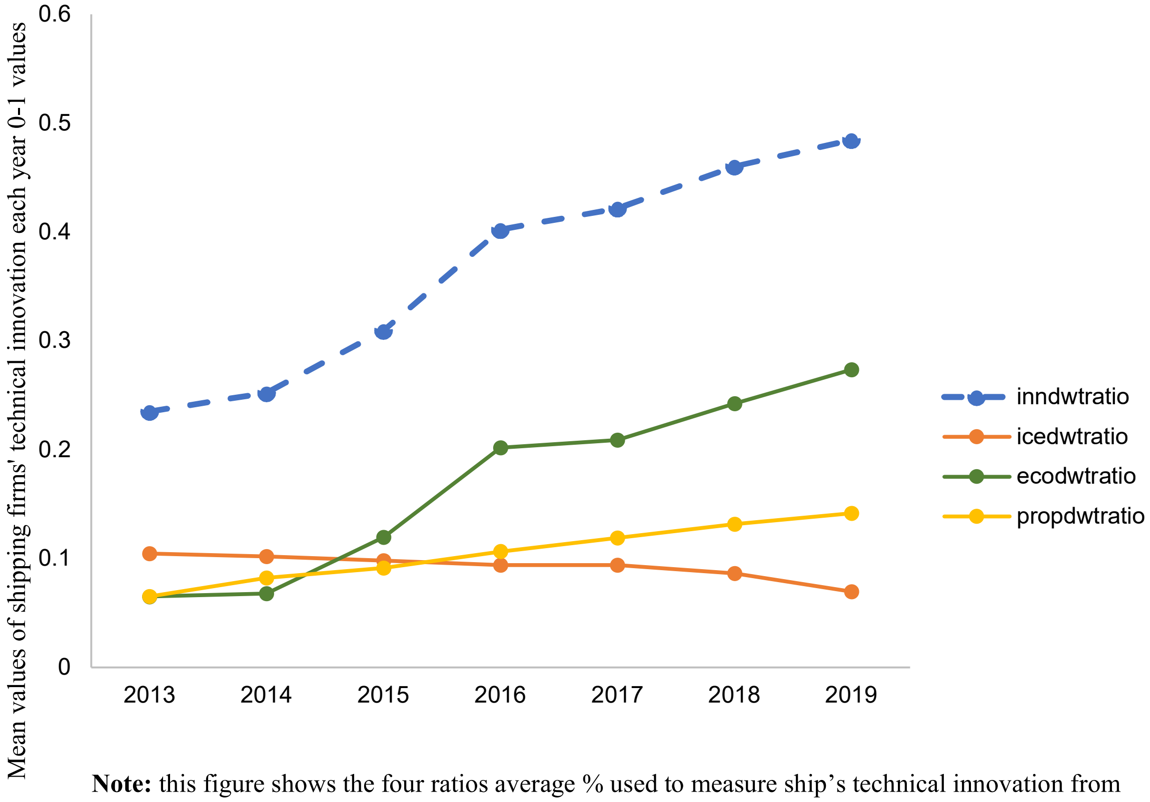
icedwtratio	-	-	0.7287 (0.24)	-
propdwtratio	-	-	-	-2.1312 (-0.69)
Control variables				
mvbv	-0.1612 (-0.10)	-0.0670 (-0.04)	0.2148 (0.13)	0.4127 (0.25)
oplev	5.9648 (1.23)	5.0627 (1.07)	4.8729 (1.01)	4.4091 (0.92)
lev	0.0578 (1.13)	0.0701 (1.43)	0.0771 (1.51)	0.0870 * (1.71)
lfreight	0.0149 (0.00)	-0.1516 (-0.03)	1.4729 (0.27)	1.6883 (0.31)
fincap	9.8592 *** (3.25)	11.0978 *** (3.51)	9.4646 *** (3.02)	9.9874 *** (3.24)
lmve	1.4646 ** (2.30)	1.5897 ** (2.46)	1.3518 ** (2.13)	1.4255 ** (2.22)
annualvol	0.2845 * (1.65)	0.3376 ** (1.99)	0.3206 * (1.87)	0.3578 ** (2.01)
Observations	129	129	129	129
Adjusted R^2	25.48%	26.89%	24.46%	24.74%

Note: this table shows the panel data random effects regression for M1-M4. *Inndwtratio* captures the ratio of the total deadweight of innovated vessels for each year for each firm over the total deadweight of ships for each shipping firm's fleet. *Icedwtratio* is ice class type technical innovation measured as a ratio of the total deadweight of ice-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year. *Ecodwtratio* is eco-class type technical innovation measured as a ratio of the total deadweight of eco-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year. *Propdwtratio* is propulsion-class type technical innovation measured as a ratio of the total deadweight of eco-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year. Hausman (1978) test statistic and Breusch-Pagan test (1980) are computed resulting in a Fixed effect OLS regression model with cluster standard errors. T-statistics and p-values are reported in (.) and [.] respectively. ***, **, * denote significance at the 1%, 5% and 10% significance levels, respectively.

2.6 Discussion of the results

The evidence of the empirical estimations shows that the investment in a technically innovated vessel creates financial value for the listed shipping firms. Figure 2.3 illustrates the average of the four ratios measured and used to capture the effect of ship's technical innovation on listed shipping firms' financial performance for each year.

Figure 2:3 Mean ratios for the four ship's technical innovation: Sample period 2013-2019



Note: this figure shows the four ratios average % used to measure ship's technical innovation from 2013 to 2019. Inndwtratio is technical innovation measured as a ratio of the total deadweight of technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year. Icedwtratio is ice class type technical innovation measured as a ratio of the total deadweight of ice-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year. Ecodwtratio is eco-class type technical innovation measured as a ratio of the total deadweight of eco-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year. Propdwtratio is propulsion-class type technical innovation measured as a ratio of the total deadweight of eco-class type technically innovated ships each firm possesses in its fleet for each year divided by the total deadweight of ships the firm owns for each year.

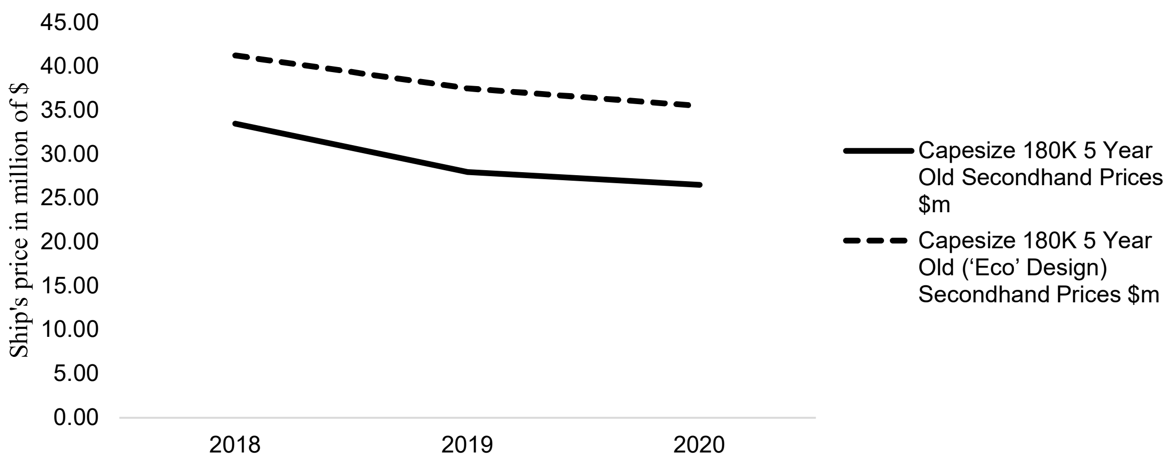
This result is in line with Adland et al. (2017) that found that a fuel-efficient ship which is considered innovated receives a freight rate premium to be chartered during normal and economically stagnated market compared to a non-technically innovated ship. During boom market conditions, fuel efficiency is insignificant for the charterers. Results also reveals that the higher the deadweight tonnage of technically innovated ships in a shipping firm's fleet, the higher the financial performance will be. This is supported by the academic literature in which many authors showed a positive relationship between innovation and business performance (Schilling and Hill, 1998c; Sok and O'Cass, 2015). Similarly, Jenssen and Randøy (2006) found a positive relationship between business performance and product/process innovation in shipping industry. However, their research lacks time variation and is conducted only for Norwegian firms. Our research contributes to the literature by introducing a new variable for capturing technical innovation and assesses its relationship with listed shipping firms' financial performance. It also employs other variables that were found to be determinants of financial performance in the literature using panel data modelling. In figure 2.3 shows the increase in investment for technically innovated ships in the fleet of the 21 listed shipping is shown.

Another possible explanation of shipping firms to invest in technically innovated firms may be due to the 'risk appetite' of shipowners. Despite the investment in ship's technical innovation being risky, results show that such an investment can create financial value for the firm. This financial value can be considered as the remedy for shipowners to cope with the long-lasting uncertainty and volatility of the shipping freight market after May 2008. Our sample period represents a low performance and economic stagnated market with low shipping freight rates. Thus, as shipowners seek to find ways to increase their revenues and cope with vessel's operating expenses and bunker costs, they decide to invest in technically innovated ships.[30] By doing so, they reduce the possibility of ships' unemployment risk during low performance market and delivering value-added services to their clients. Also, theory supports that value creation mechanisms allow firms to find new business opportunities through the provision of new products i.e., ships with value-added services i.e., navigating through ice (Yunus et al., 2010; Schneckenberg et al., 2017; Shane and

[30] Bunker costs are the responsibility of the shipowner when the ship is chartered under voyage charter whereas under a long-term chartering contract i.e., time or bareboat the responsibility lies with the charterer.

Venkataraman, 2000). According to Amit and Zott (2001), value creation mechanisms are originated in organizational decisions which are related to project structures, leverage value drivers and allocation of firms' resources for developing new business opportunities. Thus, it can be stated that shipowners allocate their funds for investing in a technically innovated ship either new or second-hand for creating financial value and increasing their financial revenues. Drobetz et al. (2019) claim that efficient investment decisions provide operational profitability, enable firm growth, and are important for corporate success. Figure 2.4 shows the price difference in millions of dollars for Capesize eco- and non-eco type ships.

Figure 2:4 5 years old eco and non-eco Capesize ship's price



Note: this figure describes the difference in second-hand Capesize eco-type and non-eco-type prices from 2018 to 2020. It is shown that there is a difference in ship price if the ship is considered eco-friendly.

Another channel through which listed shipping firms were found to invest in ship's technical innovation may be the on-going world financial crisis of May 2008, the substantial increase of fuel prices and the propensity of shipping companies to go 'green'. The collapse of the shipping freight market after May 2008 (Merika et al., 2015) and the increase of fuel prices (Clarksons, 2021) forced many shipping firms to find solutions to minimize their bunker costs. The combination of financial crisis and the bunkers' price volatility may be a reason of shipowners to take the risk to invest in technically innovated ships i.e., eco-type vessels. This has led shipbuilding firms to construct fuel efficient ships i.e., eco-type ships (Haider et al., 2013). Consequently, shipowners invested in fuel efficient eco-type ships for providing value-added services to their clients who as reported by Adland et al. (2017), fuel efficient ships are chartered with a freight rate premium during low shipping freight market conditions. Innovation has been found to be a determinant of competitive advantage and contributes to economic growth of a business (Geroski and Machin, 1992; Schumpeterian et al., 1982; Laursen and Salter, 2006). Having competitive advantage, many shipping firms try to differentiate their fleet in the market by attracting possible charterers who are eager to pay a freight rate premium in exchange of ship technical innovation. Innovation increases competition among firms in the same industry (Belloc, 2012). A fuel-efficient ship is always a choice for chartering companies that charter ships mostly on long-period contacts i.e., time charter or bareboat thus, they are responsible for paying the bunkers costs. Furthermore, green activities have been in the epicenter of the discussions in the last decade so, such a big industry the shipping is, it could not remain inactive, but it has been directly forced to invest in eco-type ships. It has been proved that CSR disclosure is positively related to shipping firms' financial performance (Drobetz et al., 2013b). Bouslah et al. (2013) supports that CSR can positively affect firm's performance if and only affects expected future cashflows and/or risk. An investment in eco-type ship is considered as environmental practice on behalf of the shipping firm. Thus, an eco-type ship is chartered with a freight rate premium during low performance market resulting in positively affecting firms' financial performance. Shipping firms seem to disclose environmentally friendly practices i.e., investing in an eco-type ship for attracting possible investors resulting in positively affecting their financial performance. Based on the sample period, shipping industry is characterized by low liquidity, credit and financial risk, and this forced many shipping companies to invest in technically innovated ships. As the shipping market passed through liquidity problems, shipowners made risk-taking decisions by investing in technically innovated ships mostly to tackle the uncertain and volatile environment of freight rates. These results are in line with Baker and Sinkula (2002), Darroch and Mcnaughton (2002) and Utterback, (1994) who support that innovation assists firms to deal with the highly volatile external environment and is considered as one of the main successful drivers in the long-term for the business.

Lastly, ice-class type ships are not seen to affect financial performance of listed shipping firms. One reason may be that these ships necessitate a huge capital investment for constructing thick hull and powerful engines thus, the maintenance costs increase as this type of ship gets older. Moreover, this type of ships is very specific as it is a market that takes place only in Arctic Ocean.

2.7 Conclusion

2.7.1 Major findings

This paper contributes to the existing literature on the issue (Jenssen, 2003; Jenssen and Randøy, 2006, 2002; Greve, 2003; Lim and Lim, 2020) by providing evidence of a positive relationship between vessels' level of technical innovation and firm's financial performance for U.S. and Oslo-listed shipping firms. This is achieved through utilizing a unique hand-collected data set including firm and vessel level data for U.S. and Oslo listed shipping firms originating from SEC 20F fillings, Thomson Reuters and Compustat. The results show that operating an eco-type vessel forms a significant determinant of listed shipping firms' financial performance compared to the propulsion and ice-class innovation types. Results are in line with Haider et al. (2013) and Adland et al. (2017) who show that during normal and low market conditions, ship's fuel efficiency is priced higher by the freight market, i.e. in a low freight market, charterers prefer fuel efficient ships for time charter contracts as they are responsible for paying the bunker costs, while in a strong freight market, high freight rates may render bunker costs less important.

By increasing the shipping firm's fleet technical innovation, a shipping firms differentiates its fleet and as a positive effect, higher financial performance can be achieved in the long-term during low freight market conditions. Shipowners can realize the significance of owning a technically innovated fleet in the market thus, achieving higher financial earnings as charterers are keener on chartering such type of ships. Nowadays, eco-friendly activities play a pivotal role in achieving corporate socially responsible success and therefore positively affecting financial performance. Shipowners should consider an investment in eco-type ships as they reduce environmental impact and can charter such type of ships with freight rate premium during low performance markets.

2.7.2 Limitations and further research

Criticism against our study may be our limited sample which uses only 21 shipping firms. However, there is not any more available data as we thoroughly investigated all possible listed shipping firms from various stock exchanges such as NYSE, Nasdaq, Hong Kong, Singapore, London and Norway. Thus, the final sample consists of 21 listed shipping firms from Norway and U.S. stock exchanges. A good further research suggestion is to exploit private data combining the chartering strategy each technically innovated ship is chartered and assess which combination has the highest effect on shipping firm's financial performance in a bigger sample i.e., eco-type ship chartered under time chartering.

2.7.3 Practical implications

Shipping firms should engage environmentally friendly practices that attract private investors in investing in their stocks. In this way, they can positively affect their firms' financial performance. Furthermore, portfolio diversification by shipping investors can be achieved when shipping firms own eco-ships because these ships are chartered with higher freight rates in the market thus, increasing the shipping firms' revenues. The results are of interest to ship lending institutions. A fleet consists of many eco-type ships means that the firm can charter these ships with freight premium during normal and low performance market conditions thus, a shipping company by earning higher freight rates it can continue paying their loan settlements.

Chapter 3 Chartering policy and financial performance: The case of U.S. listed shipping firms trading in the tanker and dry bulk shipping sectors

3.1 Introduction

Transportation by sea necessitates the use of different ships that follow different shipping routes for carrying over 80% of cargoes worldwide (UNCTAD, 2021; Stopford, 2008; Alexandridis et al., 2018). The transportation of cargoes implies that a freight agreement has been reached between the cargo owner and the ship owner using multiple freight contracts such as voyage charter or time charter of different durations (Kavussanos, 2003; Kavussanos and Alizadeh, 2002). One important characteristic of the shipping industry is market segmentation meaning that the industry may be separated into segments and sub-segments (Tsouknidis, 2016; Stopford, 2008) which can be classified by the shipping market i.e., tanker, dry or container; by the type of cargo that the ships transport (i.e., dry cargo, wet cargo etc.) or by the ship type and size (i.e., Capesize, Panamax, Handymax for dry bulk ships and ULCC, VLCC, Aframax etc for tankers). The transportation is organized based on the agreement of chartering contracts between market agents; shipowner and charterer for chartering the appropriate type of ship for sea transportation.[31] Alizadeh and Nomikos (2011) support that the segmentation effect appears because the decision to hire a ship for carrying a specific cargo is influenced by four factors: 1. type of the commodity transported, 2. the cargo parcel size, 3. the ship's route and 4. the loading/unloading port facilities.

3.1.1 Chartering policy of dry bulk and tanker U.S. listed shipping firms' segments

3.1.1.1 Shipping market segments

Such a segmentation effect will unquestionably affect the decision-making of the shipowner on which type of ship to invest, in which market to employ it and for how long

[31] Chartering contracts are used to provide charterers with a great flexibility in meeting their sea transportation needs and are used by shipowners to provide sea transportation services (Alizadeh and Talley, 2011).

i.e. the charter duration period (short or long-term).[32] The decision as to the segmentation effect is pivotal to chartering policy and is bound to effect the financial performance of the shipping firm.[33] Kavussanos and Visvikis (2006) state that these segments and sub-segments in the shipping market have different business cycles which are formed by the demand for transporting various commodity types worldwide. As a result, the chartering policy in each segment is expected to behave differently during these business cycles either in the short-term or in the long-term period.

BIMCO (2021) supports that the fixtures of tankers tend to be remarkably similar with those for dry cargo shipping i.e., both have the same elements of fixtures such as rate, size, laydays, demurrage and loading/discharge areas. In both the dry bulk and tanker chartering markets, smaller vessels are chartered for shorter trips/distances whereas larger vessels are chartered for longer distances i.e., Handysize ships are chartered for short distances whereas Capesize (dry ships) and Suezmax tankers are chartered for longer trips. Regarding the supply and demand for dry bulk and tanker cargo chartering, when demand for cargo transportation exceeds supply of tonnage, freight rates increase for both markets (Stopford, 2008). In contrast, when supply of tonnage exceeds demand, freight rates decrease (Stopford, 2008). The most important determinant of the shipping cycles is the demand for sea transportation and the trade demand in the wider world economy (Stopford, 2008; Chistè and van Vuuren, 2014). It is a well-known fact that the shipping cycles follow the world business cycle (Stopford, 2008). Supply and demand for sea transportation form the shipping cycles for both the dry bulk and tanker trades which according to various researchers, they are similar to each other (Stopford, 2008; Merika et al., 2015; Goulielmos, 2010) but not the same.

Regarding the physical characteristics of tanker market, this market is a specialized and extremely risky as flammable cargo is handled i.e., oil, gasoline, heating oil etc. Dry cargo market is observed with many family-owned shipping companies that own dry bulk ships chartered for transporting dry bulk cargo all around the world. In terms of capitalization,

[32] Chartering is defined as the agreement between shipowner who owns the fleet and the charterer who needs the ship's service, to transport goods from a port to another port worldwide (Panayides, 2016).
[33] The chartering policy is defined as the act of the shipping firm to charter its fleet using multiple chartering contracts of different durations. Due to their nature, chartering agreements entail risk because of their charter durations, short-term and long-term (Rogers et al., 2016).

big dry shipping firms are listed in the U.S. stock exchanges (Drobetz et al., 2013a). The need to reduce transportation costs led shipping players to develop dry cargo shipping (Grammenos, 2010) achieving economies of scale by increasing shipment quantity. Based on the charterer's needs to transport cargo, the decision for the size of ship is affected by four factors: the trading route, port depth, berth size, and the availability of cargo handling facilities. Seasonal behavior is identified in the dry cargo trade because of unexpected changes and volatile movements in the freight rates proved by Kavussanos and Alizadeh (2001). For example, seasonality behavior is observed in the trade of grain that harvesting takes place in the months of summer. Dry bulk shipping market is divided into sub-markets, for example according to the type of ship such as Capesize, Panamax, Supramax, Handymax and Handysize ships which carry various types of dry cargo such as iron ore, wheat, cement and other dry cargo (Stopford, 2008). Dry ships are traded based on charterparties as $/ton for short-term charters and $/day for long-term durations. Approximately, in 2019, 6682 million tons of dry cargo were loaded on ships (UNCTAD, 2021) making dry cargo the biggest market of the shipping industry in terms of cargo tons.

3.1.1.2 Motivation and research contributions

Our sample consists of 23 shipping firms listed in U.S. stock exchanges covering a period from 2000 to 2020 using annual observations. This research sheds light in investigating the relationship of chartering policy and financial performance for the U.S. listed shipping firms considering the shipping market segmentation effect. Since segments of the shipping industry follow different business cycles, it is worthwhile to investigate whether there is a segmentation effect on chartering policy and financial performance for the dry bulk and tanker shipping segments. There are four underlying reasons for this effect:[34] 1. The choice of chartering contract which reflects freight rate and contract's duration entails time varying risks (Kavussanos, 1996, 2003) and is the main source of income for each ship and consequently has an impact on the portfolio of investors holding shipping stocks. Namely, a well-diversified portfolio that includes shipping companies' stocks with a range of ship types and sizes chartered either on a short-term (voyage charter) or long-term (time charter) period

[34] Each shipping segment dry and tankers can be classified into sub-segments based on the chartering contract duration i.e., short, or long-term.

may be influenced as the choice of chartering contracts affects the cash-flow volatility for the shipowner. 2. Contracts of different charter duration are affected by time varying risks which are idiosyncratic (micro-specific), and market related (macro-specific) (Kavussanos 1996, 2003). Freight rates time-varying risks are not constant over time and form different business cycles for contracts of short or long-term charter duration. As a result, these business cycles have a time-varying impact on stock prices and shipping firms' financial performance. 3. Apart from the length of contract, there are no other costs that affect the change of chartering policy in each shipping segment. Either trading in the dry bulk or tanker segment, a shipping company can freely change its chartering policy without high costs once a ship's chartering contract matures.[35] As a result, shipowners' expectations about the future state of the freight market are reflected in the change of the chartering policy of each shipping firm trading in the dry bulk and tanker segment of the shipping industry influencing shipping firm's financial performance and 4. lastly, another motivation for this study is the fact that many shipping firms have a diversified fleet. Tanker and dry bulk shipping firms operate diverse fleets by ship type. In our sample of the dry bulk segment, there are 9 dry bulk firms with a total of 2836 ships that consist of 33 Handysize, 242 Handymax, 112 Supramax, 1489 Panamax, 825 Capesize and 835 Vlbcs. In the tanker shipping segment, there are 14 tanker firms of a total of 2747 ships that consist of 536 Handymax, 453 Panamax, 507 Aframax, 711 Suezmax and 540 Vlcc. These numbers show that the segmentation effect is very intense and obvious in both shipping segments.

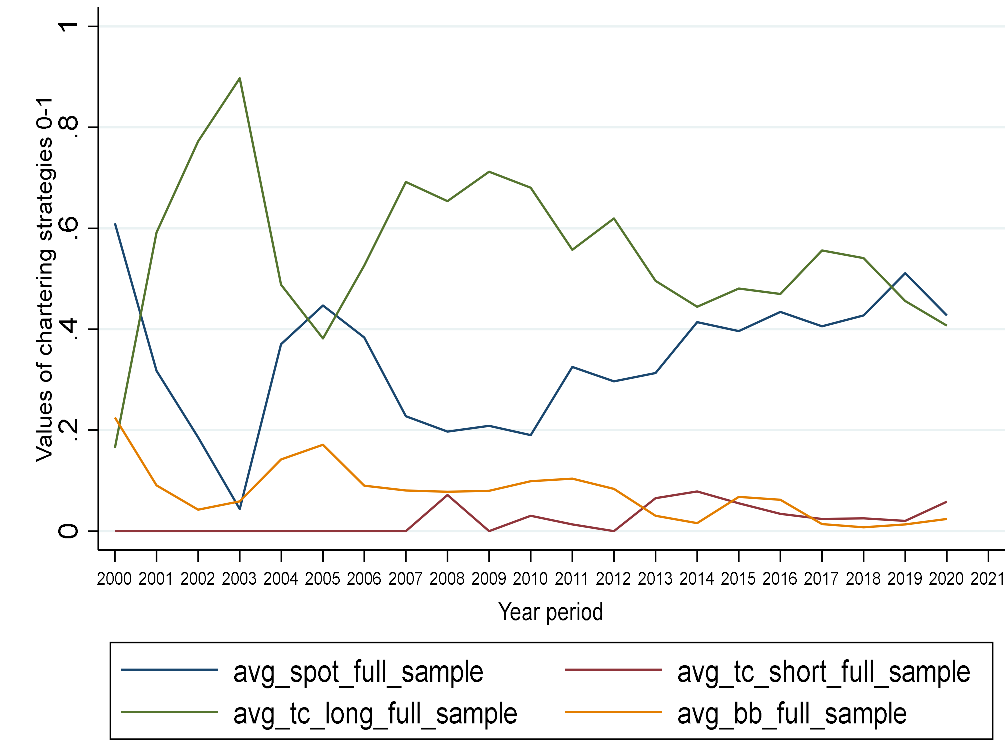
Considering the time-varying risks of freight contracts defined as volatility (Kavussanos, 1996, 2003) there is gap in the literature on how these risks influence the formation of chartering policy in the dry bulk and tanker shipping segment that has an effect on the financial performance of shipping firms. The extant literature has not adequately addressed the issue of how chartering policy in the tanker and dry bulk shipping segments impacts shipping firms' financial performance. This is despite the fact that the two shipping markets have distinct differences by virtue of the different ship types and cargoes they service. Therefore, this research by using a sample of U.S. listed shipping firms aims to fill this gap in the shipping finance literature by uncovering important inferences regarding the

[35] For example, in our sample, we observe shipping companies that change their chartering policy from chartering all ships under voyage charter to chartering all in time chartering

effect of chartering policy on shipping firms' financial performance in the dry and tanker shipping segments.

Initially, we estimate the chartering policy for the full sample (figure 3.1) identifying that there is much variation in the chartering strategies during the sample's period 2000-2020.[36] There is a negative correlation between time charter strategy with more than 1 year (*tc_long*) and *spot* charter with value -94.40%. It seems that U.S. listed shipping firms prefer chartering their ships more under time chartering strategy for ensuring future stable earnings, thus following a low risk chartering policy rather than being riskier by employing their fleet in the spot market. Based on the results, shipowners seem to ride the cycle rationally because from 2003 to 2007 it is observed that most of the ships were chartered under voyage charter and prior to the shipping crisis of May 2008, most of these ships were chartered on a long-term time charter basis.

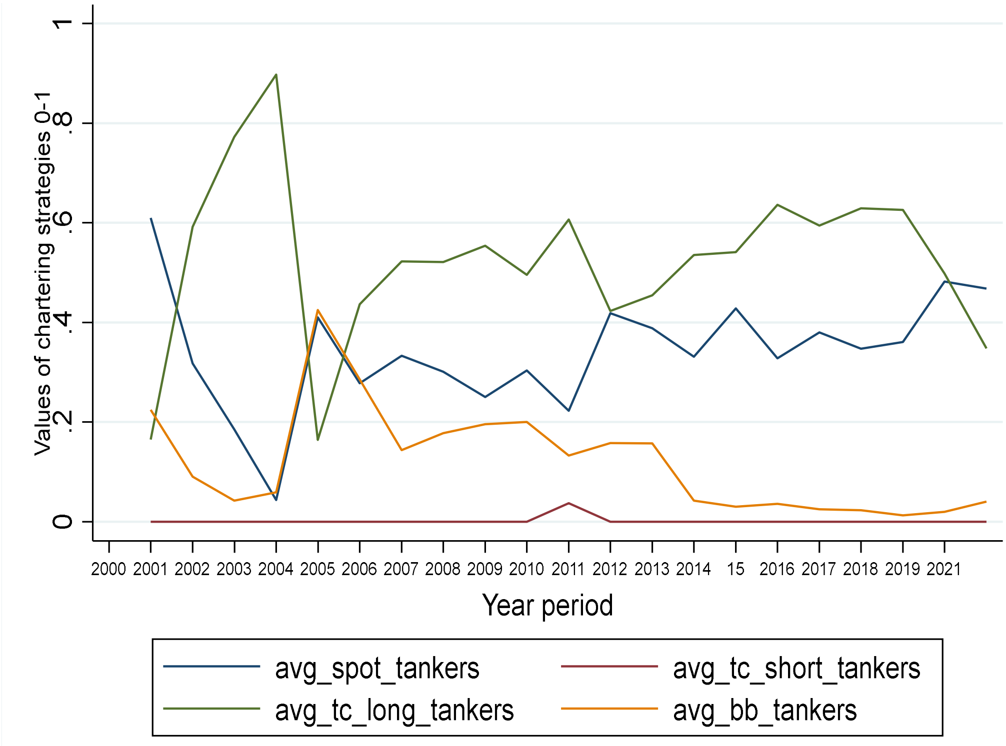
Figure 3:1 Mean values of chartering strategies between 2000-2020 for U.S. listed shipping firms



[36] This paper focuses on the chartering policy of dry and tanker shipping segments of U.S. listed shipping firms based on voyage and time charter. Bareboat chartering is used mostly for statistical comparisons.

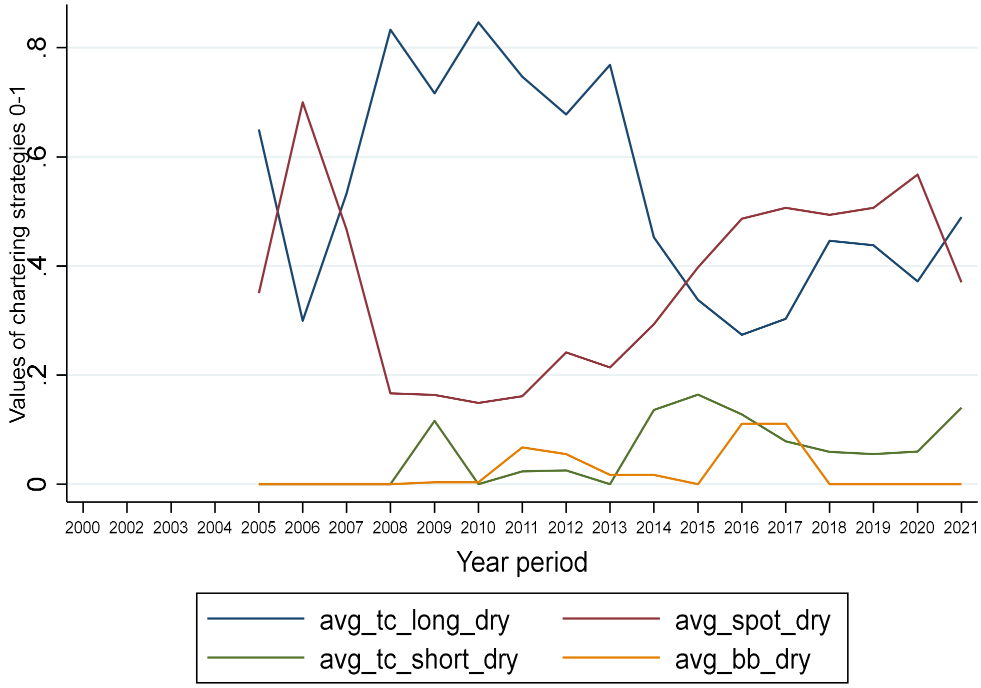
Figure 3.2 shows the chartering policy of tanker shipping segment of the U.S. listed shipping firms. Correlation between spot and time chartering strategy with more 1 year period is -78.89%. Similar to figure 3.1, shipowners realized that the increase of the freight rates was heading towards its peak thus, they chartered their ships on voyage charter prior to 2007. From 2007 and onwards, they employ most of their ships under long term chartering contracts on time charter with duration more than 1 year. This act has been continued until 2019.

Figure 3:2 Mean values of chartering strategies between 2000-2020 for U.S. tanker listed shipping firms



These results are quite different to the chartering policy in the dry bulk segment of U.S. listed shipping firms. As shown in figure 3.3. dry bulk shipowners acted in a similar way to tanker owners by employing their ships in the time charter market after 2008 but this ship chartering strategy has lasted in high levels until 2013. Probably, the higher supply of tonnage compared to the demand of tonnage in conjunction to the bunker crisis of 2014 forced tanker owners to retain their ships in the time charter market. *Tc_long* increased in 2007 and lasted until 2013.

Figure 3:3 Mean values of chartering strategies between 2000-2020 for U.S. dry bulk listed shipping firms



Note: This figure shows the mean values of chartering strategies for U.S. tanker shipping firms from 2000 to 2020

Time chartering with duration more than a year and voyage charter of U.S. Dry and Tankers listed shipping firms is shown in figure 3.4. It is noted that time chartering strategy rose more than 500% from 2006 to 2008 for dry firms and remained at high levels until 2013. From 2014, it fell back to the same level as it was in 2006 with few increases for the next years ahead. In the meantime, voyage chartering doubled from 2004 to 2005 from 35% to 70%. For tankers trading in the spot market, time chartering fell hugely from 2003 to 2004 and at that time started to increase reaching a level of four times higher until 2006 where it remained somewhat stable until 2019. *Spot* and *Tc_long* move in the opposite direction throughout the sample's period. By comparing the chartering policy for each segment (dry and tanker markets) we observe that both shipping segments follow different chartering policy, and they are expected to have a different effect on shipping firm's financial performance. One important point is that from 2014 the chartering policies for both tanker and dry bulk segments tend to concentrate in the mean values. In 2020 chartering policy tend to be very similar in both shipping segments. Time charters with duration more than 1 year started decreasing after 2004 for tanker firms but begun to increase for dry bulk firms after 2005.

These differences are due to shipping segmentation i.e., there are different time varying risks in each segment such as ship type, size and age. These time varying risks create different business cycles for each segment forcing shipowners to choose short-term contracts based on the current demand and supply for carriage of goods and long-term contracts based on their future expectations.

Figure 3:4 Mean values of TC_Long and Spot for dry & tankers U.S. listed shipping firms

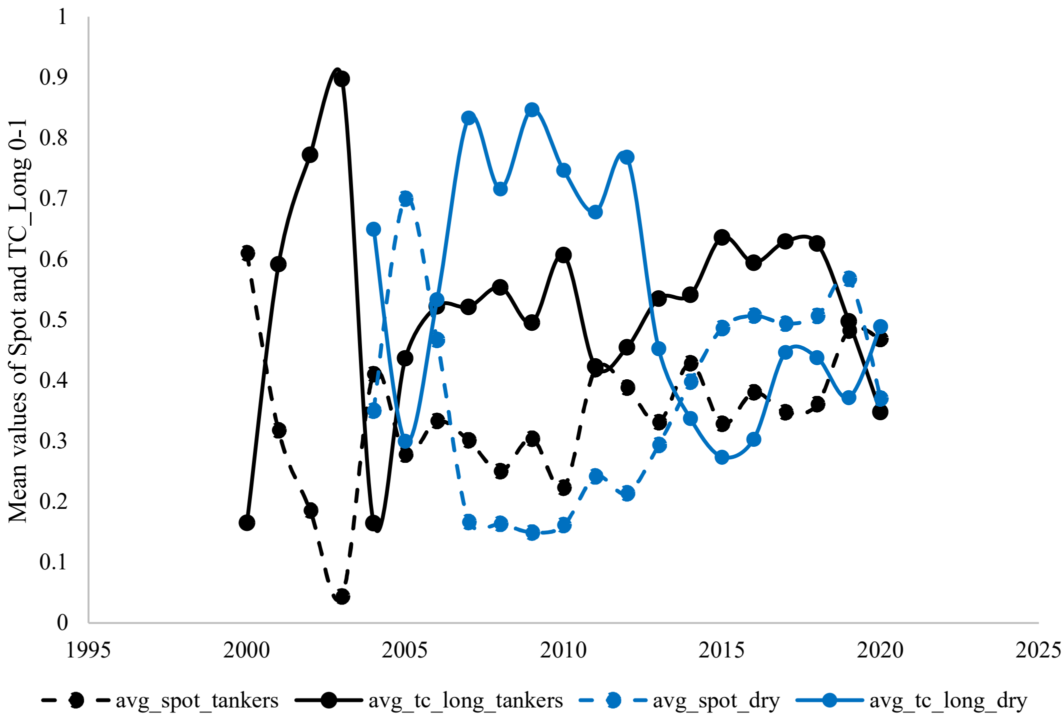
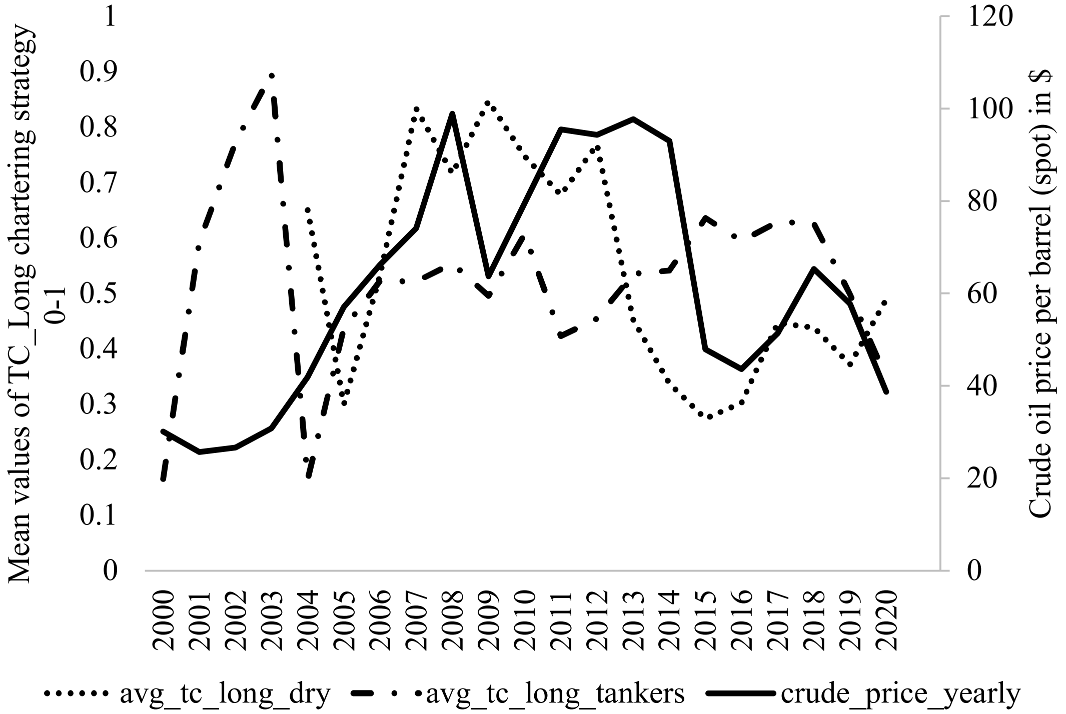


Figure 3.5 illustrates the time chartering with duration more than a year for each shipping segment dry bulk and tanker in combination to the change in the crude oil prices. It is of interest to mention that we compute correlation for crude oil price per barrel with mean values of *tc_long* for dry and tankers and we find a positive value of 40% for dry shipping segment and a negative value of 7% for tanker firms. This is not in line with Drobetz et al. (2012a) who find a positive relation of tanker segment with oil prices. Thus, we assume that price changes of crude oil per barrel have a positive but weak relation to dry bulk time chartering.

Figure 3:5 Tc_long for dry bulk and tankers versus crude oil price per barrel



Results indicate that by employing a higher proportion of the fleet under time charters with duration of more than a year, shipowners can achieve higher financial performance in both segments for the full sample. For the sub-samples of dry and tanker firms, we observe that employing a higher proportion of the fleet under time charter contracts with duration of more than a year in dry bulk shipping firms and employing a higher proportion of the fleet under voyage charter in the tanker shipping segment, shipowners can achieve higher financial performance. It can be suggested based on the results that a good approach for risk-averse investors is to invest in dry bulk firms that charter their ships mostly on time charters with duration of more than a year and in tanker firms that charter their ships mostly in the spot market for diversifying their risk. This paper has many implications for practitioners and academics. First, it captures the risk and return relationship in two sub-segments of the shipping market based on the contract's duration which influences the shipping firms' financial performance. Second, bankers can feel safe for granting a loan to a shipping firm which has a higher proportion of the fleet chartered under a long-term chartering strategy such as time charter contract. Thirdly, it assesses how the chartering policy differs in the two different shipping segments.

The rest of this paper is organized as follows. Section 3.2 discusses the extant literature and develops the research hypotheses examined. Section 3.3 outlines the methodology adopted, while Section 3.4 describes the dataset in detail. Section 3.5 reports the empirical results of the study and section 3.6 provides the ensuing discussion. Finally, Section 3.7 concludes the paper.

3.2 Literature review

3.2.1 Literature review on term structure of freight rates

In the finance literature, authors investigate the term structure of interest rates and stock prices (e.g.Campbell and Shiller, 1991;1987; Cuthbertson, 1996). The efficient market hypothesis states that in an efficient market all relevant information that is available to the investors, is accurately reflected in the stock prices (Malkiel, 1989). Thus, the shipping market is efficient if shipping services are priced correctly (Veenstra, 1999). In the shipping finance literature, the term structure of freight rates describes the relation between spot and period charter freight rates (Kavussanos and Alizadeh, 2002; Veenstra, 1999; Vanags and Hale, 1989) which can be simply explained as: a period freight rate is set and determined according to the spot rate expectations of market participants i.e. shipowners and charterers. Many studies investigate the formation and behavior of the term structure of freight rates. This study is related to the term structure of freight rates because different freight contracts' duration forms a different chartering policy for each segment i.e., the dry bulk and tanker shipping segments. Availability of chartering contracts with different durations offer the opportunity to trade risk and return based on the characteristics of each contract (short- and long-term) (Kavussanos and Alizadeh, 2002). The choice of contract's duration is expected to have an impact on shipping firms' financial performance in both tanker and dry bulk shipping segments in a different way. The expectations hypothesis of the term structure of freight rates will be valid if the long-term charter freight rates for one year will reflect the expected spot freight rates of the agents for this period. This relationship is true if the shipping freight market works efficiently. Our research is related to the term structure of freight rates studies because we use contracts of different duration i.e., short- and long-term for assessing their impact on the financial performance of shipping firms. Using spot and time charter fixtures from 1950 to 1959, Zannetos (1966) investigates the term structure of the tanker market. The author supports that the derived demand curve for oil tanker charters become upward sloping due to the formation of price-elastic expectations. Hawdon (2006) attempts to model tanker freight rates based on pre-specified assumptions. Beenstock and Vergottis (1989) support that the formation of period freight rates is a result of rational expectations in the dry cargo market. The relationship between short and long-term freight rates has also been investigated by Glen et al. (1981) that model the formation of charter rates expectations showing a link between spot and time charters. Similarly, the expectation hypothesis of the term structure of freight rates was rejected by Vanags and Hale (1989). Vanags and Hale (1989) could not find any evidence to support the expectations hypothesis. This relationship governs the dry and tanker freight markets due to the various short-term and long-term chartering contracts that are traded between shipowners and charterers in the industry. Veenstra (1999) provides empirical research for the relatiosnhip between spot and time charter rates for the bulk shipping segment using rates for 30000, 55000 and 120000 dwt dry bulk vessels. Applying the VAR model, the author concludes that there is evidence of a term structure relatiosnhip in the bulk shipping segment. Similarly, Kavussanos and Alizadeh (2002) test the term structure relatiosnhip in the shipping market by using multiple approaches for testing the validity of the term structure theory such as cointegration tests, var test, perfect foresight spread approach and EGARCH models for capturing any time-varying risk premiums. Results do not support the existence of the expectations hypothesis of the term structure in the formation of period rates in the dry bulk shipping market. This is attributed to the existence of a negative time varying risk premium.[37] Adland and Cullinane (2005) and Adland and Jia (2008) identify a risk premium and support that it should vary based on the time charter contract duration and the condition of the freight market. Also, Adland and Jia (2008) find a positive default risk premium which increases for short and long-term charter duration.[38] A negative time varying risk premium has been identified and exists due to the nature of the shipping service which is non-tradeable and non-storable

[37] Kavussanos and Alizadeh (2002) explain that the EHTS is not valid due to a negative risk premium. They support that this negative risk premium is the result of the perception the agents hold that longer-term charter contracts are less risky than a series of short-term chartering contracts. Therefore, a shipowner may accept a discount for signing a long-term chartering contract.

[38] Negative and positive risk premium are defined as: “The existence of a positive risk premium implies that forward freight rates will exceed expected future spot freight rates and, conversely, a negative risk premium implies that forward freight rates are lower than expected future spot freight rates.” (Adland and Jia, 2008a)

(Adland and Cullinane, 2005) implying that shipowners are positive to accept a loss for signing a long charter contract duration. These unique characteristics do not support the arbitrage pricing relationship i.e. one can buy from one market and sell in another for speculative purposes (Batchelor et al., 2007). Time varying risk premiums were identified in the finance literature by Domowitz and Hakkio (1985) and Engle et al. (1987) among others. Wright (2000) examines the long-run relationship between spot and period freight rates using cointegration tests resulting in the existence of a long-run parity between spot and period freight rates in the tanker market. Alizadeh and Nomikos (2011) prove the relationship between volatility of freight rates and the shape of the term structure of the freight market applying augmented E-GARCH models. Volatility is higher when the market is in backwardation and lower when is in contango. Our research contributes to the existing literature because it covers a long-time horizon in which agents in both dry and tanker markets may sign a mixture of chartering contracts (chartering policy) with different durations resulting in affecting the financial performance of the shipping firms differently.

3.2.2 Literature review on shipping segmentation

Research on shipping segmentation covers the areas of freight rate volatility, (Kavussanos, 1997; Gavriilidis et al., 2018), volatility spillover index in shipping segments (Tsouknidis, 2016), freight rate seasonality in tanker segment (Kavussanos and Alizadeh, 2002), and shipping stock betas for the different shipping segments (Kavussanos et al., 2010; Drobetz et al., 2010). The latter studies support that systematic risk does not differentiate in the various shipping segments of the industry such as dry, tanker and container. Similarly, Drobetz et al. (2016) model shipping betas as a function of firm-specific and macroeconomic variables. Market beta is observed to be cyclical and similar over the different shipping segments (bulk, container and tanker). According to Kavussanos (1996, 2003) there is a clear segmentation effect for dry and tankers segments of the industry found by computing the time-varying volatilities (using GARCH type models) of spot and time-charter freight rates for different vessel sizes. These time varying risks consist of idiosyncratic (micro-economic) and industry-related (macro-economic) risks that are not constant over time. These deviations affect the formation of shipping policies, transactions and the contracting agreements between charterers and shipowners (Brown et al., 1987; Kavussanos and Alizadeh, 2002).

Shipping freight rates are characterized by pronounced cyclicality (Stopford, 2009), distinct seasonality (Kavussanos and Alizadeh, 2001) and excess volatility (Kavussanos, 1996). Volatility of freight rates is used to measure risk. Kavussanos (1997) provides evidence of a segmentation effect in the dry cargo shipping market by examining the dynamics of conditional volatilities for 2nd hand ship prices. The sample includes data for monthly second-hand ships' prices in US dollars ($)and time charter rates as dollars per day ($/day) from 1976 to 1995 for dry bulk ships from Clarksons Research. Building an ARCH model the author shows that there are time-varying risks for different ship types and sizes resulting in different returns over time. Evidence of volatility clustering has been found as a reason of large shocks that affect the industry i.e., oil crises 1973-1974 and 1980-1981 among others.[39] Similarly, research for Capesize and Panamax ships' voaltiltiy dynamics has been undertaken by Chen et al. (2010) who show time varying evidence by applying a ECM-GARCH model. Drobetz et al. (2012) examine asymmetric impact of shocks and the influence of macroeconomic factors on time-varying volatility separately and simultaneously for both dry bulk and tanker freight shipping segments. Three different methods are applied: GARCH-X, EGARCH and EGARCH-X models proving that a t-distribution can better explain the conditional volatility. Also, macroeconomic variables must be considered in the conditional variance equation but not in the conditional mean equation. One important distinction between the two markets is that asymmetric effects are observed in the tanker freight market but not in the dry bulk freight market. Spillovers of time-varying freight rate volatilites were identified between the two segments, dry and tanker. Tsouknidis (2016) presents evidence for the segmentation effect in the shipping freight rates by investigating the existence of volatility spillovers between and within dry bulk and tanker freight market in the shipping industry using multivariate DCC-GARCH model and the volatility spillover index constructed by Diebold and Yilmaz (2012; 2009). Data includes freight rate indices from Baltic Exchange. Results show that there are volatility spillovers between dry-bulk and tanker freight market segments. Moreover, a significant result is that during the financial crisis smaller dry bulk ships transmit volatility to the higher dry bulk ships. Of importance is the finding that the tanker market transmits volatility to the dry bulk shipping market. Chen and

[39] Volatility clustering exists when "large changes in volatilities tend to occur around certain periods of time which are then followed by small changes." (Kavussanos, 1996)

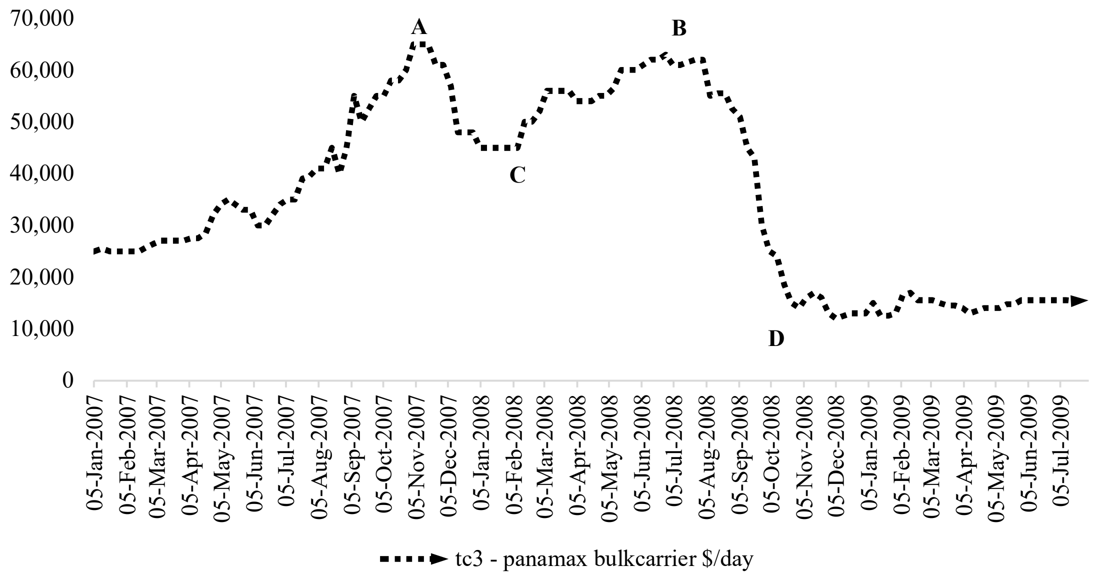
Wang (2004) examine the leverage effect in the international bulk shipping industry using Nelson's EGARCH. Volatility is pronounced during market downturns rather than upturns using daily returns of three different types of bulk vessels.

3.2.3 Theory and Hypotheses development

Business decision making in the shipping industry is an important area that entails risk because various uncertain outcomes may arise (Kavussanos et al., 2021). An example of a key business decision in shipping is the choice of chartering strategies that shipowners can adopt for each vessel owned in their fleet (Chistè and van Vuuren, 2014). The mixture of chartering strategies a shipowner chooses to adopt for the company's fleet represents the chartering policy of the shipping firm.

Chartering contracts of different durations (short-term or long-term duration) have different freight rate risks which are time varying (Kavussanos and Alizadeh, 2001; Kavussanos, 2003; Kavussanos, 1996; Kavussanos and Alizadeh, 2002). Period rates, i.e., time charter rates are formed based on the expectations for future price changes in the voyage charter rates (Kavussanos and Alizadeh, 2002; Veenstra, 1999) and offer stable future earnings but not flexibility of moving from the long-term charter market to spot charter market if the spot market rates rise steeply. Also, one important characteristic of the charterparties is that they are not tradable (Adland and Jia, 2008b) in an exchange market. Figure 3.6 shows in a period of two and a half years (January 2007 to July 2009) the change in the Clarksea index, where one can observe the extreme freight rate variability in the market for a Panamax dry bulk carrier on a 3-year charter.

Figure 3:6 3-yrs TC for Panamax dry bulker as $/day



Note: This figure shows the average time charter rates for Panamax dry bulk carriers from January 2007 to July 2009

For example, in November 2007, the time charter rates for a 3 year contract duration for a Panamax dry bulk ship was 65000 $/day falling to 45000 $/day in January 2008 and rising up again to 63000 $/day in June 2008. In November 2009 the rates fell to a low level of 14000 $/day. One can observe that had shipowners signed a time charter contract with duration of 3 years at the peaks of the shipping cycles, point A and B they could have enjoyed the high freight earnings until November 2010 and November 2011 respectively. In contrast, points C and D show the bottom of the shipping cycles.

As noted by Tsouknidis (2016) and Drobetz et al. (2012b), uncertainty and risk in shipping business decision making can be measured by volatility, which in turn affects the decisions of risk averse investors in the market. Risk averse investors prefer lower risk for certain profits rather than high risk with uncertain profits. The need to investigate the effect of chartering policy on the financial performance of the shipping firms in the dry bulk and tanker segments of the industry is unquestionably important for the reasons of portfolio diversification and better shipping stocks' investment decision making for risk averse investors. Shipping market segmentation causes different business cycles for dry and tanker shipping markets in which different chartering contracts with different durations i.e., short- and long-term are traded and exposed to freight rate risks. Freight rate risks are time varying

(Kavussanos et al., 2001), namely, freight rates change over time with the state of the market. Also, the volatilities (risks) of the freight rates vary with the changing market conditions.[40] Time varying volatilities consist of micro-specific/idiosyncratic and macro-specific/industry factors. The shipowner can diversify idiosyncratic risks i.e., to invest in other ship's sizes, to change ship's route and to replace ship's voyage charter with time charters. Practically, there are many differences between the two segments such as ship sizes, type of cargo transported and the route each type of ship follows. Thus, in different shipping segments, for example, dry versus tanker, shipowners must face different freight rate volatilities as a reason of freight contracts' charter duration and these volatilities have a direct effect on the firm's policy of ship chartering and therefore on the firm's financial performance.

Kavussanos (2003, 1997) and Kavussanos and Alizadeh (2002) estimate volatilities of different charter contracts duration and ships' sizes i.e., voyage and time charter for dry and tanker shipping segments. The results suggest that the volatilities of the dry shipping segment are higher than those in the tanker shipping segment. Kavussanos et al. (2021) estimate the volatilities of tanker and dry bulk ship segments for voyage and time charter rates (1 and 3 years). In both markets, bigger vessels, based on the ship deadweight capacity, entail higher volatilities in both spot and time charter markets. As the contract duration increases the volatilities decrease. Moreover, the dry bulk shipping segment exhibit higher values of volatilities overall compared to the tanker shipping segment. For instance, in the dry bulk segment, Capesize ships which are the larger in terms of deadweight tonnage are observed with higher volatility in both voyage and time charters with duration 1 and 3 years. The same observation stands for VLCCs in the tanker shipping segment. These outcomes support the presence of market segmentation. Therefore, the use of long-term chartering contracts ensures stable future earnings thus employing time chartering contracts in the dry shipping segment, may have a higher impact on the financial performance of dry bulk shipping firms.

Shipowners trading in the spot market are facing four risks (Kavussanos and Alizadeh, 2002): 1. Voyage charter rates are observed to be more volatile than time charter rates, 2. Voyage charters have the risk of unemployment once the contract ends, 3. The need

[40] Freight rates form the shipping cycle which follows the world economic cycle (Stopford, 2008)

to relocate the ship from a port to another port for a new voyage charter necessitates time and extra costs and 4. Under the voyage charter the volatile bunkers' cost risk lies with the shipowner. In contrast, two important advantages under time chartering are that bunkers costs is the responsibility of charterer and the shipowner secures future stable cash inflows for a period of time. Considering the uncertainty in the market which can be measured by volatility, it is expected that the two different shipping markets will exhibit significantly different behaviour in terms of chartering policy and there is a different impact on shipping firms' financial performance. Since volatility can be used to measure risk and uncertainty of a market; and dry bulk shipping exhibits higher volatilities in both spot and time charter markets, we form the following hypotheses:

Hypothesis 1: *Time chartering in the dry bulk shipping segment has a higher impact on financial performance than in the tanker shipping segment.*

Hypothesis 2: *Spot chartering in the tanker shipping segment has a higher impact on the financial performance than in dry bulk shipping segment.*

3.3 Methodology

Our aim is to investigate the impact of chartering policy on shipping firms' financial performance for the whole sample (dry and tanker firms) and separately for two different segments of the shipping market, the dry and tanker segments from 2000 to 2020.

We use a generic panel data model (1) for investigating the relationship between shipping firms' financial performance and chartering policy for a sample of 23 U.S. listed shipping firms. The generic panel data model allows for firm (fixed and time specific) and random effects. Panel data estimators account for unobserved heterogeneity among the different panel data firms.

$$y_{it} = a_i + \alpha_t + \sum_{k=1}^{K} \beta_k z_{kit} + \gamma Log(Clarksea)_t + u_i + \varepsilon_{it} \;; \qquad (3.1)$$

$$\varepsilon_{it} \sim i.i.d.(0, \sigma_\varepsilon^2), E(u_i) = 0, E(u_i^2) = \sigma_u^2, E(\varepsilon_{it} u_j) = 0, for \;\forall\; i, t, j; E(u_i u_j) = 0, for\; i \neq j$$

where y_{it} is the firm performance described by ROA, i =1, 2,…, n identifies the firm; t=1, 2,…,T denotes the time period (year); a_i and a_t are constant terms, which allow for the possibility of (constant) heterogeneous behavior between the firms (a_i) and over time periods

(a_t), respectively; β_k measures the effect that the k^{th} explanatory variable has on ROA; z_{kit} is a matrix of K variables which are firm-specific; γ measures the effect on ROA of the natural logarithm of the freight rates index *Clarksea,* which is industry-specific; u_i stands for the between-firms errors and is introduced in the model in order to allow for the possibility that firm-specific constant terms are randomly distributed across individual firms and ε_{it} is a white noise error term and stands for the within-firm errors following a distribution with mean zero and variance σ_{ε^2}. A consequence of the above is that both the u_i and ε_{it} are orthogonal with the regressors in the model; that is, $E_{(u_i z_{kit})=0}$ and $E_{(\varepsilon_{it} z_{kit})=0}$. Time constant fixed effects and a list of control variables are used for limiting the effect of endogeneity between dependent and independent variables (Roberts & Whited, 2013; Coles et al., 2012). Endogeneity may by caused by reverse causality between our dependent and independent variables. Similar panel data models were used by Kavussanos and Tsouknidis (2016; 2014) and Tsouknidis (2019).

The Hausman (1978) test is employed to assess whether a fixed or random effects panel data model is more favorable. Hausman tests the null hypothesis H_0: $\mathrm{E}(X_{\psi i}\ U_i) = 0$ and H_1: $\mathrm{E}(X_{\psi i}\ U_i) \neq 0$ Rejecting H_0 it means we proceed to fixed effects model estimation. In case, the Hausman (1978) test signifies the use of a fixed effect model, we proceed by using fixed effect model with time and firm effects. A random effects OLS model includes 2 common intercepts a_t and a_i for all panels and a random effect error term e_{it} which varies cross-sectionally but is constant over time. E_{it} captures how each entity's intercept deviates randomly from the common intercept a_i. $\chi_{\psi i}$ is a *1 x k* vector of independent variables. The following restrictions are applied on random effects OLS model:

$$E(e_{it} u_{it}) = 0$$

$$cov(e_{it} x_{\psi it}) = 0$$

$$e_{it} \sim i.i.d.(0, \sigma^2)$$

$$u_i \neq 0$$

The impact of each firm is derived from $a_i + u_i = 0$. u_i term measures any factors that are firm specific but are not accounted in the regression. The difference between the fixed and random effects OLS model is that no dummy variable exists to account for heterogeneity of the cross-sectional data. According to (Brooks, 2008), the coefficients of a random effects

OLS model are not computed efficiently due to the cross correlations between the error terms for each cross-sectional unit at different points in time. For this reason, it is plausible to use a generalised least squares random effects model to solve this issue. A GLS model procedure subtracts the weighted mean of the dependent variable over time so as to avoid the cross correlation between the error terms. If the Hausman test favours a random effects model, we then compute Breusch and Pagan (1980) Lagrange Multiplier to choose among a random-effects or a pooled OLS model. This t statistic tests the null hypothesis $H_0 : = \sigma_u^2 \ = \ 0$ and $H_1\text{: } \sigma_u^2 \ \neq \ 0$ where LM~$\chi^2(1)$. Shapiro and Wilk (1965) test is used to test for normality of the panel data variables. Shapiro and Wilk (1965) test the null hypothesis that the sample belongs to a normal distribution whereas the alternative hypothesis tests that the sample does not belong to a normal distribution. Also, tests for unit roots are generated using the Dickey-Fuller (1981) test. Regressing with variables that are not stationary may reach spurious and biased inferences. However, in case where variables are ratios or logarithm is taken, stationarity is not an important issue of the data. Treating error terms during model estimation is of utmost importance for avoiding biased inferences. According to OLS modelling, one of the assumptions is that the error term should be estimated independently and distributed identically. This distribution should be estimated in a way that the error terms are not correlated with the observations of the independent variables to avoid bias t-statistics estimations and significantly accepting independent variables that may not be so.

3.3.1 Measuring chartering policy

For measuring the chartering policy (*CP*) for our sample period from 2000 to 2020 we hand-collected data from SEC 20-F forms for each shipping firm for each year for each ship. We first identify the shipping firms with its ISIN number for avoiding any possible mistakes in the data collection and then we create four categories of charter contracts based on the SEC 20-F filings. The four categories of charter agreements that are described in SEC 20-F forms are a. Voyage agreements, b. Time charter agreements with maturity less than one year, c. Time charter agreements with maturity equal or more than a year and d. Bareboat agreements.[41]

[41] The sample included very few contracts of affreightment agreements which were excluded since their effect would be insignificant.

We then construct variables for capturing the chartering policy of each shipping firm for each year. Namely, the chartering policy consists of the charter agreements that each shipping firm charter its ships for a specific year. The variables constructed are shown below:

$$Spot_{it} = \frac{\sum_{f=1}^{F} DWT_{spot}}{\sum_{f=1}^{F} DWT_{TTL}}$$

$$TC\_short_{it} = \frac{\sum_{f=1}^{F} DWT_{TC\,<\,1\,year}}{\sum_{j=1}^{J} DWT_{TTL}}$$

Eq. (3.2)

$$TC\_long_{it} = \frac{\sum_{f=1}^{F} DWT_{TC\,\geq 1\,year}}{\sum_{j=1}^{J} DWT_{TTL}}$$

Where, f=1,…,F represents the ship's charter contract, i=1,…,n identifies each shipping firm, and t=1,…,T shows each time period of the sample i.e. each year. The deadweight tonnage chartered under each chartering agreement spot, time charter with maturity less than a year, time charter agreements with maturity equal or more than a year and bareboat are explained by DWT_{Spot} , $DWT_{TC\,<\,1\,year}$ and $DWT_{TC\,\geq\,1\,year}$ respectively. Finally, we use these three variables separately in each regression for assessing the impact of each chartering agreement of the financial performance of shipping firms for the sample period.

3.3.2 Control variables

The determinants of financial performance in the shipping industry are multiple. For that reason, we collect firm-level data from Thomson Reuters using shipping firms' tickers. This data is used as control variables for investigating the relationship between financial performance and chartering policy for the U.S. Listed shipping firms. In the finance literature, it has been found that financial performance is associated with many characteristics (Tang et al., 2012; Erhard et al., 2003; Capon et al., 1990; Masulis et al., 2007). Researchers in shipping finance found that financial performance is related to many corporate characteristics, for example, institutional ownership (Tsouknidis, 2019) corporate governance (Andreou et al., 2014) and corporate social responsibility (Drobetz et al., 2013b). As a result, being guided by the existing literature we use the following variables as controls in model (1): *log(Agev)* is the natural logarithm of the average age of the fleet measured in years. Age of firm has been found to be, *log(Avdwt)* is the natural logarithm of the average size of the fleet measured in deadweight tonnage (dwt), *log(Agef)* is the natural logarithm of the years since the firm has been incorporated. Age and firm performance were found to have a positive relationship in a sample of 43 U.S. listed sipping firms (Tsouknidis, 2019). *Lev* is the firm's long-term debt to total assets. Leverage has been found to be positively and negatively related in shipping industry by Tsouknidis (2019), Andreou et al. (2014) and Merika et al. (2015) respectively. *OpLev* is the ratio of operating expenses to total assets and has been used in (Drobetz et al., 2013a). *log(MVE)* is the natural logarithm of the market value of equity, *MVBV* is the ratio of market to book value, *clarkSea_vol* is the annualized volatility (standard deviation) of the ClarkSea's last twelve-monthly returns with a rolling window of one year, *log_clarkSea* is the weighted average index of earnings in the main sectors of commercial vessels, weighted by fleet size of the respective vessel type. *Stock_volatility* is the annualized volatility (standard deviation) of the firms' last 52 weekly stock returns (RI) with a rolling window of one year. Annual_vol_dry_spot is the annual volatility of monthly dry bulk ship spot rates for Capesize, Panamax and Handysize. Annual_vol_dry_6ms is the annual volatility of monthly dry bulk ship 6 months' time charter rates for Capesize, Panamax and Handysize. Annual_vol_dry_1tc is the annual volatility of monthly dry bulk ship 1 year's time charter rates for Capesize, Panamax and Handysize. Annual_vol_dry_3tc is the annual volatility of monthly dry bulk ship 3 years' time charter rates for Capesize, Panamax and Handysize. Annual_vol_dry_5tc is the annual volatility of monthly dry bulk ship 5 years' time charter rates for Capesize, Panamax and Handysize. Annual_vol_tanker_spot is the annual volatility of monthly tanker ship spot rates for VLCC, Suezmax, Aframax, Panamax and Handysize. Annual_vol_tanker_1tc is the annual volatility of monthly tanker ship 1 year's time charter rates for VLCC, Suezmax, Aframax, Panamax and Handysize. Annual_vol_tanker_1tc is the annual volatility of monthly tanker ship 3 years' time charter rates for VLCC, Suezmax, Aframax, Panamax and Handysize.

Annual_vol_tanker_5tc is the annual volatility of monthly tanker ship 5 years' time charter rates for VLCC, Suezmax, Aframax, Panamax and Handysize.

3.4 Dataset

The data used in this paper uses data collected for a period of 20 years from 2000 to 2020. Our initial sample includes 36 shipping companies from which the 30 are active in NYSE and Nasdaq stock exchanges whereas the remaining 6 are currently delisted. The final sample includes 23 shipping firms from which 14 are tanker firms and 9 are dry bulk firms.[42] The full-sample accounts for 353 firm-year observations. Shipping firms were chosen based on the following conditions: (a) at least 60% of their income to be generated from shipping transportation activities (b) chartering policy variable to be constructed by collecting information from SEC 20-F forms which are publicly available and mandatory for listed shipping firms in the American stock exchanges and (c) to collect any available data for constructing control variables from Compustat, Thomson Reuters Eikon and Worldscope databases.

The shipping firms' chartering policy variable was cross matched using shipping firms' CIK numbers mostly for achieving validity and efficiency of the data collection.[43] Shipping firms belong to the standard industrial code (SIC) of 4400 (Water Transportation). This parent directory consists of two sub-codes 4410/4412 (Deep Sea Foreign Transportation of Freight). SIC 4400 is the parent directory described as: "This major group includes establishments engaged in freight and passenger transportation on the open seas or inland waters, and establishments furnishing such incidental services as lighterage, towing, and canal operation. This major group also includes excursion boats, sight-seeing boats, and water taxis." (URL accessed on 20th March 2021, SIC Code 44 - Water transportation): SIC 4412 is a sub-category and has the following description: "Establishments primarily engaged in operating vessels for the transportation of freight on the deep seas between the United States and foreign ports. Establishments operating vessels for the transportation of freight which travel to foreign ports and also to non-contiguous territories are classified in this

[42] Shipping firms used for investigation are in Table A3.1 in the Appendix IV.
[43] A CIK number is a Central Index Key number. The CIK is used as a unique identifier for financial filings with the Security and Exchange Commission of the USA

industry." (URL accessed on 20th March 2021, SIC Code 4412 Deep Sea Foreign Transportation of Freight For collecting the chartering policy data, we firstly search which of the available shipping firms included in the standard industrial codes of Securities and exchange commission webpage of U.S. issue the 20-F form. If they issue this form, we then collect data regarding the chartering policy of each shipping firm from 2000 to 2020. The total number of shipping firms listed in the U.S. stock exchanges are 229 based on the SIC codes above. Among them, only 43 shipping firms were observed to issue SEC 20-F form. The final sample consists of shipping firms trading in the tanker and dry shipping sectors.[44] In our sample of dry bulk segment, there are 9 dry bulk firms with a total of 2836 ships consisting of 33 Handysize, 242 Handymax, 112 Supramax, 1489 Panamax, 825 Capesize and 835 VLBC. In the tanker shipping segment, there are 14 tanker firms of a total of 2747 ships consist of 536 Handymax, 453 Panamax, 507 Aframax, 711 Suezmax and 540 VLCC. The average age of the dry bulk ships is 9.48, 9.84, 6.20, 7.48, 6.11 and 5 years old for the 33 Handysize, 242 Handymax, 112 Supramax, 1489 Panamax, 825 Capesize and 835 VLBC, whereas the average age of the tankers is 6.73, 6.10, 6.55, 8.11 and 8. for the 536 Handymax, 453 Panamax, 507 Aframax, 711 Suezmax and 540 VLCC. There is higher variation in the age of dry bulk ships compared to tanker ships.

3.4.1 Description of the variables

All the variables used are listed and described in the table 3.1. For measuring the impact of chartering policy on shipping firm's financial performance we use chartering policy and a range of control variables. Table 3.1 also shows the sources of the data. Our dependent variable is *ROA*, which is described as the ratio of operating income before depreciation and provisions over total assets. Chartering policy (*CP*), the act of shipping firm to charter its ships under different charterparties i.e., spot, time and bareboat charter is the variable of interest. *CP* is formed by identifying the number of ships owned by each firm for each year and under which chartering strategy each ship for each firm for each year is chartered. Tickers' code and ISIN were used to match the shipping firms' firm-level data in

[44] We exclude any shipping firms that own a diversified fleet i.e. trading in multiple shipping markets rather than one i.e. dry

the Thomson Reuters data.[45] Appendix III includes the firm used for the panel data estimations.

Table 3-1: List of variables used in Equation (3.1)

Type of variable	Description	Source/item
Dependent variable	*ROA:* is the ratio of operating income before depreciation and provisions (oibdp) divided by total assets (at).	Compustat (oibdp/at)
Independent	*Chartering Policy (CP)* is measured by the following four variables for each firm and year in the sample: *Spot:* is the total deadweight tonnage of ships chartered under spot (voyage) chartering contracts over the fleet's total deadweight tonnage. *Tc_short:* is the total deadweight tonnage of ships chartered under time chartering contracts with duration less than one year over the fleet's total deadweight tonnage. *Tc_long:* is the total deadweight tonnage of ships chartered under time chartering contracts with duration equal/over one year over the fleet's total deadweight tonnage. *BB:* is the total deadweight tonnage of ships chartered under bareboat chartering contracts over the fleet's total deadweight tonnage.	SEC 20-F
Controls	*Log(Agev)* is the natural logarithm of the average age of the fleet measured in years.	SEC 20-F
	Log(Avdwt) is the natural logarithm of the average size of the fleete measured in deadweight tonnage (dwt).	SEC 20-F
	Log(Agef) is the natural logarithm of the years since the firm has been founded. The founding date of each firm is obtained through its official website and cross-checked through its publicly disclosed financial statements.	SEC 20-F
	Lev: is the ratio of the firm's long-term debt (dltt) over total assets (at).	Compustat (dltt/at)

[45] ISIN means International Securities Identification Number and is used to uniquely identify a security.

OpLev is the ratio of operating expenses total (WC01249) over total assets (at)	Worldscope and Compustat (at)
Log(MVE) is the natural logarithm of the market value of equity (MV). Market value is the share price multiplied by the number of ordinary shares in issue.	Compustat (mkvalt)
MVBV is the ratio of market to book value, computed as market value of equity (mkvalt) divided by book value of common equity (ceq).	Compustat (mkvalt/ceq)
VolClarkSea is the annualized volatility (standard deviation) of the ClarkSea's last twelve-monthly returns with a rolling window of one year.	Clarksons SIN
Log_clarkSea: The weighted average index of earnings in the main sectors of commercial vessels, weighted by fleet size of the respective vessel type.	Clarksons SIN
Retsd is the annualized volatility (standard deviation) of the firms' last 52 weekly stock returns (RI) with a rolling window of one year.	Refinitiv Eikon - RI
Annual_vol_dry_spot is the annual volatility of monthly dry bulk ship spot rates for Capesize, Panamax and Handysize	Clarksons SIN
Annual_vol_dry_6ms is the annual volatility of monthly dry bulk ship 6 months' time charter rates for Capesize, Panamax and Handysize	Clarksons SIN
Annual_vol_dry_1tc is the annual volatility of monthly dry bulk ship 1 year's time charter rates for Capesize, Panamax and Handysize	Clarksons SIN
Annual_vol_dry_3tc is the annual volatility of monthly dry bulk ship 3 years' time charter rates for Capesize, Panamax and Handysize	Clarksons SIN
Annual_vol_dry_5tc is the annual volatility of monthly dry bulk ship 5 years' time charter rates for Capesize, Panamax and Handysize	Clarksons SIN
Annual_vol_tanker_spot is the annual volatility of monthly tanker ship spot rates for VLCC, Suezmax, Aframax, Panamax and Handysize	Clarksons SIN

	Annual_vol_tanker_1tc is the annual volatility of monthly tanker ship 1 year's time charter rates for VLCC, Suezmax, Aframax, Panamax and Handysize	Clarksons SIN
	Annual_vol_tanker_1tc is the annual volatility of monthly tanker ship 3 years' time charter rates for VLCC, Suezmax, Aframax, Panamax and Handysize	Clarksons SIN
	Annual_vol_tanker_5tc is the annual volatility of monthly tanker ship 5 years' time charter rates for VLCC, Suezmax, Aframax, Panamax and Handysize	Clarksons SIN

Note: this table presents all the variables used in equation 3.1 including their description and source. Item describes the variables code in the database. RI is the total return index of the stock price each week.

Table 3.2 describes the variables used with their appropriate statistics. All the variables are winsorized at 1st and 99th percentile to avoid the effect of any outliers and errors in the data. Furthermore, Shapiro and Wilk test is used to assess the normality of the data in the sample. *Roa* has a value of 8.24% while is standard deviation is 7.18% showing the variance in the shipping firms' profitability from 2000 to 2020. Tsouknidis (2019) and Andreou et al. (2014) estimate a return on assets of 2.3% and 13.7% respectively. Variables of chartering policy are all observed with minimum and maximum values of 0 and 1 respectively. It seems that the fleet of the shipping firms over the sample period is chartered under a long-term chartering period since the average value of *tc_short*, *tc_long* and *bb* together equals to 0.7243 whereas *spot* has a value of 0.2757. The age of all the ships observed and used in the sample *(avg_ship_age)* have an average age of 8 years and the oldest ship is almost 25 years old. The mean of *avdwt* and *agef* are 109791 and 15 years respectively. Shipping firms are observed to exhibit high leverage ratio i.e., the mean is 41.3618%. A similar result is estimated by Tsouknidis (2019) and Andreou et al. (2014). Maximum value of leverage shows that shipping firms may reach high gearing ratios showing their dependence on borrowing. The operating leverage (*oplev*) has a mean value of 14.69% and standard deviation of 10.35%. This mean value is in contrast to Drobetz et al. (2013a) that identifies a mean value of 50% and Alexandridis et al. (2019) that estimate a mean value of 47%. Market value of equity (mve) has a mean value of $595 mn. Market to book value ratio (*mvbv*) mean equals 0.9867 while its standard deviation is 0.9677. This average value is similar to Tsouknidis (2019) and Drobetz et al. (2013a). *Clarksea* index measured in $/day has an average value of $15593.1500 and standard deviation equals to $7204.8890 showing the variance in the freight earnings of shipping industry. Kavussanos and Tsouknidis (2014) and Tsouknidis (2019) report an average value of $25209 and $17243 respectively. *Annual_vol* and *annual_vol_ret* shows the volatility of freight earnings of the industry and shipping stocks' respectively. both are observed with extreme volatility as per their average values of 0.45 and 0.54 respectively. *Avg_vol_dry_spot* and *Avg_vol_tanker_spot* show the annyalized volatilities for dry and tanker segments for vessels Capesize, Panamax, Handysize and VLCC, Suezmax, Aframax, Panamax and Handysize respectively. Their mean values are 43.75% and 53.79% respectively. *Avg_vol_dry_6ms*, *Avg_vol_dry_1tc*, *Avg_vol_dry_3tc*, *Avg_vol_dry_5tc* and *Avg_vol_tanker_1tc*, *Avg_vol_tanker_3tc*, *Avg_vol_tanker_5tc* shows the volatilities for dry and tanker vessels mentioned above for time charter contract duration of six months (6ms), 1 year (1tc), 3 years (3tc) and 5 years (5tc).

Table 3-2: Descriptive statistics of variables used in Equation 3.1

Variables	Mean	Median	Standard Deviation	Min	Max	Skewness	Kurtosis	S-W [p-value]
ROA (%)	0.0824	0.0794	0.0718	-0.3119	0.3634	-0.3205	11.1507	8.386 [0.0000]
Spot	0.2757	0.0812	0.3558	0	1	1.0095	2.5178	7.203 [0.0000]
Tc_short ratio	0.0227	0	0.1053	0	1	6.2364	48.1523	10.839 [0.0000]
Tc_long ratio	0.6256	0.7573	0.3821	0	1	-0.5136	1.7085	5.993 [0.0000]
Bb ratio	0.0602	0	0.1644	0	1	3.4332	15.0357	10.416 [0.0000]
Avg_ship_age (years)	8.0076	1.6034	3.8717	0	24.8	0.7238	4.4502	4.852 [0.0000]
Avdwt	109791.4000	92126.8300	66717.0400	4243.3330	357134	0.9538	3.8091	6.581 [0.0000]
Agef (years)	15.5249	11	15.2613	0	73	1.8849	6.2735	9.654 [0.0000]
Lev (%)	41.3618	44.2220	18.6265	0	99.6235	-0.5258	3.2005	5.268 [0.0000]
Oplev (%)	14.6914	12.3756	10.3522	4.1878	83.3459	3.3419	19.4702	10.175 [0.0000]
Mve ($mln)	565.9266	360.0270	579.4185	2.7847	2632.6620	1.4415	4.7277	8.463 [0.0000]

Mvbv ratio	0.9867	0.6886	0.9577	0.0221	6.1688	2.6493	12.4741	9.525 [0.0000]
Clarksea ($/day)	15593.1500	12314.5200	7204.8890	9440.6560	33061.2600	1.5172	3.9211	10.562 [0.0000]
Annual_vol	0.4533	0.4284	0.1485	0.2371	0.9160	1.2301	4.8881	8.157 [0.0000]
Annual_vol_ret (%)	0.5419	0.4476	0.3673	0	2.3230	1.9126	8.6396	8.842 [0.0000]
Avg_vol_dry_spot	0.4379	0.3877	0.1682	0.2789	0.9332	1.6393	5.0528	9.810 [0.0000]
Avg_vol_dry_6ms	0.4716	0.4209	0.2029	0.2270	1.2083	2.4780	9.3870	11.290 [0.0000]
Avg_vol_dry_1tc	0.3467	0.3175	0.1812	0.1525	1.0563	3.1300	12.3951	12.183 [0.0000]
Avg_vol_dry_3tc	0.2306	0.2061	0.1698	0.0733	0.9039	3.2081	12.9734	12.141 [0.0000]
Avg_vol_dry_5tc	0.1962	0.1345	0.2261	0.0832	1.0637	3.4158	13.2870	12.203 [0.0000]
Avg_vol_tanker_spot	0.5975	0.5292	0.2010	0.2970	1.0808	0.7860	2.9510	7.301 [0.0000]
Avg_vol_tanker_1tc	0.2018	0.1935	0.0867	0.1104	0.4801	1.9246	1.0788	10.450 [0.0000]
Avg_vol_tanker_3tc	0.1012	0.0965	0.0421	0.0145	0.1822	0.1215	2.8733	5.909 [0.0000]
Avg_vol_tanker_5tc	0.0804	0.0755	0.0399	0.0262	0.1673	0.2614	2.0412	6.365 [0.0000]

Note: this table shows the descriptive statistics of variables used in equation 1. Min and max stands for minimum and maximum values of the sample respectively. S-W is the Shapiro and Wilk (1965) test for normality. Numbers in [.] describes p-values. Skewness and kurtosis describe the 3rd and 4th moment of the data. All the variables are winsorized at 1% and 99% percentiles to treat any extreme values in the data (outliers) or possible errors.

Table 3.3 describes the pair-wise Pearson correlation matrix for the variables used in equation (1). The values show the low correlation between our variables signifying the absence of multicollinearity in our model estimation. We also include the variables for measuring volatilities in the pearson correlation matrix. Results shows high correlation between Clarksea ($/day), Annual_vol, Annual_vol_ret (%), Avg_vol_dry_spot, Avg_vol_dry_6ms, Avg_vol_dry_1tc, Avg_vol_dry_3tc, Avg_vol_dry_5tc, Avg_vol_tanker_spot, Avg_vol_tanker_1tc, Avg_vol_tanker_3tc, Avg_vol_tanker_5tc. However, this is not a problem since they are used separately in each model. The Pearson correlation matrix is not included in the text or appendices due to space unavailability.

Table 3-3: Pearson correlation matrix (Chapter 3)

Variables	roa	spot	tc_short	tc_long	bb	avg_ship_age	avdwt	agef	lev	oplev	mve	mvbv	ckarksea	annual_vol	annual_vol_ret
roa	1.000														
spot	-0.235*	1.000													
tc_short	-0.102	-0.114*	1.000												
tc_long	0.224*	-0.824*	-0.129*	1.000											
bb	0.026	-0.102*	-0.074	-0.300*	1.000										
avg_ship_age	0.088	0.141*	-0.044	-0.105*	-0.026	1.000									
avdwt	0.206*	0.210*	-0.072	-0.132*	-0.110*	-0.021	1.000								
agef	0.095	-0.114*	-0.034	0.165*	-0.082	0.418*	-0.002	1.000							
lev	0.148*	-0.227*	-0.027	0.305*	-0.129*	0.054	0.111*	0.218*	1.000						
oplev	-0.159*	0.455*	-0.049	-0.506*	0.009	0.270*	0.120*	-0.049	-0.228*	1.000					
mve	0.174*	-0.005	-0.116*	0.073	-0.092	0.055	0.331*	0.278*	0.168*	-0.202*	1.000				
mvbv	0.186*	-0.072	-0.104	0.051	-0.019	0.201*	0.213*	0.212*	0.173*	0.098	0.443*	1.000			
clarksea	0.308*	-0.048	-0.084	0.041	0.095	0.100	0.067	-0.111*	-0.032	-0.019	0.026	0.209*	1.000		
volclarksea	0.104	-0.006	0.009	-0.019	0.000	0.087	0.031	0.004	0.003	0.001	-0.021	-0.096	0.004	1.000	
Retsd	-0.198*	0.111*	0.127*	-0.130*	-0.090	-0.085	-0.184*	-0.132*	-0.081	0.235*	-0.331*	-0.230*	-0.103*	0.206*	1.000

Note: this table shows the Pearson correlation matrix with the variables pair-wise linear correlations. These variables are used in Eq(3.2). Tc_long and spot are highly correlated however, these variables are never used in the equation together but individually every time. *** p<0.01, ** p<0.05, * p<0.1

3.5 Empirical estimations

3.5.1 Panel data regressions estimations

In this section we present the results of the panel data estimations (Table 3.4). We firstly present the results of the whole sample and then we present table 3.5 with the variables of interest for dry and tanker firms separately. We regress the dependent variable *Roa* with the variables of interest and the control variables.

Table 3-4: Panel data regressions for each model (Full sample)

Variables	M1	M2	M3	M4	Standardized coefficients
Constant	-25.7074 (-1.04)	-7.9356 (-0.36)	-25.1777 (-1.17)	-14.7758 (-0.67)	-
Spot	-0.8568 * (-1.91)	-	-	-	-0.3514
TC_short	-	-2.4040 *** (-3.86)	-	-	-0.3696
TC_long	-	-	1.4977 *** (3.54)	-	0.6059
BB	-	-	-	0.0042 (0.01)	0.0379
Log(Avagev)	-0.2606 ** (-1.91)	-0.1345 (-0.61)	-0.1875 ** (-2.47)	-0.2095 (-1.03)	-
Log(Avdwt)	0.1886 (1.13)	0.1981 (0.76)	0.3972 * (2.00)	0.0286 (0.13)	-
Log(Agef)	-0.2069 (-1.26)	-0.1582 (-1.15)	-0.0601 (-0.57)	-0.1794 (-1.04)	-
Lev	-0.4027 (-1.26)	-0.1276 (-0.38)	-0.2206 (-0.90)	-0.1861 (-0.51)	-
OpLev	4.2820 *** (3.64)	3.1086 *** (3.38)	4.9161 *** (5.16)	3.4405 *** (3.66)	-
Log(MVE)	0.3714 *** (3.69)	0.2289 *** (3.15)	0.3960 *** (4.01)	0.3096 *** (3.99)	-
MVBV	-0.0983 (-0.96)	-0.0824 (-0.98)	-0.1255 (-1.60)	-0.0797 (-0.73)	-
Log(ClarkSea)	1.7775 (0.78)	0.1923 (0.08)	1.5640 (0.71)	1.1078 (0.47)	-
VolClarkSea	0.3446 (0.37)	0.8981 (1.07)	0.2103 (0.25)	0.6607 (0.71)	-
Retstd	-0.8951 ** (-2.70)	-0.6430 ** (-1.60)	-0.6088 * (-2.01)	-0.9355 ** (-2.69)	-
Observations (firm-year)	224	224	224	224	-
Cluster standard errors	Yes	Yes	Yes	Yes	
Adjusted R^2	33.23%	37.26%	35.86%	30.09%	-
F-stat	16.46	31.13	30.05	14.91	
[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	
Firm fixed effects	Yes	Yes	Yes	Yes	-

Time fixed effects	Yes	Yes	Yes	Yes	-

Note: This table shows the results of the estimated panel data regressions for the 28 shipping firms from 2000 to 2020 using ROA as dependent variable for examining its relationship with chartering policy (spot, tc_short, tc_long and bb). Also, control variables were used. Hausman (1978) test is used to choose between fixed or random effects model. In case, a random effects model is resulted, we then use Breusch-Pagan test for choosing among a pooled OLS or a random effects model. T-statistics and p-values are reported in (.) and [.], respectively. Statistical significance of the estimated coefficients is denoted with *, ** and *** for 10%, 5% and 1% significance levels, respectively. As a final robustness test, we follow Petersen (2009) cluster adjusted standard errors at the firm level.

Both short-term chartering strategies i.e., *spot* and *tc_short* variables have negative and are statistically significant in 5% and 1% confidence interval respectively. Their coefficients are equal to -0.8568 and -2.4040 respectively. In contrast, *tc_long* and *bb* (bareboat) have a positive sign with *tc_long* to have a p-value equals to 0.002. *Tc_long* has a coefficient equals to 1.4977 and *bb* coefficient is 0.0042. The coefficient for both long-term chartering strategies i.e., *tc_long* and *bb* shows the positive relationship with *roa* (financial performance). R^2 ranges between 14.91% and 31.13%. Similar values are found by Kavussanos and Tsouknidis (2016, 2014). Regarding the control variables, *lavagev* is statistically significant for all models 1 and 3 in 5% confidence interval. *Oplev* and *lmve* are statistically significant in 1% confidence interval for all the chartering strategies *spot*, *tc_short*, *tc_long* and *bb*. *Retsd* is statistically significant in 5% and 10% confidence interval for *spot*, *tc_short, bb and tc_long* respectively. Results of the panel data regression for the full-sample show that increasing the long-term chartering strategies and decreasing the short-term chartering strategies a shipping firm can achieve higher financial performance. Increasing the deadweight tonnage chartered under long-term chartering strategies will lead to higher financial performance.

Table 3-5: Panel data regression for dry (sub-sample 1) and tanker firms (sub-sample 2) separately

	Dry firms sub-sample 1			
Variables	**M1**	**M2**	**M3**	**M4**
Spot	-0.6564 (-0.73)	-	-	-
TC_short	-	-2.3793 ** (-2.18)	-	-
TC_long	-	-	2.0174 ** (3.35)	-
BB	-	-	-	1.3818 (1.04)

Number of observations	100	100	100	100
Adjusted R^2	44.63%	42.55%	41.00%	44.63%
Cluster standard errors	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes
Tanker firms sub-sample 2				
Spot	-0.2323 (-1.19)	-	-	-
TC_short	-	0.3079 (0.19)	-	-
TC_long	-	-	0.3039 (1.16)	
BB	-	-	-	0.1081 (0.19)
Number of observations	124	124	124	124
Adjusted R^2	7.74%	3.26%	11.55%	4.18%
Cluster standard errors	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes

Note: this table shows the panel data regression model for dry and tanker firms individually. Panel data regressions were estimated for the dry and tanker shipping firms from 2000 to 2020 using *ROA* as dependent variable for examining its relationship with chartering policy (*spot*, *tc_short*, *tc_long* and *bb*). T-statistics are reported in (.). Statistical significance of the estimated coefficients is denoted with *, ** and *** for 10%, 5% and 1% significance levels, respectively.

Table 3.5 shows the results of panel data regression for dry firms (sub-sample 1) and tanker firms (sub-sample 2). For dry firms, we notice that *tc_short* and *tc_long* are statistically significant with p-values equal to 0.038 and 0.018 respectively. For the tanker firms, none chartering strategy is statistically significant. Based on the results, long-term chartering strategies receive a positive coefficient for both sub-samples. The only difference between the two sub-samples is the coefficient of *tc_short* variable is positive for tanker firms whereas is negative for dry firms. Spot variable has a negative sign which represents voyage between 30-50 days whereas *tc_short* and *tc_long* are shipping trips with longer chartering duration. *Tc_long* has a positive sign and is significant for dry bulk shipping segment so we can accept the hypothesis 1a that time chartering in dry bulk shipping segment has a higher impact on financial performance than tanker shipping segment. Both spot strategies for tanker and dry bulk segments they are not receiving any statistical significance, however, results mean that *roa* decreases by 0.65 (dry) and 0.23 (tankers) when spot strategy decreases by 1.

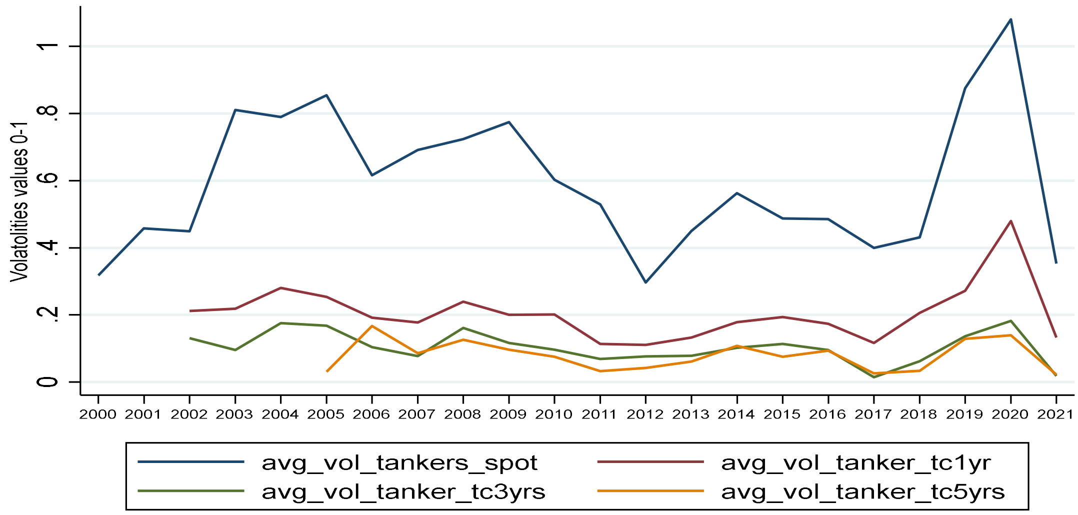
Thus, we accept the hypothesis 1b, that spot chartering in tanker shipping segment has a higher impact on financial performance than in dry bulk shipping segment.

3.5.2 Volatility estimations for dry and tanker segments

In this section, we provide explicit explanation of the results for measuring volatilities in the dry and tanker segments of the shipping industry. We use data from Clarksons research intelligence for dry and tankers shipping segments using period and spot rates for different types and size of vessels. For the time charter period rates, we use rates for period of 6 months, 1 year, 3 years and 5 years. Spot rates are gathered from different ship' voyages charter rates. Both time charter and spot rates can be found in Appendix VI in table A3.1. by using these data, we compute the annualized volatility of freight rates for spot and time charter rates. The computation is explained in Appendix VII.

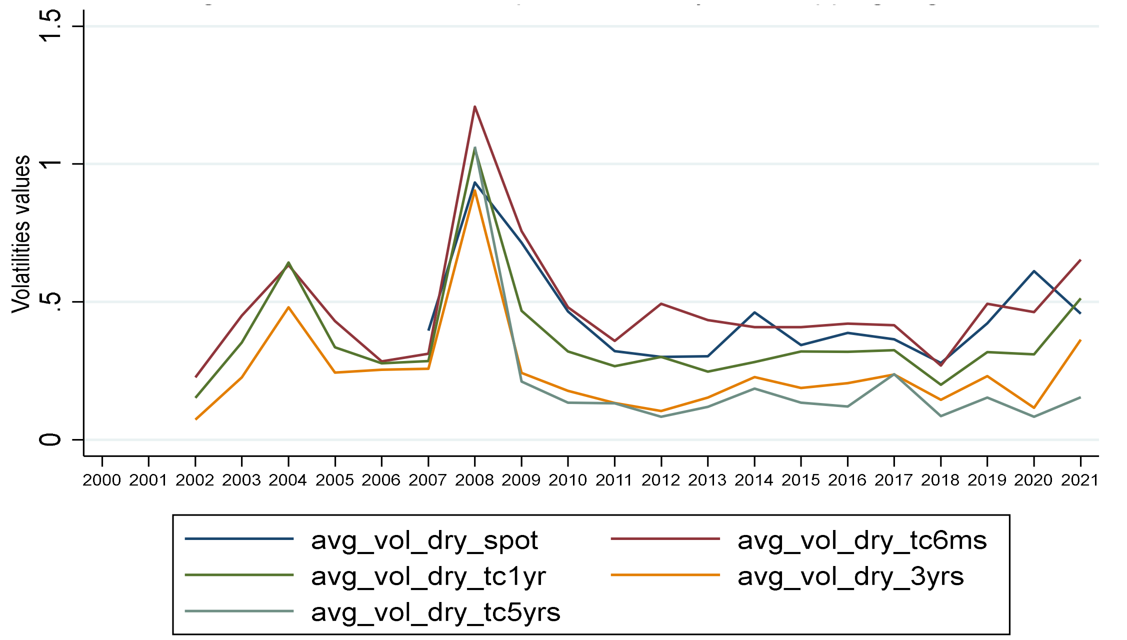
In the following text, we will present the results of volatilities computations in the voyage and period charter rates for the tanker shipping segment. Figure 3.7 shows the volatilities values for tanker shipping segment including Vlcc, suezmax, panamax, aframax and handymax tankers. We observe that spot market exhibits higher volatility than time charter market in both shipping segments. This is in line with other research papers such as (Alizadeh and Nomikos, 2011; Drobetz et al., 2012b; Kavussanos, 1996; Tsouknidis, 2016). Spot market is influenced by the supply and demand for cargo transportation and exhibits higher fluctuation than period charter rates market. From 2000 to 2020, the average volatility for spot rates of tankers equals to 60.41% whereas the average volatilities for 1 year, 3 years and 5 years for time charter market in the tankers segment are 20.80%, 10.82% and 8.26% respectively. This is an expected result because the rates in the time charter market are less volatile as the chartering agreement is for long-term period. Their correlation ranges between 55.31% and 83.41%. as it is expected volatility of spot rates is highly correlated with time charter rates of 1 year period. This correlation value supports the term structure of freight rates that the period freight rates are determined based on future expectations about the movement of rates in the spot market. However, another important observation is that the volatilities of tanker time charters are far less than the spot freight rates.

Figure 3:7 Volatilities computation for tanker shipping segment



Dry bulk shipping freight rates are used for measuring volatilities for spot and time charter markets. Compared to tanker freight volatilities, it seems that volatilities in both spot and time charter market are highly correlated in the dry bulk shipping segment as shown by Figure 3.8. Their correlations range between 76% and 97% with the higher volatility to be between time charter 5 years and time charter 4 years. In 2008, volatilities rose over 100% in both charter markets. There is not a significant difference between spot and time charter rates volatilities as they move together throughout the time. This correlation value supports the term structure of freight rates that the period freight rates are determined based on future expectations about the movement of rates in the spot market. Average volatilities estimation for the dry bulk shipping segment for spot, time charter with 6 months, 1 year, 3 years and 5 years period are accounted to 45.06%, 47.11%, 35.70%, 24.24% and 21.13%.

Figure 3:8 Volatilities computation for dry bulk shipping segment



In table 3.6, panel data regression models are run for assessing the relation between chartering policy and financial performance. For dry bulk shipping segments, *tc_short* and *tc_long* are statistically significant when we input volatility in the models. One important observation is that volatilities significantly weaken as the period of the time charter contract increases. However, there is a difference in the parameter sign of *tc_short* and *tc_long* with the first to receive a negative value and the latter to have a positive value. No significance is estimated in tanker firms. Furthermore, following the same procedure, we run a random effect panel data regression as shown in Appendix V.

Table 3-6: Panel data regression for dry (sub-sample 1) and tanker firms (sub-sample 2) using time varying volatilities of time charter versus voyage charter. Models with tc_short are in light grey colour whereas models with tc_long are in bold grey colour.

	Dry firms sub-sample 1				
Variables	**M1**	**M2**	**M3**	**M4**	**M5**
Spot	-0.4601 (-0.47)	-	-	-	-
TC_short (light grey)	-	-2.5150 ** (-2.62)	-2.5150 ** (-2.62)	-2.5150 ** (-2.62)	-2.5899 ** (-2.77)
TC_long (bold grey)	-	2.1271 ** (2.93)	2.1271 ** (2.93)	2.1271 ** (2.93)	2.1925 ** (2.96)
Avg_vol_dry_spot	-7.1943 * (-1.88)	-	-	-	-
Avg_vol_dry_6mstc	-	-59.6529 ** (-2.24)	-	-	-

		-49.9282 ** (-2.93)			
Avg_vol_dry_1tc	-	-	74.4688 ** (2.24) 62.3308 ** (2.2)	-	-
Avg_vol_dry_3tc	-	-	-	14.6148 * (2.24) 12.2327 ** (2.93)	-
Avg_vol_dry_5tc	-	-	-	-	1.4466 (1.75) 1.1366 (1.26)
Number of observations	100	100	100	100	100
Adjusted R^2	36.60%	40.24% 38.24%	40.24% 38.24%	40.24% 38.24%	39.18% 36.19%
Cluster standard errors	Yes	Yes	Yes	Yes	
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes
			Tanker firms sub-sample 2		
Spot	-0.2724 (-1.17)	-	-	-	-
TC_short (light grey)	-	0.2534 (0.16)	0.2334 (0.16)	0.3103 (0.19)	-
TC_long (bold grey)	-	0.2983 (1.20)	0.2983 (1.20)	0.2910 (1.19)	-
BB	-	-			-
Avg_vol_tanker_spot	0.1256 (0.15)				-
Avg_vol_tanker_1tc		0.2564 (0.28) 0.0938 (0.11)			- -
Avg_vol_tanker_3tc			1.1770 (0.28) 0.4287 (0.11)		- -
Avg_vol_tanker_5tc				-2.8564 (-0.83) -3.6286 (-1.04)	- -
Number of observations	124	124	124	124	-
Adjusted R^2	7.74% -	3.26% 9.98%	11.55% 9.97%	4.18% 6.61%	-
Cluster standard errors	Yes	Yes	Yes	Yes	-
Firm fixed effects	Yes	Yes	Yes	Yes	-
Time fixed effects	Yes	Yes	Yes	Yes	-

Note: this table shows the panel data regression model for dry and tanker firms individually. Panel data regressions were estimated for the dry and tanker shipping firms from 2000 to 2020 using *ROA* as dependent variable for examining its relationship with chartering policy (*spot*, *tc_short*, *tc_long* and *bb*). T-statistics are reported in (.). Statistical significance of the estimated coefficients is denoted with *, ** and *** for 10%, 5% and 1% significance levels, respectively. Avg_vol_dry_spot and Avg_vol_tanker_spot show the annyalized volatilities for dry and tanker segments for vessels Capesize, Panamax, Handysize and VLCC, Suezmax, Aframax, Panamax and Handysize respectively. Their mean values are 43.75% and 53.79% respectively. Avg_vol_dry_6ms, Avg_vol_dry_1tc, Avg_vol_dry_3tc, Avg_vol_dry_5tc and Avg_vol_tanker_1tc, Avg_vol_tanker_3tc, Avg_vol_tanker_5tc shows the volatilities for dry and tanker vessels mentioned above for time charter contract duration of six months (6ms), 1 year (1tc), 3 years (3tc) and 5 years (5tc).

3.5.3 Robustness tests

In this study, we repeat the panel data regression models by providing five robustness tests for ensuring that our results are robust reaching important unbiased conclusions. Robustness results are qualitatively the same with our previously reported results. We check the validity of our inferences by applying robustness tests for mitigating the possibility of spurious results of our regression models. For four different model specifications, firstly, we run the panel data regression using *spot, tc_short, tc_long* and *bb* again using cluster adjusted standard errors of Petersen (2009). Full sample panel data regression results are reported in table 3.7. Reported results are qualitatively the same with table 3.4. *tc_long*, *tc_short* and *spot* remain statistically significant showing the robust relationship between y (*roa*) and variables of interest.

Table 3-7: Panel data regressions for each model (Full-sample) – Petersen (2009) cluster adjusted standard errors

Variables	M1	M2	M3	M4
Constant	-12.0950 *** (-2.36)	-11.2320 *** (-5.02)	-13.4561 *** (-6.23)	-11.7721 *** (-5.06)
Spot	-0.5511 ** (-2.36)	-	-	-
TC_short	-	-2.0736 ** (-2.05)	-	-
TC_long	-	-	0.8440 *** (2.86)	-
BB	-	-	-	0.2757 (0.71)
Log(Avagev)	-0.1265 (-1.25)	-0.0579 (-0.43)	-0.1046 (-1.02)	-0.1105 (-0.96)
Log(Avdwt)	0.2922 *** (2.91)	0.2202 * (1.91)	0.2810 *** (2.84)	0.2716 *** (2.91)
Log(Agef)	-0.1532 (-1.61)	-0.1881 *** (-2.94)	-0.0726 (-0.71)	-0.2303 ** (-2.56)

Lev	0.0167 (0.06)	0.3433 (1.04)	0.1264 (0.40)	0.1815 (0.53)
OpLev	2.6427 ** (2.26)	1.0687 (0.71)	2.8392 ** (2.28)	1.6667 (1.17)
Log(MVE)	0.0866 ** (2.05)	0.0864 *** (2.78)	0.0881 * (1.84)	0.0869 ** (2.05)
MVBV	0.1291 (1.18)	0.1096 (1.34)	0.1522 (1.32)	0.1118 (1.11)
Log(ClarkSea)	0.5782 *** (2.73)	0.5671 *** (1.34)	0.6330 *** (3.26)	0.5709 *** (2.78)
VolClarkSea	1.1499 *** (3.18)	0.9654 *** (2.71)	1.0657 *** (3.75)	1.1416 *** (2.79)
Retstd	-0.4893 * (-5.11)	-0.2640 *** (-0.98)	-0.4477 * (-1.69)	-0.4535 (-1.45)
Observations (firm-year)	224	224	224	224
Adjusted R^2	30.77%	36.93%	36.14%	27.50%
Petersen cluster adjusted standard errors	Yes	Yes	Yes	Yes
F-stat	9.59	10.71	8.53	9.44
[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
Firm fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes

Note: This table shows the results of the estimated panel data regressions for the 23 shipping firms from 2000 to 2020 using *ROA* as dependent variable for examining its relationship with chartering policy (spot, tc_short, tc_long and bb). T-statistics and p-values are reported in (.) and [.], respectively. Statistical significance of the estimated coefficients is denoted with *, ** and *** for 10%, 5% and 1% significance levels, respectively. We follow Petersen (2009) cluster adjusted standard errors at the firm level.

Table 3.8 reports the results of cluster-adjusted standard errors of Petersen (2009) for dry (sub-sample 1) and tanker (sub-sample 2) firms which support the results of Table 3.5. for the sub-samples *tc_long* remains statistically significant for 5% confidence interval for dry shipping firms however no statistical significance exists for tanker firms. Coefficients remain the same with the results in table 3.5.

Table 3-8: Panel data regression for dry and wet firms separately (Sub-samples) – Petersen (2009) cluster adjusted standard errors

Dry firms sub-sample 1				
Variables	**M1**	**M2**	**M3**	**M4**
Spot	-0.5701 (-1.02)	-	-	-
TC_short	-	-2.0594 ** (-1.95)	-	-
TC_long	-	-	1.2750 *** (2.85)	-
BB	-	-	-	1.8640 (1.47)

Number of observations	100	100	100	100
Adjusted R^2	33.08%	42.32%	41.48%	32.26%
Petersen cluster adjusted standard errors	Yes	Yes	Yes	Yes
F-stat	8.38 [0.0000]	8.53 [0.0000]	7.83 [0.0000]	7.07 [0.0000]
Firm fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes
Tanker firms sub-sample 2				
Spot	-0.3753 (-1.32)	-	-	-
TC_short	-	-3.4235 *** (-11.41)	-	-
TC_long	-	-	0.3911 * (1.63)	
BB	-	-	-	0.0255 (0.05)
Number of observations	124	124	124	124
Adjusted R^2	33.11 %	33.54 %	33.48%	30.84%
Petersen cluster adjusted standard errors	Yes	Yes	Yes	Yes
F-stat	7.16 [0.0000]	7.85 [0.0000]	7.83 [0.0000]	7.62 [0.0000]
Firm fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes

Note: this table shows the panel data regression model for dry and wet firms individually. Panel data regressions were estimated for the dry and wet shipping firms from 2000 to 2020 using ROA as dependent variable for examining its relationship with chartering policy (spot, tc_short, tc_long and bb). T-statistics and p-values are reported in (.) and [.], respectively. Statistical significance of the estimated coefficients is denoted with *, ** and *** for 10%, 5% and 1% significance levels, respectively.

Secondly, we replace chartering policy (*CP*) with the number of vessels owned by each firm for each year divided by total number of ships in the fleet instead of deadweight tonnage. Therefore, the new chartering strategies variables are converted into:

$$Spot_{it} = \frac{\sum_{f=1}^{F} Number\ of\ ships_{spot}}{\sum_{f=1}^{F} Total\ number\ of\ ships\ in\ the\ fleet}$$

$$TC\_short_{it} = \frac{\sum_{f=1}^{F} Number\ of\ ships_{TC\,<\,1\,year}}{\sum_{j=1}^{J} Total\ number\ of\ ships\ in\ the\ fleet}$$

$$TC\_long_{it} = \frac{\sum_{f=1}^{F} Number\ of\ ships_{TC\ \geq 1\ year}}{\sum_{j=1}^{J} Total\ number\ of\ ships\ in\ the\ fleet}$$

Where, f=1,…,F represents the ship's charter contract, i=1,…,n identifies each shipping firm, and t=1,…,T shows each time period of the sample i.e. each year. The number of ships chartered under each chartering agreement spot, time charter with maturity less than a year, time charter agreements with maturity equal or more than a year and bareboat are explained by $Number\ of\ ships_{spot}$, $Number\ of\ ships_{TC\ <1\ year}$, $Number\ of\ ships_{TC\ \geq 1\ year}$ respectively. The results of the panel data regression in Table 3.9 still prove a statistically significant relationship between financial performance *roa* and chartering policy (*CP*). More specifically, long-term chartering strategy *tc_long* has a robust positive relationship with *roa* whereas chartering strategies with maturity less than a year i.e., *spot* and *tc_short* has a robust negative relationship with *roa*.

Table 3-9: Panel data regressions for each model (Full-sample) – Chartering policy based on the number of ships in the fleet per firm per year

Variables	M1	M2	M3	M4	Standardized coefficients
Constant	-19.3995 (-0.90)	-9.4573 (-0.44)	-21.2093 (-1.00)	-14.0345 (-0.64)	
Spot_vessels	-0.8766 ** (-1.99)				-0.3520
TC_short_vessels		-2.3567 *** (-3.59)			-0.3699
TC_long_vessels			1.4453 *** (3.68)		0.5978
BB_vessels				-0.0579 (-0.11)	-0.1956
Log(Avagev)	-0.2305 ** (-1.98)	-0.1181 (-0.54)	-0.1468 ** (-1.94)	-0.1924 (-0.95)	
Log(Avdwt)	0.1149 (0.71)	0.1778 (0.73)	0.1705 (0.95)	0.0278 (0.13)	
Log(Agef)	-0.1761 (-1.10)	-0.1217 * (-0.96)	-0.0556 (-0.55)	-0.1379 (-0.83)	
Lev	-0.2427 (-0.78)	-0.0681 (-0.21)	-0.0761 (-0.29)	-0.0983 (-0.25)	
OpLev	4.3549 *** (3.69)	3.1662 *** (3.37)	4.7222 *** (5.18)	3.5331 *** (3.72)	
Log(MVE)	0.3927 *** (3.90)	0.2363 *** (3.24)	0.4144 *** (4.19)	0.3188 *** (4.06)	
MVBV	-0.1113 (-1.09)	-0.0944 (-1.15)	-0.1513 * (-1.83)	-0.0846 (-0.78)	
Log(ClarkSea)	1.4835 (0.65)	0.3627 (0.16)	1.4052 (0.63)	1.0051 (0.42)	
VolClarkSea	0.3655 (0.40)	0.7558 (0.88)	0.2669 (0.32)	0.6241 (0.67)	

Retstd	-0.8735 ** (-2.64)	-0.6097 (-1.53)	-0.6226 *** (-2.08)	-0.9009 ** (-2.60)	
Observations (firm-year)	224	224	224	224	-
Adjusted R^2	32.48%	36.46%	34.78%	29.53%	-
Cluster standard errors	Yes	Yes	Yes	Yes	
F-stat [0.0000]	15.94 [0.0000]	29.96 [0.0000]	23.45 [0.0000]	13.45 [0.0000]	
Firm fixed effects	YES	YES	YES	YES	-
Time fixed effects	YES	YES	YES	YES	-

Note: This table shows the results of the estimated panel data regressions for the 23 shipping firms from 2000 to 2020 using *ROA* as dependent variable for examining its relationship with chartering policy (*spot*, *tc_short*, *tc_long* and *bb*). (Full-sample) – Chartering policy based on the number of ships in the fleet per firm per year. T-statistics and p-values are reported in (.) and [.], respectively. Statistical significance of the estimated coefficients is denoted with *, ** and *** for 10%, 5% and 1% significance levels, respectively.

Table 3.10 shows the results of the sub-samples for the chartering policy based on the number of ships in the fleet per firm per year. Results of table 3.10 are qualitatively the same with tables 3.7 and 3.5 proving that our results of free from bias and support robustness.

Table 3-10: Panel data regression for dry (sub-sample 1) and tanker (sub-sample 2) firms separately.

Dry firms sub-sample 1				
Variables	**M1**	**M2**	**M3**	**M4**
Spot_vessels	-0.6613 (-0.79)	-	-	-
TC_short_vessels	-	-2.3099 * (-2.01)	-	-
TC_long_vessels	-	-	1.8120 ** (2.99)	-
BB_vessels	-	-	-	1.3578 (0.76)
Number of observations	100	100	100	100
Adjusted R^2	44.49 %	42.30%	42.07%	44.92%
Cluster standard errors	YES	YES	YES	YES
Firm fixed effects	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES
Tanker firms sub-sample 2				
Spot_vessels	-0.3298 (-1.28)	-	-	-
TC_short_vessels	-	0.3100 (0.19)	-	-
TC_long_vessels	-	-	0.3229 (1.23)	
BB_vessels	-	-	-	0.2087 (0.28)
Number of observations	124	124	124	124

Adjusted R^2	7.81%	3.27%	11.18%	4.12%
Cluster standard errors	YES	YES	YES	YES
Firm fixed effects	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES

Note: this table shows the panel data regression model for dry and wet firms individually. Panel data regressions were estimated for the dry and wet shipping firms from 2000 to 2020 using ROA as dependent variable for examining its relationship with chartering policy (spot, tc_short, tc_long and bb). Also, control variables were used. Hausman (1978) test is used to choose between fixed or random effects model. In case, a random effects model is resulted, we then use Breusch-Pagan test for choosing among a pooled OLS or a random effects model. T-statistics and p-values are reported in (.) and [.], respectively. Statistical significance of the estimated coefficients is denoted with *, ** and *** for 10%, 5% and 1% significance levels, respectively.

Thirdly, we use the average bunker prices for four major bunker ports i.e. Singapore, Houston, Gibraltar and Rotterdam, *lavbunkers* variable (Table 3.11). *tc_long*, *tc_short* and *spot* remain statistically significant showing the robust relationship between y (*roa*) and variables of interest. Bunkers' cost plays a vital role in determining the financial performance of the shipping firms because of the high variability they have due to the frequent change of their price at different ports worldwide.

Table 3-11: Panel data regressions for each model (Full-sample)

Variables	M1	M2	M3	M4
Constant	2.4790 (0.02)	-64.6589 (-0.43)	-12.2486 *** (-5.37)	-21.2423 (-0.14)
Spot	-0.8548 * (-1.92)	-		
TC_short	-	-2.3976 *** (-3.86)		
TC_long	-	-	1.4670 *** (3.50)	
BB	-	-	-	0.1282 (0.29)
Log(Avagev)	-0.2636 ** (-2.17)	-0.1376 (-0.65)	-0.1900 ** (-2.48)	-0.2132 (-1.08)
Log(Avdwt)	0.1892 (1.17)	0.1844 (0.73)	0.3431 * (1.71)	0.0368 (0.17)
Log(Agef)	-0.1982 (-1.28)	-0.1497 (-1.16)	-0.0642 (-0.60)	-0.1763 (-1.04)
Lev	-0.3778 (-1.20)	-0.1062 (-0.32)	-0.2265 (-0.89)	-0.1804 (-0.48)
OpLev	4.3060 *** (3.65)	3.1185 *** (3.34)	4.8331 *** (5.09)	3.4609 *** (3.68)
Log(MVE)	0.3728 *** (3.68)	0.2305 ** (3.16)	0.3940 *** (4.05)	0.3090 *** (3.98)
MVBV	-0.1005 (-0.99)	-0.0859 (-1.02)	-0.1295 (-1.58)	-0.0801 (-0.74)

Log(ClarkSea)	-3.8240 (-0.11)	12.3980 (0.36)	1.4024 (0.04)	2.3830 (0.07)
VolClarkSea	5.1187 (0.17)	-9.2820 (-0.31)	0.3686 (0.01)	-0.3651 (-0.01)
Retstd	-0.8867 *** (-2.70)	-0.6433 (-1.62)	0.1160 (0.00)	-0.9312 ** (-2.74)
Lavbunkers	4.3439 (-0.16)	-9.1193 (-0.33)	-0.3851 ** (-2.39)	-0.8895 (-0.03)
Observations (firm-year)	224	224	224	224
Adjusted R^2	14.52%	11.79%	35.63%	31.05%
Cluster standard errors	YES	YES	YES	YES
Firm fixed effects	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES

Note: This table shows the results of the estimated panel data regressions for the 28 shipping firms from 2000 to 2020 using ROA as dependent variable for examining its relationship with chartering policy (spot, tc_short, tc_long and bb). Also, control variables were used. Hausman (1978) test is used to choose between fixed or random effects model. In case, a random effects model is resulted, we then use Breusch-Pagan test for choosing among a pooled OLS or a random effects model. T-statistics and p-values are reported in (.) and [.], respectively. Statistical significance of the estimated coefficients is denoted with *, ** and *** for 10%, 5% and 1% significance levels, respectively. As a final robustness test, we follow Petersen (2009) cluster adjusted standard errors at the firm level. Finally, VIF is calculated and is under 5 showing the absence of multicollinearity.

Table 3.12 illustrates the results of the two sub-samples for dry and tankers adding in the panel data regression the average bunkers price of four major ports i.e., Singapore, Houston, Gibraltar and Rotterdam. Average bunkers price does not take a robust relationship with dry firms whereas they are observed with a robust significant relationship for tanker firms.

Table 3-12: Panel data regression for dry (sub-sample 1) and tanker (sub-sample 2) firms separately

Dry firms sub-sample 1				
Variables	**M1**	**M2**	**M3**	**M4**
Spot	-0.6564 (-0.73)	-	-	-
TC_short	-	-2.3793 ** (-2.18)	-	-
TC_long	-	-	2.0174 ** (2.95)	-
BB	-	-	-	1.3818 (1.04)
lavbunkers	-0.4762 (-0.34)	-2.8362 (-1.05)	-0.7834 (-0.69)	-1.0112 (-0.56)
Number of observations	100	100	100	100
Adjusted R^2	44.63 %	42.55%	41.00%	44.63 %
Cluster standard errors	YES	YES	YES	YES
Firm fixed effects	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES
Tanker firms sub-sample 2				

Spot	-0.2891 (-1.31)	-	-	-
TC_short	-	0.2506 (0.16)	-	-
TC_long	-	-	0.2986 (1.27)	
BB	-	-	-	0.0519 (-0.10)
lavbunkers	37.6550 * (1.82)	37.5150 * (1.82)	38.5796 * (1.87)	3737464 * (1.83)
Number of observations	124	124	124	124
Adjusted R²	9.20 %	9.80 %	8.90%	9.55%
Cluster standard errors	YES	YES	YES	YES
Firm fixed effects	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES

Note: this table shows the panel data regression model for dry and wet firms individually. Panel data regressions were estimated for the dry and wet shipping firms from 2000 to 2020 using ROA as dependent variable for examining its relationship with chartering policy (spot, tc_short, tc_long and bb). Also, control variables were used. Hausman (1978) test is used to choose between fixed or random effects model. In case, a random effects model is resulted, we then use Breusch-Pagan test for choosing among a pooled OLS or a random effects model. T-statistics and p-values are reported in (.) and [.], respectively. Statistical significance of the estimated coefficients is denoted with *, ** and *** for 10%, 5% and 1% significance levels, respectively.

Fourth, we use freight earnings index for bulkers *lndry* and tankers *lntankers* instead of the clarksea index (Table 3.13). Results remain qualitatively the same and significant mostly for dry ships rather than tanker firms. We also run random effects data regression as is shown in the Appendix V. Still, the results uncover a positive and statistically significant coefficient of *tc_long* in 1% confidence interval for the full sample. *Tc_long* has a positive impact on *ROA* for the sub-samples.

Table 3-13: Panel data regression for dry and tanker firms separately with dry and tanker index respectively

	Dry firms (sub-sample 1)			
Variables	**M1**	**M2**	**M3**	**M4**
Spot	-0.6564 (-0.73)	-	-	-
TC_short	-	-2.3793 * (-2.18)	-	-
TC_long	-	-	2.0175 ** (2.95)	-
BB	-	-		1.3818 (1.04)
lndry	1.1295 (0.47)	3.9905 (1.18)	1.5130 (1.49)	1.8001 (0.52)

Firm fixed effects	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES
Adjusted R^2	44.63%	42.55%	41.00%	44.63%
Robust standard errors	Yes	Yes	Yes	Yes
Tanker firms (Sub-sample 2)				
Spot	-0.2891 (-1.21)	-	-	-
TC_short	-	0.2506 (0.16)	-	-
TC_long	-	-	0.2986 (1.27)	-
BB	-	-	-	-0.0519 (-0.10)
lntanker	1.5010 * (2.05)	1.4614 * (1.96)	1.5323 * (2.07)	1.4671 * (2.02)
Robust standard errors	Yes	Yes	Yes	Yes
Firm fixed effects	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES
Adjusted R^2	7.50%	4.29%	10.07%	5.39%

Note: this table shows the results of panel data regressions with cluster adjusted standard errors of Petersen (2009) for the dry and wet shipping firms from 2000 to 2020 using ROA as dependent variable for examining its relationship with chartering policy (spot, tc_short, tc_long and bb). T-statistics and p-values are reported in (.) and [.], respectively. Statistical significance of the estimated coefficients is denoted with *, ** and *** for 10%, 5% and 1% significance levels, respectively.

3.6 Discussion of the results

The results of this study reveal important information for the two different market shipping segments i.e., dry bulk and tankers listed companies of U.S. stock exchanges. This research investigates the relationship between financial performance and chartering policy in the dry and tanker shipping segments of the shipping industry considering the segmentation effect. Applying panel data regression for four models using firm and vessel level data we provide evidence of a robust relationship between *CP* (chartering policy) and firms' financial performance in a sample of 21 years (2000-2020) for 23 shipping firms (9 dry and 14 tankers). For capturing chartering policy, we use the three ratios *spot*, *tc_short* and *tc_long* instead of the four used in Chapter 1 which are then used to investigate the relationship with financial performance (*roa*). Only these three were used because spot and time chartering are the two most widely used chartering strategies with different durations, characteristics, expenses allocation and risks.

The research shows that chartering policy differs between the two shipping segments during the sample period and have a different effect on the financial performance of the shipping firms because of the time varying risks that form different business cycles for each segment. Chartering policy is affected by shipping segmentation and time varying risks i.e., freight rate volatilities. There are different types of ships trading in each segment with different deadweight capacity chartered under contracts of different durations resulting in the formation of different chartering policy for each segment. It has also been identified that there is variation in the age of dry ships compared to tanker ships. Thus, these factors affect the financial performance of shipping firms in a different way in each segment. The results are in line with previous studies in the literature (e.g., Drobetz et al., 2012a; Kavussanos, 1997; Kavussanos and Alizadeh, 2002; Tsouknidis, 2016) who found that shipping segmentation exists due to different time varying risks in the industry.

Results indicate that chartering policy is important for shipowners or risk-averse investors who aim to maximize financial performance. During the sample period, shipping firms that employ their ships under a time chartering strategy with maturity more than one year can achieve higher financial performance. In contrast, for chartering strategies with short-term maturity (less than a year) i.e. *tc_short* and *spot* it can be concluded that by decreasing these charterparties within a shipping firm's chartering policy a shipping firm can maximize its financial performance. As it is well-known, a time chartering strategy provides stable future earnings for the shipowner who also avoids paying the bunker cost. Bunker cost is the responsibility of the charterer (Kavussanos and Alizadeh, 2001).

The results cover the sample period of twenty-one years considering important crises such as the world financial crisis of 2008 (Ivashina and Scharfstein, 2010) and the oil price shocks in 2014 (Baumeister and Kilian, 2016). World financial and oil crises in 2008 and 2014 have a negative impact on the world economy which has a direct effect on the formation of the shipping cycles and the determination of freight rates. Another reason of explaining the results may be the extreme volatility observed in the industry. This is supported by various academic researches such as (Tsouknidis, 2016; Kavussanos, 2003; Dai et al., 2015; Drobetz et al., 2012a). While volatility is transmitted between and within the shipping segments (Tsouknidis, 2016) the shipowners attempt to minimize the risk of financial losses by chartering their ships under a time chartering strategy with long-term maturity. In this way, they stabilize their freight earning in the long-term. This is an advantage for the shipowners as they can achieve better negotiation agreements in terms of applying for a bank loan or borrowing money in the open market by issuing bonds.

Apart from the above results, panel data regression of the full sample shows that market value of equity, operating leverage, vessels 'age and the volatility of stock price are associated with higher financial performance. Market value of equity can capture the size of the shipping firm thus, higher firms in size can achieve higher financial performance. This may be attributed to the reputation, the highly skilled personnel they may have. As a result, they attract the best charterers in the market for transporting cargo worldwide. Vessel's age matters as newer ships can attract better chartering rates for carrying cargo all around the world. As volatility of share price decreases, financial performance increases. This is supported by the academic literature where authors estimate low market betas for shipping stocks (Kavussanos et al., 2010a; Kavussanos and Marcoulis, 2000, 1997a, 1997b; Markoulis and Kavussanos, 2001; Makrominas, 2018; Drobetz et al., 2010).

We also separate the sample in dry and tanker shipping segments. Time chartering with short-term or long-term plays an important role in the financial performance of shipping firms. For both tankers and dry bulk shipping firms, increasing the time charter with duration more than a year and decreasing spot and time charter with short term duration can have a higher impact on financial performance. Significant results can be extracted from risk-averse investors when volatility of freight rates is considered. Volatility of freight rates also has a positive relationship with financial performance, and this is due to the fact that freight market is volatile and uncertain (Gavriilidis et al., 2018; Tsouknidis, 2016). It seems that risk averse investors can invest their money in shipping firms that follow a low-risk chartering policy by chartering more of their fleet in long term time charters (more than 1 year) in the dry bulk segment. No results can be drawn regarding the chartering policy in the tanker shipping segment. Crude oil is the main product carried by tankers and its price influences other products that are produced after crude oil exploitation such as gasoline, jet oil, heating oil etc. Their correlation is positively related to crude oil. In contrast, in the dry bulk shipping segment, price of major and minor bulks is not highly correlated between and among them.

3.7 Conclusion

3.7.1 Major findings

This study examines the relationship between financial performance and chartering policy of U.S. listed shipping firms forming a sample of dry bulk and wet firms filling this theoretical gap in the literature. Traditional mean-variance analysis has been found unable to explain the risk-return relationship in the shipping freight market. This study employs the chartering duration as a method for capturing risk and to assess its effect on shipping firms' financial performance. It uses a unique data set comprising of firm and vessel level data to empirically investigate this relationship. Results show a robust positive relationship between contracts of long-term duration and shipping firms' financial performance for U.S. listed shipping firms from 2000 to 2020. This relationship is robust even though during this period we have seen the world financial crisis of 2008, the oil crisis of 2014 and covid-19 crisis of 2019. Furthermore, results show that employing a higher percentage of ships under time chartering strategy with duration more than a year in the dry segment has a higher impact on financial performance compared to tanker shipping segment. No results can be drawn for the tanker shipping segment. Results are useful for the risk averse investors who can diversify risks by investing in dry bulk shipping firms trading most of their fleet under time chartering and in tanker shipping firms employing most of their fleet under voyage charter.

3.7.2 Limitations and recommendations for further study

One limitation of the study is the small sample of shipping firms. However, it must be noted that the only source for chartering decisions information for shipping firms is the Securities and Exchange Commission of U.S. All possible information was gathered from SEC 20F fillings for investigating this interesting topic reaching important inferences. Further research can be done in investigating the chartering policy for sub-segments of each shipping market based on the chartering strategy followed for each type of ship for each year for each firm and to assess its impact in the firm's financial performance. Freight derivatives contracts (Batchelor et al., 2007) is another way of hedging the risk of freight volatility thus, it would be very interesting to assess the impact of chartering policy on the financial performance of shipping firms considering any hedging techniques.

3.7.3 Practical implications

The decision to charter a ship either short-term or long-term certainly has an impact on the shipping firms' cash inflows which in turn affect the shipping firms' financial performance in the short- and long-term period. Based on the results of the study, the findings of this study have important implications for private and institutional investors for capital allocation, ship lending institutions and shipowners. Regarding capital allocation, investors who wish to diversify their portfolio risk should invest in 1. dry bulk shipping firms that have higher portion of their fleet chartered under time chartering contracts with duration more than a year and 2. tanker shipping firms that charter higher percentage of their fleet under voyage chartering. Ship lending institutions should be careful and should manage the liquidity and default risk of shipping firms when granting loans to shipping firms by assessing the chartering policy in different shipping segments i.e., dry bulk and tanker segments. Shipowners should assess their chartering policy regularly and try to form it based on the state of the shipping cycles for achieving higher cash flow stability and revenues. In a bearish shipping freight market, they should employ their ships under time chartering strategy with duration more than a year thus, they can stabilize their earnings and avoid paying the bunker costs. This approach would assist them to avoid any negative effects from such a volatile shipping freight market. During expansion markets i.e., 2003 to 2007 as it has been shown by the results of the chartering policy, shipowners can employ their ships in the spot market thus they exploit the increasing freight rates and on the peak of the cycle they can employ their ships in a long-term basis by agreeing and signing chartering contracts with long duration and high freight rates. However, as Stopford (2008) says, it is not easy to ride the shipping cycles and choose the best time to charter the ships more efficiently. It is necessary for the shipowner to undertake market analysis and follow the market sentiment.

The formation of the chartering policy is absolutely the choice of the shipowner. A risk lover shipowner would charter their ships in the spot market however a risk averse shipowner may choose a more conservative chartering policy by employing their ships under long-term chartering duration.[46] Based on our sample's duration and shipping firms, time chartering with duration more than a year in the dry bulk shipping segments has a higher impact on the shipping firm's financial performance and this may be due to the fact that there is higher volatility in the chartering rates, vessel sizes and ages in this specific shipping segment (Kavussanos, 2003, 1997; Kavussanos and Alizadeh, 2002) as proved by other authors. Also, our results of computation of dry bulk shipping segment chartering volatilities show that spot and time chartering rates are highly correlated thus it is better to charter a ship under a long-term chartering strategy (for instance, time chartering with duration more than a year) for avoid paying the bunker costs.[47] In contrast, in tanker shipping segment ships should be employed more in the spot market, however there is not statistically significant results. In this market: 1.the cargoes are derivatives of crude oil i.e., diesel, gasoline, etc and since crude oil is the major cargo that drives world economies (Kilian, 2009) and 2. these cargoes' prices are highly correlated and their price is influenced from the price of crude oil which is a global cargo that its price changes regularly. 3. Volatilities in the tanker shipping segment chartering rates, ships' ages and sizes are lower. Thus, by employing their ships in the spot market, the owners can exploit these price' changes which will result in a higher positive income in shipping firms' financial performance.

It is worth noting that there are shipowners that prefer chartering their fleet either in the spot or time chartering market. This can be explained by the fact that these shipowners probably have long-standing relationships with their clients/charterers who are global/well-known companies in the market (their default and bankruptcy risk is almost zero) thus shipowners feel certain and secure that their ships will be chartered in the short- and long-term period by these firms. Another explanation, may be that shipowners who charter their ships in the spot market may be shipping firms who are based their firm's viability on their own private funds and not on borrowed funds from financing institutions as proved by (Drobetz et al., 2016)

[46] Bareboat and time chartering is long-term chartering contracts however, time chartering has lower duration giving the advantage of the shipowner to charter the ship to another charterer that pays higher chartering rates in case the economy is flourishing.
[47] As proved in the introduction in Figure 3.5, crude oil is 40% correlated with dry bulk shipping segment chartering rates.

Conclusions

This thesis contains three essays on chartering policy, technical innovation, the risk/return relationship in shipping and shipping financial performance with major research focus on the factors affecting the shipping firm's financial performance using firm and vessel hand-collected data. We have argued throughout this work that the risk in shipping has multiple sources that can be distinguished into micro- and macro-specific which diversely affect the financial performance of listed shipping firms.

Business decision making is the cornerstone for a shipping firm's viability because of the high capital requirements behind any decision of the shipowner and the risk that such a decision may not perform well financially. Risk is found in every shipowner's decision, for example, under which charterparty to charter the ship, for how long duration, in which shipping segment and which type of ship to invest among others. Emphasis was given on chartering policy of U.S. listed shipping firms and its market segmentation, and ship's technical innovation and how these two areas can affect the financial performance of listed shipping firms. One significant innovation of the research is the hand-collection of data for chartering strategies for each shipping firm of four different market segments i.e., tanker, dry, container and gas and the data collection for listed shipping firm's fleet technical innovation. This data collection was gathered for each ship, for each firm and for each year, constructing a dynamic dataset of four chartering strategies: voyage, time charter with duration less and more than a year and bareboat charter vessel-level observations.

This research applies panel data modelling for providing insightful results and filling the research gaps in the academic literature. Cross sectional and time series data was used for estimating panel data regressions. Apart from these, other econometric tools such as cluster adjusted standard errors, Hausman test, Shapiro and Wilk test and data envelopment analysis among others were applied. Results of the three chapters show that employing a low risk rather than a high-risk chartering policy by assigning the ships on long-term chartering contracts such as time chartering with duration more than a year, shipping firms can positively affect their financial performance (for the period investigated). Chartering contracts are observed with different time varying risks derived from market segmentation i.e., different ship size and age, and different type of cargo each ship is transporting in each shipping segment. This can be used by risk-averse investors who wish to diversify their portfolio risks by investing in shipping stocks. Another important inference is the estimation of high freight rate volatilities in long-term charter rates of the dry bulk shipping segment compared to the tanker shipping segment. Volatilities of freight rates in the spot market are higher in the tanker segment than the dry bulk segment in the shipping industry. By investing in shipping firms that employ a higher percentage of ships under time chartering strategy with duration more than a year in the dry bulk shipping segment (low risk chartering policy) and under voyage charter in the tanker market (high risk chartering policy), risk averse investors can achieve higher financial performance by diversifying the volatilities of the shipping freight markets. Finally, another important results, include the investment in eco-innovated ships for listed shipping firms. It has been shown that eco-innovation in the shipping industry has a positive effect on firm's financial performance.

The results are of interest to shipowners, bankers, private and institutional investors, and various lending authorities. Shipowners can realize that by employing a higher portion of the fleet under time chartering for long period can positively impact the shipping firms' financial performance during low freight market conditions. Apart from this, investing in eco-type ships shipowners can also increase their cash inflows since these ships are chartered with freight rate premium during bearish shipping market conditions. Risk diversification can be achieved by investors by investing in shipping firms that trade most of their ships under time chartering with duration more than a year in the dry bulk shipping segment and voyage chartering in tanker shipping segments (results showed that higher financial performance can be achieved). Lastly, ship lending authorities can feel more secure by lending money to shipping firms that charter their ships or most of their ships under time chartering since this type of chartering strategy entails lower risk compared to voyage chartering.

It would be interesting to assess the relationship between chartering policy and financial performance of U.S. Listed shipping firms considering the Covid-19 pandemic and the recent Ukraine crisis. By using event study, important inferences may be drawn for this relationship. A good further research suggestion is to exploit private data combining the chartering strategy each technically innovated ship is chartered and assess which combination has the highest effect on shipping firm’s financial performance in a bigger sample i.e., eco-type ship chartered under time chartering.

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Appendix I

Table A1.1: Measuring Chartering Capabilities using Data Envelopment Analysis per year

Firm	Chartering capabilities	Year
Capital product partners	0.418989	2010
Costamare	0.859479	2010
Danaos	0.267803	2010
DHT Holdings	1	2010
Diana	0.672902	2010
Dryships	0.390539	2010
Euronav	0.637378	2010
Euroseas	0.692078	2010
Frontline	0.525702	2010
GasLog	0.0931363	2010
Global ship lease	0.784496	2010
Globus	0.148352	2010
Golar LNG	0.634205	2010
Golden Ocean	0.399116	2010
Navios Maritime partners	0.258884	2010
Nordic American Tankers	0.255562	2010
Performance Shipping	0.0363952	2010
Safebulkers	0.404471	2010
Scorpio Tankers	0.0917524	2010
Seanergy	1	2010
Seaspan Corporation	0.209352	2010
Star bulk	0.467843	2010
StealthGas	1	2010
Teekay LNG	0.785092	2010
Teekay Tankers	0.41891	2010
Top Ships	0.700176	2010
Tsakos Energy	0.394749	2010
Capital product partners	0.418176	2011
Costamare	0.567978	2011
Danaos	0.353384	2011
DHT Holdings	0.481101	2011
Diana	0.788859	2011
Dryships	0.582948	2011
Euronav	0.50423	2011
Euroseas	0.994507	2011
Frontline	1	2011
GasLog	0.36957	2011
Global ship lease	0.642805	2011
Globus	0.328146	2011
Golar LNG	0.619159	2011

Golden Ocean	0.793512	2011
Navios Maritime partners	0.798471	2011
Nordic American Tankers	0.277436	2011
Performance Shipping	0.242241	2011
Safebulkers	0.595957	2011
Scorpio Tankers	0.478478	2011
Seanergy	1	2011
Seaspan Corporation	0.331439	2011
Star bulk	0.418606	2011
StealthGas	0.576753	2011
Teekay LNG	0.637621	2011
Teekay Tankers	0.305158	2011
Top Ships	0.562229	2011
Tsakos Energy	0.586693	2011
Capital product partners	0.197406	2012
Costamare	0.270599	2012
Danaos	0.171337	2012
DHT Holdings	0.383013	2012
Diana	0.207458	2012
Dryships	0.614662	2012
Euronav	0.191708	2012
Euroseas	0.328338	2012
Frontline	1	2012
GasLog	0.168798	2012
Global ship lease	0.220365	2012
Globus	0.281062	2012
Golar LNG	0.568138	2012
Golden Ocean	0.189921	2012
Navios Maritime partners	0.324453	2012
Nordic American Tankers	0.166517	2012
Performance Shipping	0.170775	2012
Safebulkers	0.256549	2012
Scorpio Tankers	0.272218	2012
Seanergy	1	2012
Seaspan Corporation	0.162725	2012
Star bulk	0.364372	2012
StealthGas	0.217195	2012
Teekay LNG	0.244511	2012
Teekay Tankers	0.258008	2012
Top Ships	0.218358	2012
Tsakos Energy	0.226342	2012
Capital product partners	0.169876	2013
Costamare	0.226986	2013
Danaos	0.478929	2013
DHT Holdings	0.546043	2013

Diana	0.204639	2013
Dryships	0.488777	2013
Euronav	0.799936	2013
Euroseas	0.846196	2013
Frontline	1	2013
GasLog	0.0737993	2013
Global ship lease	1	2013
Globus	1	2013
Golar LNG	1	2013
Golden Ocean	0.263748	2013
Navios Maritime partners	0.215581	2013
Nordic American Tankers	0.895276	2013
Performance Shipping	0.187299	2013
Safebulkers	0.379606	2013
Scorpio Tankers	0.158838	2013
Seanergy	0.0021917	2013
Seaspan Corporation	0.30064	2013
Star bulk	0.216405	2013
StealthGas	0.271594	2013
Teekay LNG	0.308631	2013
Teekay Tankers	0.803518	2013
Top Ships	1	2013
Tsakos Energy	0.40412	2013
Capital product partners	0.151798	2014
Costamare	0.142419	2014
Danaos	0.264449	2014
DHT Holdings	0.0149327	2014
Diana	0.0429428	2014
Dryships	0.0795371	2014
Euronav	0.0121602	2014
Euroseas	0.0341675	2014
Frontline	0.0247138	2014
GasLog	0.0070983	2014
Global ship lease	0.0683917	2014
Globus	1	2014
Golar LNG	1	2014
Golden Ocean	0.0057443	2014
Navios Maritime partners	0.0412968	2014
Nordic American Tankers	0.131215	2014
Performance Shipping	0.0255243	2014
Safebulkers	0.0313127	2014
Scorpio Tankers	0.0072279	2014
Seanergy	1	2014
Seaspan Corporation	0.0530313	2014
Star bulk	0.0083381	2014

StealthGas	0.0293037	2014
Teekay LNG	0.0596717	2014
Teekay Tankers	0.588347	2014
Top Ships	0.0023223	2014
Tsakos Energy	0.0557301	2014
Capital product partners	0.301551	2015
Costamare	1	2015
Danaos	1	2015
DHT Holdings	0.697895	2015
Diana	0.241213	2015
Dryships	1	2015
Euronav	0.677856	2015
Euroseas	0.880022	2015
Frontline	0.322218	2015
GasLog	0.1845	2015
Global ship lease	0.395304	2015
Globus	1	2015
Golar LNG	0.683587	2015
Golden Ocean	0.137787	2015
Navios Maritime partners	0.380624	2015
Nordic American Tankers	0.742185	2015
Performance Shipping	0.197464	2015
Safebulkers	0.274941	2015
Scorpio Tankers	0.299445	2015
Seanergy	0.0252639	2015
Seaspan Corporation	0.306127	2015
Star bulk	0.172884	2015
StealthGas	0.275216	2015
Teekay LNG	0.448835	2015
Teekay Tankers	0.245763	2015
Top Ships	0.116183	2015
Tsakos Energy	0.636349	2015
Capital product partners	0.314277	2016
Costamare	0.509822	2016
Danaos	0.315191	2016
DHT Holdings	0.504231	2016
Diana	0.146986	2016
Dryships	1	2016
Euronav	0.496822	2016
Euroseas	1	2016
Frontline	0.48257	2016
GasLog	0.200781	2016
Global ship lease	0.425996	2016
Globus	0.180786	2016
Golar LNG	0.37725	2016

Golden Ocean	0.247725	2016
Navios Maritime partners	0.335417	2016
Nordic American Tankers	0.582304	2016
Performance Shipping	0.253961	2016
Safebulkers	0.196176	2016
Scorpio Tankers	0.322905	2016
Seanergy	0.251908	2016
Seaspan Corporation	0.31916	2016
Star bulk	0.213774	2016
StealthGas	0.297064	2016
Teekay LNG	0.304631	2016
Teekay Tankers	0.602113	2016
Top Ships	0.318863	2016
Tsakos Energy	0.29803	2016
Capital product partners	0.722733	2017
Costamare	0.821323	2017
Danaos	0.593052	2017
DHT Holdings	0.55244	2017
Diana	0.406208	2017
Dryships	0.148219	2017
Euronav	0.657989	2017
Euroseas	1	2017
Frontline	0.522323	2017
GasLog	0.471979	2017
Global ship lease	1	2017
Globus	0.602321	2017
Golar LNG	1	2017
Golden Ocean	0.607361	2017
Navios Maritime partners	0.403031	2017
Nordic American Tankers	1	2017
Performance Shipping	1	2017
Safebulkers	0.487005	2017
Scorpio Tankers	0.381409	2017
Seanergy	0.761096	2017
Seaspan Corporation	0.532749	2017
Star bulk	0.536234	2017
StealthGas	0.525509	2017
Teekay LNG	0.314434	2017
Teekay Tankers	0.906409	2017
Top Ships	0.516767	2017
Tsakos Energy	0.484085	2017
Capital product partners	0.26207	2018
Costamare	0.192603	2018
Danaos	0.222021	2018
DHT Holdings	0.267167	2018

Diana	0.273668	2018
Dryships	0.236392	2018
Euronav	0.189864	2018
Euroseas	1	2018
Frontline	0.378594	2018
GasLog	0.167024	2018
Global ship lease	0.197303	2018
Globus	0.248961	2018
Golar LNG	1	2018
Golden Ocean	0.353953	2018
Navios Maritime partners	0.224888	2018
Nordic American Tankers	0.42668	2018
Performance Shipping	0.357727	2018
Safebulkers	0.230213	2018
Scorpio Tankers	0.186332	2018
Seanergy	0.531913	2018
Seaspan Corporation	0.194145	2018
Star bulk	0.25732	2018
StealthGas	0.195102	2018
Teekay LNG	0.168737	2018
Teekay Tankers	0.760258	2018
Top Ships	0.192737	2018
Tsakos Energy	0.265425	2018

Note: We use the following variables as inputs: (i) total assets (TA) (ii) capital expenditure (CAPEX) and output: (iii) Revenue. TA is the sum of fixed assets, current assets and other non-current assets; CAPEX is the amount spent for the construction of new vessels and expenditures ensuring that vessels comply with international regulatory standards. REVENUE measures how efficiently a shipping firm utilized its resources. The DEA process (constant returns to scale) yields the variable Chartering Capabilities (CC) for each firm and year combination examined.

Table A1.2: Measuring Chartering Capabilities using Data Envelopment Analysis per firm from 2010 to 2018.

Firm	Chartering capabilities	Year	Year_founded
Capital product partners	0.26207	2018	2007
Capital product partners	0.722733	2017	2007
Capital product partners	0.314277	2016	2007
Capital product partners	0.301551	2015	2007
Capital product partners	0.151798	2014	2007
Capital product partners	0.169876	2013	2007
Capital product partners	0.197406	2012	2007
Capital product partners	0.418176	2011	2007
Capital product partners	0.418989	2010	2007
Costamare	0.192603	2018	1975
Costamare	0.821323	2017	1975
Costamare	0.509822	2016	1975
Costamare	1	2015	1975
Costamare	0.142419	2014	1975
Costamare	0.226986	2013	1975
Costamare	0.270599	2012	1975
Costamare	0.567978	2011	1975
Costamare	0.859479	2010	1975
Danaos	0.222021	2018	1972
Danaos	0.593052	2017	1972
Danaos	0.315191	2016	1972
Danaos	1	2015	1972
Danaos	0.264449	2014	1972
Danaos	0.478929	2013	1972
Danaos	0.171337	2012	1972
Danaos	0.353384	2011	1972
Danaos	0.267803	2010	1972
DHT Holdings	0.267167	2018	2005
DHT Holdings	0.55244	2017	2005
DHT Holdings	0.504231	2016	2005
DHT Holdings	0.697895	2015	2005
DHT Holdings	0.0149327	2014	2005
DHT Holdings	0.546043	2013	2005
DHT Holdings	0.383013	2012	2005
DHT Holdings	0.481101	2011	2005
DHT Holdings	1	2010	2005
Diana	0.273668	2018	1999
Diana	0.406208	2017	1999
Diana	0.146986	2016	1999
Diana	0.241213	2015	1999
Diana	0.0429428	2014	1999
Diana	0.204639	2013	1999

Diana	0.207458	2012	1999
Diana	0.788859	2011	1999
Diana	0.672902	2010	1999
Dryships	0.236392	2018	2004
Dryships	0.148219	2017	2004
Dryships	1	2016	2004
Dryships	1	2015	2004
Dryships	0.0795371	2014	2004
Dryships	0.488777	2013	2004
Dryships	0.614662	2012	2004
Dryships	0.582948	2011	2004
Dryships	0.390539	2010	2004
Euronav	0.189864	2018	1995
Euronav	0.657989	2017	1995
Euronav	0.496822	2016	1995
Euronav	0.677856	2015	1995
Euronav	0.0121602	2014	1995
Euronav	0.799936	2013	1995
Euronav	0.191708	2012	1995
Euronav	0.50423	2011	1995
Euronav	0.637378	2010	1995
Euroseas	1	2018	2005
Euroseas	1	2017	2005
Euroseas	1	2016	2005
Euroseas	0.880022	2015	2005
Euroseas	0.0341675	2014	2005
Euroseas	0.846196	2013	2005
Euroseas	0.328338	2012	2005
Euroseas	0.994507	2011	2005
Euroseas	0.692078	2010	2005
Frontline	0.378594	2018	1985
Frontline	0.522323	2017	1985
Frontline	0.48257	2016	1985
Frontline	0.322218	2015	1985
Frontline	0.0247138	2014	1985
Frontline	1	2013	1985
Frontline	1	2012	1985
Frontline	1	2011	1985
Frontline	0.525702	2010	1985
GasLog	0.167024	2018	2003
GasLog	0.471979	2017	2003
GasLog	0.200781	2016	2003
GasLog	0.1845	2015	2003
GasLog	0.0070983	2014	2003
GasLog	0.0737993	2013	2003

GasLog	0.168798	2012	2003
GasLog	0.36957	2011	2003
GasLog	0.0931363	2010	2003
Global ship lease	0.197303	2018	2007
Global ship lease	1	2017	2007
Global ship lease	0.425996	2016	2007
Global ship lease	0.395304	2015	2007
Global ship lease	0.0683917	2014	2007
Global ship lease	1	2013	2007
Global ship lease	0.220365	2012	2007
Global ship lease	0.642805	2011	2007
Global ship lease	0.784496	2010	2007
Globus	0.248961	2018	2006
Globus	0.602321	2017	2006
Globus	0.180786	2016	2006
Globus	1	2015	2006
Globus	1	2014	2006
Globus	1	2013	2006
Globus	0.281062	2012	2006
Globus	0.328146	2011	2006
Globus	0.148352	2010	2006
Golar LNG	1	2018	2007
Golar LNG	1	2017	2007
Golar LNG	0.37725	2016	2007
Golar LNG	0.683587	2015	2007
Golar LNG	1	2014	2007
Golar LNG	1	2013	2007
Golar LNG	0.568138	2012	2007
Golar LNG	0.619159	2011	2007
Golar LNG	0.634205	2010	2007
Golden Ocean	0.353953	2018	2004
Golden Ocean	0.607361	2017	2004
Golden Ocean	0.247725	2016	2004
Golden Ocean	0.137787	2015	2004
Golden Ocean	0.0057443	2014	2004
Golden Ocean	0.263748	2013	2004
Golden Ocean	0.189921	2012	2004
Golden Ocean	0.793512	2011	2004
Golden Ocean	0.399116	2010	2004
Navios Maritime partners	0.224888	2018	2007
Navios Maritime partners	0.403031	2017	2007
Navios Maritime partners	0.335417	2016	2007
Navios Maritime partners	0.380624	2015	2007
Navios Maritime partners	0.0412968	2014	2007
Navios Maritime partners	0.215581	2013	2007

Navios Maritime partners	0.324453	2012	2007
Navios Maritime partners	0.798471	2011	2007
Navios Maritime partners	0.258884	2010	2007
Nordic American Tankers	0.42668	2018	1995
Nordic American Tankers	1	2017	1995
Nordic American Tankers	0.582304	2016	1995
Nordic American Tankers	0.742185	2015	1995
Nordic American Tankers	0.131215	2014	1995
Nordic American Tankers	0.895276	2013	1995
Nordic American Tankers	0.166517	2012	1995
Nordic American Tankers	0.277436	2011	1995
Nordic American Tankers	0.255562	2010	1995
Performance Shipping	0.357727	2018	2010
Performance Shipping	1	2017	2010
Performance Shipping	0.253961	2016	2010
Performance Shipping	0.197464	2015	2010
Performance Shipping	0.0255243	2014	2010
Performance Shipping	0.187299	2013	2010
Performance Shipping	0.170775	2012	2010
Performance Shipping	0.242241	2011	2010
Performance Shipping	0.0363952	2010	2010
Safebulkers	0.230213	2018	2007
Safebulkers	0.487005	2017	2007
Safebulkers	0.196176	2016	2007
Safebulkers	0.274941	2015	2007
Safebulkers	0.0313127	2014	2007
Safebulkers	0.379606	2013	2007
Safebulkers	0.256549	2012	2007
Safebulkers	0.595957	2011	2007
Safebulkers	0.404471	2010	2007
Scorpio Tankers	0.186332	2018	2009
Scorpio Tankers	0.381409	2017	2009
Scorpio Tankers	0.322905	2016	2009
Scorpio Tankers	0.299445	2015	2009
Scorpio Tankers	0.0072279	2014	2009
Scorpio Tankers	0.158838	2013	2009
Scorpio Tankers	0.272218	2012	2009
Scorpio Tankers	0.478478	2011	2009
Scorpio Tankers	0.0917524	2010	2009
Seanergy	0.531913	2018	2008
Seanergy	0.761096	2017	2008
Seanergy	0.251908	2016	2008
Seanergy	0.0252639	2015	2008
Seanergy	1	2014	2008
Seanergy	0.0021917	2013	2008

Seanergy	1	2012	2008
Seanergy	1	2011	2008
Seanergy	1	2010	2008
Seaspan Corporation	0.194145	2018	2005
Seaspan Corporation	0.532749	2017	2005
Seaspan Corporation	0.31916	2016	2005
Seaspan Corporation	0.306127	2015	2005
Seaspan Corporation	0.0530313	2014	2005
Seaspan Corporation	0.30064	2013	2005
Seaspan Corporation	0.162725	2012	2005
Seaspan Corporation	0.331439	2011	2005
Seaspan Corporation	0.209352	2010	2005
Star bulk	0.25732	2018	2006
Star bulk	0.536234	2017	2006
Star bulk	0.213774	2016	2006
Star bulk	0.172884	2015	2006
Star bulk	0.0083381	2014	2006
Star bulk	0.216405	2013	2006
Star bulk	0.364372	2012	2006
Star bulk	0.418606	2011	2006
Star bulk	0.467843	2010	2006
StealthGas	0.195102	2018	2004
StealthGas	0.525509	2017	2004
StealthGas	0.297064	2016	2004
StealthGas	0.275216	2015	2004
StealthGas	0.0293037	2014	2004
StealthGas	0.271594	2013	2004
StealthGas	0.217195	2012	2004
StealthGas	0.576753	2011	2004
StealthGas	1	2010	2004
Teekay LNG	0.168737	2018	2004
Teekay LNG	0.314434	2017	2004
Teekay LNG	0.304631	2016	2004
Teekay LNG	0.448835	2015	2004
Teekay LNG	0.0596717	2014	2004
Teekay LNG	0.308631	2013	2004
Teekay LNG	0.244511	2012	2004
Teekay LNG	0.637621	2011	2004
Teekay LNG	0.785092	2010	2004
Teekay Tankers	0.760258	2018	2007
Teekay Tankers	0.906409	2017	2007
Teekay Tankers	0.602113	2016	2007
Teekay Tankers	0.245763	2015	2007
Teekay Tankers	0.588347	2014	2007
Teekay Tankers	0.803518	2013	2007

Teekay Tankers	0.258008	2012	2007
Teekay Tankers	0.305158	2011	2007
Teekay Tankers	0.41891	2010	2007
Top Ships	0.192737	2018	2000
Top Ships	0.516767	2017	2000
Top Ships	0.318863	2016	2000
Top Ships	0.116183	2015	2000
Top Ships	0.0023223	2014	2000
Top Ships	1	2013	2000
Top Ships	0.218358	2012	2000
Top Ships	0.562229	2011	2000
Top Ships	0.700176	2010	2000
Tsakos Energy	0.265425	2018	1993
Tsakos Energy	0.484085	2017	1993
Tsakos Energy	0.29803	2016	1993
Tsakos Energy	0.636349	2015	1993
Tsakos Energy	0.0557301	2014	1993
Tsakos Energy	0.40412	2013	1993
Tsakos Energy	0.226342	2012	1993
Tsakos Energy	0.586693	2011	1993
Tsakos Energy	0.394749	2010	1993

Note: We use the following variables as inputs: (i) total assets (TA) (ii) capital expenditure (CAPEX) and output: (iii) Revenue. TA is the sum of fixed assets, current assets and other non-current assets; CAPEX is the amount spent for the construction of new vessels and expenditures ensuring that vessels comply with international regulatory standards. REVENUE measures how efficiently a shipping firm utilized its resources. The DEA process (constant returns to scale) yields the variable Chartering Capabilities (CC) for each firm and year combination examined.

Appendix II

Table A1.3: List of shipping firms examined

Panel A: Container sector
Costamare
Danaos
Global Ship Lease Inc.
Seaspan Shipping
Panel B: Wet sector
DHT Holdings
Euronav
Frontline
GasLog Partners
Golar LNG
Nordic American Tankers
Scorpio Tankers
StealthGas
Teekay LNG
Teekay Tankers
Top Ships
Tsakos Energy Navigation
Panel C: Dry sector
Diana Shipping
Dryships
Globus
Golden Ocean Group
Safe Bulkers
StarBulk
Synergy
Panel D: Diversified
Capital Product Partners
Euroseas
Performance Shipping
Navios Maritime Partners

Note: This table lists the U.S. listed shipping companies examined in this paper according to the shipping segment where the majority of the their vessels operate within.

Appendix III

Table A2.1: List of shipping firms for data period between 2013 and 2019

Panel A: Wet sector	**Stock exchange**
Ardmore shipping	NYSE
Awilco LNG	Oslo stock exchange
Belships	Oslo stock exchange
Navigator Holdings	NYSE
DHT Holdings	NYSE
Dynagas	NYSE
Nordic American Tankers	NYSE
Euronav	NYSE
Okeanis eco tankers	Oslo stock exchange
Pyxis Tankers	NASDAQ
Gaslog Ltd	NYSE
Knot Offshore	NYSE
Scorpio tankers	NYSE
Capital product partners	NASDAQ
Tsakos energy navigation	NYSE
Stealthgas	NASDAQ
Teekay LNG	NYSE
Top Ships	NASDAQ
Panel B: Dry sector	
Diana shipping	NYSE
Safe bulkers	NYSE
Panel C: Container sector	
Global ship lease	NYSE

Note: This table shows the 21 U.S. and Norwegian listed shipping companies for the data period from 2013 to 2019 and their sector of operation consisting of Panel A: Wet Sector; Panel B: Dry Sector, Panel C: container sector.

Appendix IV

Table A3.1: List of shipping firms examined

Sub-sample 1: Dry Sector
Diana
Dryships
Globus
Golden Ocean
Navios Maritime partners
Paragon shipping
Safebulkers
Seanergy
Star bulk
Sub-sample 2: Tanker Sector
Ardmore shipping
Capital product partners
DHT Holdings
Frontline
Knot Offshore
Nordic American Tankers
Performance Shipping
Pyxis Tankers
Scorpio Tankers
Stelmar
Teekay Tankers
Top Ships
Tsakos Energy

Note: This table lists the U.S. listed shipping companies examined in this paper according to the shipping segment.

Appendix V

Full-sample estimations: Panel random effects models

Variables	M1	M2	M3	M4	Standardized coefficients
Constant	0.00 (0.00)	0.00 (0.00)	0.00	0.00	-
Spot	-0.5172 * (-1.67)	-	-	-	-
TC_short	-	-1.7337 (-1.62)	-	-	-
TC_long	-	-	0.7607 *** (2.53)	-	-
BB	-	-	-	0.4480 (0.76)	-
Observations (firm-year)	224	224	224	224	-
Cluster standard errors	Yes	Yes	Yes	Yes	
Adjusted R^2	39.87 %	43.26%	43.63%	37.15%	-
Firm random effects	Yes	Yes	Yes	Yes	-
Time fixed effects	Yes	Yes	Yes	Yes	-

Note: This table shows the results of the estimated panel data random effects regressions for the 28 shipping firms from 2000 to 2020 using ROA as dependent variable for examining its relationship with chartering policy (spot, tc_short, tc_long and bb). T-statistics and p-values are reported in (.) and [.], respectively. Statistical significance of the estimated coefficients is denoted with *, ** and *** for 10%, 5% and 1% significance levels, respectively. As a final robustness test, we follow Petersen (2009) cluster adjusted standard errors at the firm level.

Sub-samples estimations: Panel random effects models

		Dry firms sub-sample 1		
Variables	**M1**	**M2**	**M3**	**M4**
Spot	-0.3992 (-0.73)	-	-	-
TC_short	-	-1.8077 (-1.46)	-	-
TC_long	-	-	1.1536 ** (2.13)	-
BB	-	-	-	1.3894 (1.49)
Number of observations	100	100	100	100
Adjusted R^2	37.40%	44.77%	43.66%	37.15%
Cluster standard errors	Yes	Yes	Yes	Yes
Firm random effects	Yes	Yes	Yes	Yes
		Tanker firms sub-sample 2		
Spot	-0.3753 (-1.36)	-	-	-
TC_short	-	-3.8170 *** (-6.87)	-	-
TC_long	-	-	0.4033 (1.53)	

BB	-	-	-	0.1906 (0.32)
Number of observations	124	124	124	124
Adjusted R^2	61.18%	62.07%	61.50 %	59.08%
Cluster standard errors	Yes	Yes	Yes	Yes
Firm random effects	Yes	Yes	Yes	Yes

Note: this table shows the panel data random effects regression model for dry and tanker firms individually. Panel data regressions were estimated for the dry and tanker shipping firms from 2000 to 2020 using *ROA* as dependent variable for examining its relationship with chartering policy (*spot*, *tc_short*, *tc_long* and *bb*). T-statistics are reported in (.). Statistical significance of the estimated coefficients is denoted with *, ** and *** for 10%, 5% and 1% significance levels, respectively.

Sub-samples random effects panel data regressions including volatilities:

	Dry firms sub-sample 1				
Variables	**M1**	**M2**	**M3**	**M4**	**M5**
Spot	-0.4850 (-0.53)	-	-	-	-
TC_short (light grey)	-	-1.5360 (-2.62)	-1.5360 (-2.62)	-1.5360 (-1.02)	-1.5360 (-1.05)
TC_long (bold grey)	-	1.1906 ** (1.95)	1.1922 ** (1.95)	1.1922 ** (1.95)	1.2363 ** (2.05)
Avg_vol_dry_spot	1.3060 (0.31)	-	-	-	-
Avg_vol_dry_6mstc	-	5.7427 (0.32) -1.3627 ** (-0.05)	-	-	-
Avg_vol_dry_1tc	-	-	-7.1690 (-0.32) 1.7012 (0.05)	-	-
Avg_vol_dry_3tc	-	-	-	-1.4069 (-0.32) 0.3338 (0.05)	-
Avg_vol_dry_5tc	-	-	-	-	0.3815 (0.47) 0.4677 (0.63)
Number of observations	100	100	100	100	100
Adjusted R^2	46.48%	52.45% 38.24%	52.45% 38.24%	52.45% 38.24%	51.18% 36.19%
Cluster standard errors	Yes	Yes	Yes	Yes	Yes
Firm random effects	Yes	Yes	Yes	Yes	Yes
	Tanker firms sub-sample 2				
Spot	-0.3086 (-1.35)	-	-	-	-
TC_short (light grey)	-	-3.7430 *** (-6.38)	-3.7430 *** (-6.38)	-3.6777 *** (-6.28)	-

TC_long (bold grey)	-	0.3786 (1.34)	0.3786 (1.34)	0.3671 (1.35)	-
BB	-	-			-
Avg_vol_tanker_spot	0.3579 (0.40)				-
Avg_vol_tanker_1tc		0.1921 (0.23)			-
		0.5309 (0.70)			-
Avg_vol_tanker_3tc			0.5772 (0.23)		-
			1.5447 (0.70)		-
Avg_vol_tanker_5tc				1.2788 (0.49)	-
				0.5672 (0.20)	-
Number of observations	124	124	124	124	-
Adjusted R^2	10.93%	61.65%	61.65%	59.61%	-
	-	60.92%	60.92%	58.80%	
Cluster standard errors	Yes	Yes	Yes	Yes	-
Firm random effects	Yes	Yes	Yes	Yes	-

Note: this table shows the panel data regression model for dry and tanker firms individually. Panel data regressions were estimated for the dry and tanker shipping firms from 2000 to 2020 using *ROA* as dependent variable for examining its relationship with chartering policy (*spot*, *tc_short*, *tc_long* and *bb*). T-statistics are reported in (.). Statistical significance of the estimated coefficients is denoted with *, ** and *** for 10%, 5% and 1% significance levels, respectively. Avg_vol_dry_spot and Avg_vol_tanker_spot show the annyalized volatilities for dry and tanker segments for vessels Capesize, Panamax, Handysize and VLCC, Suezmax, Aframax, Panamax and Handysize respectively. Their mean values are 43.75% and 53.79% respectively. Avg_vol_dry_6ms, Avg_vol_dry_1tc, Avg_vol_dry_3tc, Avg_vol_dry_5tc and Avg_vol_tanker_1tc, Avg_vol_tanker_3tc, Avg_vol_tanker_5tc shows the volatilities for dry and tanker vessels mentioned above for time charter contract duration of six months (6ms), 1 year (1tc), 3 years (3tc) and 5 years (5tc).

Appendix VI

Dry cargo segment		
Ship type	**Ship size**	**Time charter duration**
Capesize	120,000-170,000 DWT	6 months, 1 year, 3 and 5 years
Panamax	82,000 DWT	6 months, 1 year, 3 and 5 years
Handymax	58,000 DWT	6 months, 1 year, 3 and 5 years
Handysize	32,000 DWT	6 months, 1 year, 3 and 5 years

Tanker segment		
Ship type	**Ship size**	**Time charter duration**
Vlcc	310,000 DWT	1 year, 3 and 5 years
Suezmax	150,000 DWT	1 year, 3 and 5 years
Aframax	110,000 DWT	1 year, 3 and 5 years
Panamax	74,000 DWT	1 year, 3 and 5 years
Handysize	37,000 DWT	1 year, 3 and 5 years

Dry cargo segment		
Ship type	**Ship size**	**Voyage charter routes**
Capesize	120,000-170,000 DWT	H. Rds – Rotterdam Bolivar – Rotterdam Tubarao – Rotterdam Goa – Qingdao Port Cartier – Rotterdam Tubarao – Oita H. Rds, R. Bay – Japan Richards Bay – Rotterdam Dampier – Qingdao Saldanha Bay – Qingdao Rizhao – Rotterdam Tubarao – Qingdao Narvik – Rotterdam Hay Point – Gwangyang Banjarmasin – Rotterdam Baltimore – Rotterdam Dampier – Oita Hay Point – Rotterdam W. Australia – Rotterdam Tubarao - El Dekheila Hay Point – Qingdao Richards Bay – Gangavaram Nouadhibou - Rotterdam
Panamax	50,000-82,000 DWT	USGulf/Rott Baltimore/ARA Bank/Japan Newcastle/Japan Nopac/Japan Bolivar/ARA Richards Bay/Rotterdam Bank/Rotterdam

		NSW/Cont R. Bay/Sp. Med. Indo/Rotterdam Maracaibo/Rotterdam USGulf/Japan USGulf/ARA Ventspils/Rotterdam Murmansk/Rotterdam US Gulf/Jorf Lasfar Richards Bay/Krishnapatnam Richards Bay/Mundra Dalrymple Bay/Longkou Roberts Bank/Longkou Dalrymple Bay/Rotterdam Samarinda/Dahej Samarinda/Ennore Tubarao – Rotterdam Tubarao – China Santos – Qingdao Santos – Rotterdam Baltimore – ARA US Gulf – ARA Richards Bay – Qingdao Dalrymple Bay - Praia Mole Richards Bay – Krishnapatnam Richards Bay – Mundra Samarinda – Ennore Samarinda – Dahej W. Aus - N. China New Orleans – Qingdao US Gulf – Egypt Hamburg – Jeddah NOPAC - N. China W. Aus – Dammam Kamsar - San Ciprian Indonesia – Med Samarinda - S. China PDM – Ghent New Orleans - Qingdao
Handymax	40,000-49,999 DWT	US Gulf/Japan Richards Bay/Visakhapatnam Richards Bay/Mundra Samarinda/Paradip Samarinda/Pipavav Qinhuangdao-Guangzhou Houston – Rotterdam Texas – China Houston – Kandla Bolivar – Chile Boston – Turkey Chesapeake Bay – Amsterdam

Tanker segment		
Ship type	**Ship size**	**Voyage charter routes**
Vlcc	260,000-320,000 DWT	Sidi Kerir – Rotterdam Ras Tanura - Ulsan Ras Tanura - Chiba Ras Tanura - Loop Bonny Off – Loop Bonny Off – Kaohsiung Ras Tanura – Rotterdam Bonny Off - WC India Rotterdam – Singapore Bonaire – Singapore Ras Tanura – Singapore Ras Tanura - Ain Sukhna Ras Tanura Loop Bonny Off Ningbo Ras Tanura – Jamnagar Mongstad – LOOP Bonny Off – Rotterdam Ras Tanura – Ningbo USG – Singapore USG – Ningbo STS GOLA – Jamnagar Hound Point – Ningbo Angra Dos Reis – Ningbo Bonny Off - WC India
Suezmax	130,000-150,000 DWT	Bonny Off Philadelphia Sidi Kerir – Fos Ras Tanura – Huizhou Bonny Off Lavera Novorossiysk – Augusta Ras Tanura – Jamnagar Basra – Lavera Marsa El Hariga – Ningbo Sture – Wilhelmshaven Sture – LOOP Bonny Off – Rotterdam Houston – Rotterdam Houston – Singapore Bonny – Singapore Ras Tanura – Durban Novorossiysk – Ulsan Novorossiysk – Sikka Bonny - Durban
Aframax	70,000-100,000 DWT	Sidi Kerir Trieste Curacao - Texas City Arzew Philadelphia Ras Tanura Singapore Singapore – Chiba Ras Tanura Chiba Hound Point Bayway Curacao – Hamburg Hound Point Trieste Novorossisyk Augusta Seria Brisbane

		Hound Point Wilhelmshaven Mina al-Ahmadi Rotterdam Primorsk – Rotterdam Mellitah – Fos Bonny Off – Fos Bonny Off – Houston Kozmino – Ulsan Zuetina – Singapore Yanbu – Chiba Rotterdam – Chiba Skikda – Chiba Ulsan – Singapore Ras Tanura – Singapore Arzew – Trieste Ceyhan – Augusta Kozmino – Qingdao Novorossiysk – Bourgas Corpus Christi – Rotterdam Corpus Christi – Canaport Yanbu – Rotterdam Jubail - Mombasa
Panamax	50,000-60,000 DWT	Rotterdam Bayway Milford Haven Milazzo Ras Tanura Chiba Milford Haven Wilhelmshaven Curacao New York Antwerp – Houston Immingham Milazzo Augusta – Houston Mina al-Ahmadi Rotterdam Yanbu – Chiba Yanbu – Rotterdam Rotterdam – Chiba WC India - US East Coast WC India – Jeddah St Eustatius – Houston Amsterdam – Malta Skikda – Houston Cap Limbe – Houston Amsterdam – Lome Skikda – Chiba Ulsan - Los Angeles Houston – Suape Houston – Amsterdam Houston – Chiba Houston - St Eustatius
Handysize	37,000 DWT	Bahrain Bombay Tees – Dunkirk Skikda – Philadelphia Curacao - New York Ras Tanura Dar Es Salaam Tuapse Augusta Ventspils Amsterdam Augusta – Lavera Rotterdam - New York

		Ras Tanura Chiba Tees Amsterdam Bombay Chiba Ras Lanuf Immingham Skikda Rotterdam Skikda – Lavera Mina al-Ahmadi Rotterdam Singapore Chiba Odessa Augusta Lavera Augusta Fawley- Rotterdam Augusta - New York Skikda - Houston Skikda - Sao Luis Houston - Amsterdam Houston - Rio de Janeiro Houston - Quintero UKC - WAF Red Sea - Japan WC India – Singapore Singapore – Sydney Singapore - Hong Kong Ulsan – Singapore Ulsan - Los Angeles WC India - Red Sea Yanbu – Rotterdam WC India - Jebel Ali Augusta – Lavera Augusta – Rotterdam Tuapse - Agioi Theodoroi Zawia - Milazzo Dirty Zawia – Houston Amsterdam – Houston Zawia – Amsterdam Sillamae – Amsterdam San Lorenzo - Jawaharlal Nehru Odessa - Agioi Theodoroi Lavera – Augusta Sillamae – Amsterdam Suez – Chiba Sikka – Gizan Yosu – Sydney Houston – Tuxpan Houston – Rosarito Jubail - Jebel Ali

Appendix VII

As a first step, we take the logarithmic differences of the time charter and voyage rates for ship voyages mentioned in appendix IV. Secondly, we estimate the standard deviation of the logarithmic differences using the formula below:

$$\sigma = \sqrt{\frac{\sum(\chi_i - \mu_n)}{n}}$$

Where:

σ is the standard deviation of logarithmic differences for ships chartered under short-term duration (in the spot market) and time charter rates of the appropriate ships.

χ_i is the logarithmic difference of freight rates for each ship in each freight segment (voyage or time charter) in a rolling window 12 months.

μ_n is the mean of the respective sample of time charter or voyage rates for each ship in each segment (dry or tanker) in a rolling window 12 months.

n is the number of each sample's freight observations for each ship in each segment equals to 12 monthly observations.

Thirdly, we compute the annual volatility of freight rates either voyage or time charter for each vessel in each segment in a rolling window 12 months using the following formula:

$$Vol = \sigma * \sqrt{n}$$