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Do Green Forerunners Perform Better?

An Empirical Investigation of the Global Shipping Stock Market

Master Thesis

by

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Abstract

This thesis studies the relationship between the financial and environmental performance of global tanker and dry bulk shipping stocks between 2016 and 2022. We construct two different green stock portfolios consisting of i) shipping companies that invest in scrubbers, and ii) shipping companies that publish sustainability reports. We compare the financial performance of these green portfolios with the global stock market, the shipping stock market, and their non-green peers. The results are consistent regardless of the green portfolio and indicate that green shipping stocks do not outperform the global market or the shipping market. Yet, we find evidence that green shipping stocks outperform their non-green peers. Relative to their non-green peers, the green portfolios generate abnormal monthly returns ranging from 0.359 to 0.631. These results are driven by negative and significant abnormal returns generated by the non-green portfolios, indicating that the market punishes shipping stocks that ignore environmental efforts. The evidence is consistent with increased investor scrutiny due to expanding regulatory structures in the maritime industry. We acknowledge that the small and constructed sample size of shipping stocks may cause biased results. However, we conclude that a comprehensive data selection process in consultation with Pareto Securities and Yara Marine Technologies answers such issues.

Keywords: shipping, tanker, dry bulk, climate change, sustainability, ESG, emissions, IMO, sustainability reporting, portfolio performance, stock returns, regression analysis

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List of Abbreviations

Capital Expenditures	CAPEX
Conservative Minus Aggressive	CMA
Corporate Social Responsibility	CSR
Environmental, Social and Governance	ESG
High Minus Low	HML
High Sulfur Fuel Oil	HSFO
International Maritime Organization	IMO
Low Sulfur Fuel Oil	LSFO
Marine Environment Protection Committee	MEPC
Momentum	MOM
Operating Expenditure	OPEX
Ordinary Least Squares	OLS
Robust Minus Weak	RMW
Small Minus Big	SMB
Sustainable Development Goals	SDGs
Very Low Sulfur Fuel Oil	VLSFO

1 Introduction

In this thesis, we study the financial performance of listed shipping companies that we view as "forerunners." Shipping companies that act early with environmental efforts and drive ambitious green targets compared to their peers. Furthermore, we present green shipping companies in two ways: i) companies whose primary investment is scrubbers (to comply with IMO 2020[1]), and ii) companies that publish sustainability or ESG reports. We construct two green portfolios based on these two definitions of green shipping stocks. This thesis aims to evaluate the financial performance of these two portfolios to see whether investors favor forerunners compared to the global stock market and their non-green peers.

International shipping sets the pace for the global economy by accounting for approximately 90 percent of the world trade volume (OECD, 2019). It is one of the world's largest and fastest GHG polluting sectors (Gibbs et al., 2014), making the sector play a critical role in the greening of the economy. As a result of the Paris Agreement in September 2015[2], The International Maritime Organization (IMO) adopted "the initial strategy" of reducing GHG emissions by at least 50 percent by 2050 (IMO, 2022a). The increasing attention to climate change and GHG emissions has led to expanding regulatory structures in shipping. As a result, companies must make defining strategic decisions about their environmental efforts, although the key driver may be increased investor scrutiny.

To our knowledge, the relationship between financial and environmental performance is not investigated in the shipping sector. We aim to fill this gap by analyzing whether green shipping stocks generate abnormal returns compared to the stock market and non-green peers by asking the following research question: *What are the financial implications of listed shipping companies' environmental performance?*

The critical goal when constructing the data sample is to seize companies that have invested in scrubbers and published sustainability reports between 2016 and 2022.

[1] See subsection 2.2.

[2] In December 2015, 196 parties agreed to limit global warming to below 2 degrees Celsius, preferably 1.5 degrees Celsius by entering into the Paris Agreement on climate change. The Paris Agreement is a landmark in the international work toward climate change (United Nations, 2021).

The collection of data is based on several assumptions to achieve this goal and thus be able to answer our research question. First, shipping companies operate their assets worldwide. As a result, shipping companies often have complex structures with ship owners, intra-group charterers, and headquarters located worldwide. A shipping company can also be listed on several stock exchanges. As such, the shipping sector can be perceived as a global sector, thus we choose to investigate global shipping stocks. Second, the shipping sector consists of several subsectors. This thesis investigates the tanker and dry bulk subsectors. This choice is because the tanker and dry bulk subsectors are the two largest subsectors in number of ships, are highly operating businesses, and have essential investor interest. Additionally, this makes tanker and dry bulk companies to highly invest in green technologies, thus making them suitable for analyzing environmental performance. Last, we exclude investment companies and holding companies from the data sample. The reason for this is the assumption that these companies might not implement defining business decisions for their fleets. We make these assumptions and decisions in consultation with the Head of Research and shipping analysts in Pareto Securities[3] and the Strategic Director of Business Development in Yara Marine Technologies[4], and we believe they make the constructed data sample the best fit to answer our research question.

We construct portfolios consisting of green and non-green stocks, which we compare with the shipping stock market and the global stock market. Additionally, we create difference portfolios to compare the financial performance of the green portfolios with that of the non-green portfolios. The difference portfolios consist of a net-zero investment strategy, taking a long-short position in the green and non-green portfolios. We analyze the financial performance of the portfolios by using the Carhart (1997) four-factor and Fama and French (2015) five-factor models. Our work relates to the methodology of Andrade et al. (2021), who investigate the financial performance of green and non-green energy stocks. They conclude that green stocks generate abnormal returns compared to the market, and they find evidence that the green stocks outperform non-green stocks considering the energy market.

[3] Pareto Securities are one of the most well-known broker houses in the Nordic and have developed to be an important broker house within the offshore industry (Pareto Securities, 2022).
[4] Yara Marine Technologies is a subsidiary of Yara International and provide technologies to enable a greener maritime industry (Yara Marine Technologies, 2022).

We believe that there is a positive relationship between a shipping company's stock and its environmental performance. Being a forerunner within social responsibility gives the company a competitive advantage among investors in the circumstance of expanding regulatory structures in a conservative industry. Hence, we think green shipping stocks will outperform the market and their non-green peers. Yet, this thesis does not find empirical evidence indicating that investing in green shipping stocks will generate abnormal returns compared to the market. Despite this, we find that green shipping stocks outperform non-green shipping stocks. The difference portfolios generate monthly abnormal returns ranging from 0.359 to 0.631 percent in monthly terms. The main driver behind this significant finding is that non-green shipping stocks seem to destroy value compared to the market by delivering monthly abnormal returns ranging from -0.445 and -0.607 percent. In other words, the results indicate a favorable financial implication for environmental performance in the shipping sector.

The remainder of this thesis is structured into five sections. Chapter two presents background information about the shipping sector, existing literature on the topic, research questions, and related hypotheses. The third chapter explains the methodology and relevant economic theory and discusses the weaknesses of the selected models. The fourth chapter describes the data selection process and how we construct the portfolios to analyze the financial performance. The fifth chapter provides the results, robustness tests, a discussion of the main findings, limitations, and recommendations for future research. The conclusion is presented in the sixth and final chapter.

2 Background and Literature Review

In the following chapter, we present essential characteristics of the shipping sector. The shipping sector consists of several subsectors such as tanker, dry bulk, container, ro-ro, and cruise ships, among others. The subsectors vary by their unique characteristics and perform different operational and economic activities. In consultation with Pareto Securities and Yara Marine Technologies, we decide to investigate the tanker and dry bulk subsectors. There are several reasons for this. First, tanker and dry bulk are the two largest subsectors, given market shares noted in the number of ships and gross tonnage. As of March 2022, the world shipping fleet consists of 103,161 ships (see table 12 in Appendix 1). Tanker and dry bulk ships account for approximately 30 percent of the world fleet (see tables 13 in Appendix 1), thus making them the largest investors in scrubbers. Second, according to Pareto Securities, tanker and dry bulk companies are highly operating businesses and have an essential investor interest compared to companies in other subsectors. Last, we can capture the unique characteristics of both subsectors. Tankers operate in freight markets for oil, gas, and chemicals, and dry bulk operates in freight markets for raw materials such as iron ore, coal, and grain. These characteristics make the respective stock prices subject to macroeconomic factors such as the oil price and interest rates.

This chapter also presents relevant regulations and concepts of sustainability to construct a fundament for how we measure environmental performance. After that, we review existing literature on this topic and explain how this thesis will contribute to this research. Finally, we introduce our research question and the developed hypotheses.

2.1 The Shipping Sector

International trade has had a considerable growth rate since the 1950s (Estevadeordal et al., 2003). This has led shipping to become a global sector, meaning that shipping companies operate their assets worldwide. The international aspect of the sector causes shipping companies to have a complex structure. For example, a shipping company can flag their ships in Panama, have a Bermudan shipowner, a Norwegian intra-group charterer, a beneficial English owner, have headquarters in the US, and be listed on several stock exchanges. For instance, dual listings on the Oslo Stock Exchange and the New York Stock Exchange are commonly seen. Consequently, these varieties can diminish labor costs, make it possible to receive tax advantages, and obtain external financing.

Shipping is unique because of its asset-heavy and capital-intensive operations. This leads shipping companies to exhibit higher leverage ratios than other industries often. As corporate leverage is mainly related to asset tangibility, the high leverage ratios are explained by the high intensity of fixed assets, i.e., ships (Drobetz et al., 2013, 2016; Mohanty et al., 2021). Further, a shipping company's investment decisions rely on the asset specificity of its ships, considering ships' average lifetime of 22 years (Mohanty et al., 2021). This may cause shipping companies to take on higher investment[5] and regulatory risk[6] when investing in new technologies. However, declining shipping costs due to rapid growth in global trade give rise to technological developments in the shipping sector (Hummels, 2007; Knick Harley, 1980; Mohammed & Williamson, 2004). We suggest that forerunners in environmental performance exploit technological development contrary to having a conservative attitude.

Another characteristic of the shipping sector is its cyclicality due to fluctuations in shipping prices, namely day rates. Day rates are driven by supply and demand for sea transport which are relatively volatile compared to other sectors (Drobetz et al., 2016). In the short term, high demand leads to shipping volume becoming short and day rates increasing rapidly. Increasing rates cause shipowners to buy or order additional vessels, which may lead to excess capacity and, as a result, reduced day rates, primarily if other external factors affect international trade. Additionally, ship supply increase and negative demand shock cause day rates to fall drastically, often below OPEX and CAPEX. Consequently, ships may stop in many ports and countries to realize their potential in terms of price (Hummels, 2007). It also exists internal and external factors that influence day rates. Macroeconomically, factors such as interest rates, exchange rates, and oil prices are proven to significantly impact day rates and shipping stock returns (Mohanty et al., 2021).

2.2 IMO 2020

In 1948, the United Nations formally adopted the IMO. The organization was established to improve sea safety by developing international regulations that all shipping nations follow (IMO, 2022b). As a result of the Paris Agreement, IMO adopted a strategy of reducing GHG emissions by at least 50 percent by 2050, namely the Initial Strategy (IMO, 2022a). This strategy called for the widespread use of energy efficiency measures and lower polluting fuels.

In October 2016, the IMO's Marine Environment Protection Committee announced: "IMO 2020". The regulation limits the sulfur content in the fuel oil used

[5] Investment risk can be defined as the probability or likelihood of losses relative to the expected return on investment (The Economic Times, 2022a).
[6] Regulatory risk is the risk of changing regulations that might affect a company or a business (The Economic Times, 2022b).

in ships to 0.5 percent, representing a substantial cut from the previous limit of 3.5 percent. To comply with the regulation, shipping companies could either install exhaust gas cleaning systems (referred to as “scrubbers”) on ships and continue using high sulfur fuel oil (HSFO) or switch to fuel oil with very low sulfur content (VLSFO). Before the new limit, ships used HSFO regularly. IMO 2020 made fuel oil with lower sulfur content compulsory as ships can use scrubber technology. Scrubbers remove sulfur oxides from ships’ engines and boiler exhaust gasses. A ship fitted with a scrubber can use the cheaper HSFO because the sulfur level will be reduced to 0.5 percent (IMO, 2022c). By January 2022, 4662 scrubber systems have been installed or ordered (number of scrubbers retrieved from dataset received from Clarksons Research, see section 4.1.1).

A substantial factor impacting the cost of scrubbers is the VLSFO-HSFO spread which is the price difference between VLSFO and HSFO. When this spread is high, it is more beneficial to use a scrubber than in the presence of a low spread (Fan et al., 2020). See figure 7 in Appendix 5 for the VSLFO-HSFO spread growth from September 2019 to January 2022.

Nevertheless, it is found that some scrubber types raise environmental concerns. This is because these types discharge wastewater into the sea. These concerns raise doubt about treating scrubbers as a green investment. Yet, this remains a widely discussed matter as there are solutions to remove wastewater from the scrubbers (Barona et al., 2021).

2.3 Sustainability Reporting in Shipping

The expanding environmental regulations in shipping lead shipping companies to increase transparency and define sustainability targets. Additionally, investor scrutiny increases the pressure on shipping companies to drive sustainable efforts. Shipping must handle ESG efforts on a company level to achieve a more sustainable industry. Sustainability and ESG reports are a helpful tool for all stakeholders to ensure that sustainability measures materialize as it increases monitoring and management commitment (Solberg, 2021).

In 2017, DNV and the Norwegian Shipowner Association published a report exploring shipping’s potential contributions to the Sustainable Development Goals

(SDGs).[7] To map sustainability, the report establishes plans and objectives related to the biosphere, society, and economy. Through these categories, the report identifies five opportunity areas for shipping: i) act on the Paris Agreement, ii) build sustainable communities & infrastructure, iii) protect life in the oceans, iv) create a sustainable future for the ocean economy, and v) promote responsible practices. The combined effects of these factors encourage shipping companies to perform sustainable operations and put requirements on their suppliers (DNV & Norwegian Shipowners' Association, 2017; Solberg, 2021). The first opportunity area is of the most interest for this thesis.

From the shipping companies' perspective, the increasing focus on the sustainability of their operations increases the need to communicate their ESG practices and performance. This has resulted in guidelines for reporting. The EU, US securities and Exchange Commission, stock exchanges, and regulators globally are requiring companies to disclose information on their work with sustainability. Among the hundreds of sustainability reporting frameworks, three initiatives stand out in the global reporting shipping landscape: Global Reporting Initiative (GRI), The Value Reporting Foundation, and the UN's SDGs (see figure 6 in Appendix 2). A pivotal step to reaching a sustainable shipping sector is managing and monitoring SDGs through reporting on a company-level (Solberg, 2021). Goal number 13 captures efforts to fight climate change and seize the Paris Agreement (United Nations, 2019). Hence it is the most relevant for this thesis.

2.4 Literature Review

As the concept of environmental performance has become more established, more research about the relationship between financial and environmental performance has surfaced. However, research on shipping's financial and environmental performance is limited.

2.4.1 Financial and Environmental Performance

In 1970, Milton Friedman published the well-known "shareholder theory" and started a long dispute about social responsibility at the company level. The shareholder theory states that a company's primary responsibility is to maximize

[7] The SDGs, also known as the Global Goals, were adopted by the UN in 2015, as a universal call to end poverty and protect the planet and consists of 17 integrated goals within social, economic, and environmental sustainability (UNDP, 2022).

revenue and increase shareholder returns. According to Friedman (1970), a company is not obligated to engage in social responsibility unless the shareholders choose to. Furthermore, the theory suggests that the only social responsibility of a company is to use its resources and engage in activities "*designed to increase its profits so long as it stays within the rules of the game….*" (Friedman, 1970).

Some studies that engage in corporate social responsibility (CSR) do not find empirical evidence that it increases business performance long-term, supporting Friedman (1970). CSR is seen to only serve the management's interests, such as increasing social status and reputation, at the cost of stakeholder's interests (Bénabou & Triole, 2010; Martin Curran & Moran, 2007). Yet, CSR activities are gaining an increasing focus. Several studies investigate whether CSR positively affects companies' performance. El Ghoul et al. (2011) compare companies with low and high CSR scores and found that companies with high CSR scores are more eligible for cheaper financing. Attig et al. (2013) find a positive relationship between a company's CSR score and credit rating. Consistent with previous findings, this indicates that CSR performance leads to financing advantages and lower financing costs, highlighting the importance of complying with environmental matters. Consequently, this may lead to a higher alternative cost arising long-term when companies ignore ESG.

In a similar vein of research, Edmans (2011) finds that companies with high employee satisfaction produce earnings that consistently outperform analyst projections. In a later study, Edmans connect stock returns and sustainability, where he finds a positive correlation between stock returns and environmental performance from sustainable activities (Edmans, 2020). Supporting Friedman (1970), several studies suggest that environmental performance is costly and hurt a company's bottom line, as there is little economic payback in sight. In contrast, Dowell et al. (2000) find evidence that companies that adopt more stringent environmental standards have higher market values. Thus companies that default to lax standards are perhaps of poorer quality and less competitive. Consistent with these findings, Ambech and Lanoie (2008), Freeman and Evan (1990), and Porter and Linde (1995) suggest that increasing environmental performance can result in a competitive advantage, higher productivity, and lower company costs.

From the investor's perspective, several studies investigate the effects of environmental events on stock prices. Despite that, little research exists on the economic impact of investing in green companies. Especially existing research on the shipping stock market is scarce. Studies on green stocks and the energy sector investigate whether green portfolios outperform non-green portfolios (Anderloni & Tanda, 2017; Andrade et al., 2021; Ng & Zheng, 2018). Andrade et al. (2021) found that the constructed portfolio of green energy stocks outperforms the energy market and the non-green portfolios. The outperformance is mainly due to a performance improvement in most recent years.

Some studies also suggest that the financial performance of green versus non-green companies is related to the effects of increasing demand. If a considerable number of investors search for stocks in non-controversial sectors, there will be a relative overpricing of green stocks compared to their non-green peers (Boermans & Galema, 2019). This will, in return, penalize the performance of green investments. By contrast, arguments exist that investors who hold companies categorized as non-green are substantially exposed to environmental[8] and regulatory risks (Boermans & Galema, 2019; Trinks et al., 2018), as new regulations may diminish asset values. Several studies examine the price pressure on green stocks and the returns of environmental risk. Investors with ESG preferences can outperform other investors if the ESG factors provide information that the market has not yet incorporated (Pedersen et al., 2021).

Several studies find that investors value sustainability and green stocks (Ammann et al., 2019; Hartzmark & Sussman, 2019). Ammann et al. (2019) find strong evidence that retail investors move their money from funds with low Morningstar sustainability ratings toward funds with high ratings. Confirming this, Halcoussis & Lowenberg (2019) investigate institutional investors' divestments in fossil fuel stocks and find that their low-carbon portfolio outperforms the market due to the low performance of the fossil fuels industries.

[8] Environmental risk is the likelihood of occurrence and severity of the potential consequences from credible environmental hazards (Speight, 2015).

2.4.2 Financial and Environmental Performance in Shipping

Despite the broad empirical research on the importance of green shipping (Lai et al., 2011; Lee & Nam, 2017; Yuen et al., 2017), few studies address environmental and financial performance.

Lun et al. (2015) introduces the concept of Greening Performance Relativity (GPR) when conducting financial and environmental analyses. These findings suggest that green operations positively affect business performance, emphasizing the relevance of GPR to all investors to evaluate the degree of environmental and financial performance. Moreover, Zhu et al. (2020) investigate cost-effective solutions that comply with the IMO 2020 regulations. They perform sensitivity analysis by testing scrubbers and compare this to scenarios with VLSFO. They conclude that scrubbers are more appealing except when VLSFO hits low prices and becomes more profitable. Both studies (Lun et al., 2015; Zhu et al., 2020), found positive relationships between green operations and business performance.

Previous literature focuses on CSR in the light of corporate culture and sustainability concerns. Drobetz et al. (2014) analyze drivers of sustainable shipping practices and find that CSR disclosures are due to a company's characteristics, such as ownership structure and special access to external finance. These findings imply that first-movers like Maersk and Evergreen Marine helm CSR and that remaining companies in the sector must follow to avoid competitive burdens. In contrast, Yuen and Lim (2016) suggest that shipping companies have a low incentive to pay for CSR. A survey of 600 Singaporean companies finds that elements such as high regulatory standards and lack of strategic vision are significant barriers to CSR in shipping companies.

Lastly, extensive research on the SDGs in the shipping sector is still lacking. Rahdari et al. (2016) emphasizes that companies must widen their corporate responsibility scope by involving climate issues. Furthermore, as a critical part of world trade, shipping companies cooperate with world trade members to contribute to the broader sustainability agenda. Wang et al. (2020) stress that such cooperation may bring economic, social, and environmental benefits. Ultimately, this thesis contributes to the existing literature by investigating how working towards sustainability, and the SDGs is reflected in the financial performance of shipping companies.

2.5 Research Question and Hypotheses

This thesis will contribute to existing research by exploring the relationship between environmental and financial performance in the global shipping sector, raising the research question:

What are the financial implications of listed shipping companies' environmental performance?

To answer this research question, we study the financial performance of listed shipping companies by constructing portfolios consisting of green and non-green shipping stocks. We define the criteria for inclusion in the green portfolios in two ways: shipping companies' level of investments in scrubbers (referred to as "level of green investments"), and shipping companies' ability to measure and report sustainability issues through publishing sustainability reports. This gives mainly two different green portfolios and two different non-green portfolios of peers.

The two first hypotheses look at the green and non-green shipping stocks defined by the level of green investments. The level of green investments is the number of scrubbers installed on or ordered for the respective shipping companies' fleet. We use this measurement in consultation with Yara Marine Technologies.

Hypothesis A1: Listed shipping companies with a high level of green investments will outperform the market

Hypothesis A2: Listed shipping companies with a high level of green investments will outperform non-green peers

If we only assess the level of green investments for shipping companies, we may ignore important environmental efforts from companies that do not invest in scrubbers. The last two hypotheses define green and non-green shipping companies by their ability to report efforts towards sustainable development, focusing on the environmental aspect. Sustainability ratings are not widespread among shipping stocks. Thus, we choose to look at shipping stocks that measure their ESG efforts with reports. Among the largest shipping companies, there is found that 90 percent report one of the most common initiatives (see figure 6 in Appendix 2). Sustainability reports help companies structure their ESG disclosures to become useful for internal and external stakeholders (DNV & Norwegian Shipowners' Association, 2017; Solberg, 2021). Yet, we believe that non-green shipping companies do not have the incentives to publish sustainability reports.

Hypothesis B1: Listed shipping companies that publish sustainability reports outperform the market

Hypothesis B2: Listed shipping companies that publish sustainability reports outperform non-green peers

We believe that green forerunners outperform the market and their non-green investing peers. In contradiction to Friedman (1970), we suppose that companies' responsibilities have expanded to include social responsibilities, i.e., environmental efforts, due to the recent focus on climate change. Particularly in shipping, where more rigorous regulations to reduce GHG emissions force companies and investors to act. Supporting Ammann et al. (2019), we believe that investors move their funds from companies with evidence of low sustainability efforts to companies with high. Consequently, we believe that green stocks outperform their non-green peers, given recent divestments and a decrease in return related to low-environmental performing stocks (Halcoussis & Lowenberg, 2019).

3 Methodology

In this chapter, we will elaborate on the methodology used in this thesis. Firstly, we will present the economic theory and related regression models used to analyze the green and non-green portfolio returns. Finally, we present the weaknesses of the chosen methodology.

3.1 Economic Theory

We analyze the return of the green portfolios compared to market benchmarks and non-green portfolios. We start by calculating the alphas for the green and non-green portfolios by regressing the excess portfolio returns on two different market benchmarks. Further, we make difference portfolios to compare the green and the non-green portfolios. These portfolios employ a net-zero investment strategy, taking a long position in the green and a short position in the non-green portfolios. We apply the Carhart (1997) four-factor model and the Fama and French (2015) five-factor model for all portfolios in relation to the methodology in Andrade et al., 2021. These models are expansions of the capital asset pricing model (CAPM) and the Fama and French (1993) three-factor model by adding various company-specific risk factors (Hayes, 2021). We apply the ordinary least squares (OLS) for all regressions.

3.1.1 The Capital Asset Pricing Model and Jensen's Alpha

CAPM was developed by Lintner (1965), Mossin (1966), Sharpe (1964) and Treynor (1961). The model shows the relationship between systematic risk and expected return for stocks, portfolios, and other assets (Kenton, 2022). The rationale is that investors receive higher returns as compensation for higher systematic risk. Systematic risk is undiversifiable as it applies to the whole market. Unsystematic risk is company-specific risk and thus can be diversified (Chen, 2022). If the market is efficient and the CAPM holds, the alpha should be zero for all expected returns (Mullins, Jr., 1982). Nevertheless, this model often gets criticized for its simplicity and weaknesses, for example, its lack of explanatory variables (Fama & French, 2004).

Jensen's Alpha represents the average return on a portfolio or other assets above or below what is predicted by CAPM (Jensen, 1969). The rationale of the alpha is that if a portfolio performs better/worse than the market, the applied model will return a significantly positive/negative alpha. On the other hand, if incorrect factors are used, a non-zero alpha may represent a pricing error (Jarrow & Protter, 2011).

The CAPM and Jensen's Alpha explain the return on a portfolio in the following way:

$$r_{i,t} - r_{f,t} = \alpha_i + \beta_{mrkt} * (r_{m,t} - r_{f,t}) + \varepsilon_t \quad (1)$$

Where $r_{i,t}$ is the return on portfolio i and $r_{f,t}$ is the risk-free rate of return at time t, $(r_{i,t} - r_{f,t})$ is the portfolio's excess return, α_i is Jensen's Alpha, i.e., the intercept or the abnormal return, β_{mrkt} is the portfolio's exposure to the market, $r_{m,t}$ is the market return at time t, $r_{m,t} - r_{f,t}$ is the excess on the market portfolio, and ε_t is the error term.

3.1.2 The Fama-French Three-Factor Model

Fama and French (1993) presented two new factors to describe portfolios that historically generated abnormal returns compared to the market. The size factor (SMB) represents how small market cap stocks tend to outperform more extensive market cap stocks. Furthermore, they find that high book-to-market stocks, i.e., value stocks, tend to outperform low book-to-market stocks, i.e., growth stocks, resulting in the value factor (HML). SMB stands for "small minus big" and refers to the return of investing in small market cap stocks minus the return of investing in extensive market cap stocks. HML stands for "high minus low" and refers to the return of investing in stocks with high book-to-market ratios less the return by investing in stocks with low book-to-market ratios. The three-factor model is expressed as the following regression:

$$r_{i,t} - r_{f,t} = \alpha_i + \beta_{mrkt} * (r_{m,t} - r_{f,t}) + \beta_{SMB} * SMB_t + \beta_{HML} * HML_t + \varepsilon_t \quad (2)$$

Where β_{SMB} is the portfolio's exposure to the size factor, SMB_t is the size premium at time t, $\beta_{HML}$is the portfolio's exposure to the value factor, and HML_t is the value premium at time t.

3.1.3 The Carhart Four-Factor Model

Carhart (1997) proposes a fourth factor to the three-factor model, the momentum factor (MOM). By including this factor, Carhart incorporates the historical performance of stocks. MOM captures the return of a stock that have performed well minus the return of stocks that have performed poorly (Carhart, 1997). The four-factor model is stated as:

$$r_{i,t} - r_{f,t} = \alpha_i + \beta_{mrkt} * (r_{m,t} - r_{f,t}) + \beta_{SMB} * SMB_t + \beta_{HML} * HML_t + \beta_{MOM} MOM_t + \varepsilon_t \quad (3)$$

Where β_{MOM} is the exposure to the momentum factor and MOM_t is the momentum premium at time t.

3.1.4 The Fama-French Five-Factor Model

In 2015, Fama and French developed a five-factor model by introducing two additional factors of systematic risk, namely the profitability factor (RMW) and the investment factor (CMA) (Fama & French, 2015). RMW stands for “robust minus weak” and represents the return on stocks with robust profitability less the return on stocks with weak profitability. CMA stands for “conservative minus aggressive” and represents the return on stocks with low (conservative) investments less the return on stocks with high (aggressive) investments. These factors aim to mitigate the bias of low volatility anomaly performance (Jordan & Riley, 2015), and result in the following regression model:

$$r_{i,t} - r_{f,t} = \alpha_i + \beta_{mrkt} * (r_{m,t} - r_{f,t}) + \beta_{SMB} * SMB_t + \beta_{HML} * HML_t + \beta_{RMW} * RMW_t + \beta_{CMA} * CMA_t + \varepsilon_t \quad (4)$$

Where β_{RMW} is the portfolio’s exposure to the profitability factor, RMW_t is the profitability premium, β_{CMA} is the portfolio’s exposure to the investment factor, and CMA_t is the investment premium.

3.2 Model Weaknesses

Similar to CAPM, Fama-French models are also criticized. Daniel and Titman (1997) criticize the three-factor model by stating that firm characteristics determine expected return, suggesting that factor loadings do not necessarily exist. They mean that small companies with high book-to-market ratios are not necessarily risky, as the analysis shows that loadings on the size and value factor do not explain high returns but act as a proxy for these characteristics. Conversely, Fama and French (1996) state that the three factors fully capture returns, except for one factor that captures the short-term continuation of returns, which is suggested to be the momentum factor. Moreover, Blitz et al. (2018) identify five concerns with the five-factor model. Two of the concerns are related to i) the lack of the momentum factor and ii) that the two additional explanatory variables are deemed risky. Furthermore, they suggest that it may be hard to characterize the cross-section of stock returns as the investment and profitability factors are likely to interact. Existing research on the two factors is still new and may be inadequate to cover the factor definitions from Fama and French accurately enough.

4 Data

This chapter will present the data and the choices made during the data collection. We construct portfolios based on 36 green and non-green global shipping stocks, whereas 17 are tanker stocks and 19 are dry bulk stocks. The number of green and non-green stocks varies depending on the definition of green. When considering investments in scrubbers, the green portfolio consists of 17 stocks, and the non-green portfolio consists of 19 stocks. When considering sustainability reporting, the green portfolio consists of 21 stocks, and the non-green portfolio consists of 15 stocks. The chosen stocks must be solid in describing the global shipping sector and related environmental performance.

We will start by presenting how we collected the green companies and their non-green peers. After that, we will explain factors that impacted the choice of period and geographical span. The key goal when collecting data was to seize companies that have invested in scrubbers and published sustainability reports between 2016 and 2022, a period we argue covers a significant increase in environmental efforts in shipping. Also, it was essential to find their non-green peers who matched the sample according to subsector and company structure. All choices made in the data selection process are made carefully with consultation from Pareto Securities and Yara Marine Technologies. As shipping can be perceived as unavailable to the public, we reached out to the research department in Clarksons.[9] We received a data set of all installed and ordered scrubbers since 2016, sorted by owner, operator and ship.

We present how we construct green and non-green portfolios, as well as the difference portfolios. We calculate all portfolio returns as an equal-weighted index mitigating volatile large cap stocks in small data sample. Furthermore, we present how we retrieve the Fama-French risk factors and the alternative market factor: The Solactive Global Shipping index. Lastly, we present potential data biases related to the data selection process which in turn can have an impact on the results of our empirical analysis.

[9] Clarksons Research is a worldwide, ISO9000 certified provider of intelligence for global shipping (Clarksons Research, 2022).

4.1 Data Selection

4.1.1 Selection of Green Companies

Shipping is perceived as a sector with limited information available to the public. Subsequently, we received a data set from Clarksons that show all investments in scrubbers among global shipping companies. The data set consisted of all vessels on the world fleet with an installed or ordered scrubber in the period between 2016 and 2022. The 4662 scrubbers are distributed among approximately 550 ship owners. From these owners, we end up with 75 listed companies. Among these, we find 44 dry bulk and tanker stocks.

4.1.2 Selection of Non-Green Peers

To find the non-green shipping stocks, we went through all constituents within the subindustries "Marine Freight & Logistics" and "Oil & Gas Transportation" in Refinitiv Eikon Datastream, 267 and 134, respectively. Out of these, we retrieve the tanker and dry bulk stocks with historical prices for the given period which have not invested in scrubbers nor published a sustainability report. Additionally, we use the Clarksons Research data set to retrieve non-green peers, as we define companies that have a level of investment in scrubbers below 10 percent as non-green (see section 4.2.2).

4.1.3 Selection of Time and Geographical Span

The chosen period is from January 2016 to January 2022. As IMO announced its implementation date for IMO 2020 in October 2016, we set January 2016 as the starting point for our analysis to ensure all information sharing about the regulation in the shipping sector. Additionally, the SDGs were implemented in 2015. The choice of period is done in consultation with Pareto Securities and Yara Marine Technologies.

Additionally, we chose not to set any geographical limit to our data set because shipping companies operate globally (see section 2.1).

4.2 Portfolio Construction

This section will explain how we construct the portfolios and thus what criteria we use to ensure an appropriate data sample for the chosen methodology and research question. We decide to exclude investment companies and holding companies from the portfolios by choosing companies with the same operator and owner for their fleet. In consultation with Yara Marine Technologies, we infer that holding and investment companies might not implement essential business decisions for their fleets, making it difficult to define whether the company is green. This enables us to reach the key goal of our data construction process by capturing companies that implement green business decisions with scrubber investments and other environmental efforts.

4.2.1 Calculating the Return

We retrieve all historical returns from the Refinitiv Eikon database. To get prices adjusted for dividends and stock splits, we retrieve the total return directly from Refinitiv Eikon database for each shipping stock to construct the returns of the portfolios.

The portfolio stocks are equal-weighted. Meaning that all stocks, regardless of share volumes or price, have an equal impact on the portfolios' return. We choose equal-weighted, instead of price- or value-weighted to prevent a particular large stock from having too much effect on the portfolio returns, impacting the results. The size of our portfolios are small, and an impact of a large stock will not be diversified in the same way as with a portfolio with a higher number of stocks, i.e., Cosco Shipping Holdings with a significantly larger market cap than its portfolio peers (see table 1). The returns on the equal-weighted portfolios are calculated with the following formula,

$$r_{p,t} = \frac{\sum_{i=1}^{N} r_{i,t}}{N} \tag{5}$$

Where $r_{p,t}$ is the return on the portfolio at time t, $r_{i,t}$ is the return on each stock in the portfolio, and N is the number of stocks in the portfolio.

4.2.2 The Green Investing and Non-Green Investing Portfolios

Table 1 presents descriptive characteristics of the green investing and the non-green investing portfolios. In the green investing portfolio, we include companies that have either installed 20 or more scrubbers or have a level of green investments of 30 percent or above. For the non-green investing portfolio, we included companies with a level of green investments of 10 percent or below. We define the level of green investments with the following formula,

$$LGI = \frac{Number\ of\ Installed\ Scrubbers}{Fleet\ Size} \qquad (6)$$

Where LGI is the level of green investments.

Table 1: Descriptive Characteristics, Green Investing and Non-Green Investing Portfolios

The table shows descriptive characteristics for 36 stocks distributed among 17 green investing and 19 non-green investing stocks. Stock Exchange presents the different stocks exchanges the stocks are listed on. The total 36 stocks present 13 different stock exchanges in Asia, Europe, and North America, and both portfolios have companies distributed on all three continents. The green investing/non-green investing portfolio has a 41%/21% geographic exposure to Asia, 24%/16% to Europa, and 35%/63% to North America. The geographic exposures = number of stock exchanges in respective continent/number of stock exchanges in the portfolio. Company Name presents the company name as written on the stock exchanges. Market Cap presents the market capitalization for each stock per December 2021 in billion USD. We retrieve market cap from the Refinitiv Eikon database. LGI (Nr. of Scrubbers) presents the level of green investments in scrubbers (the number of scrubbers installed or ordered on their fleet). Subsector presents which subsector the respective stock belongs to based on its related activities. If a company has both tanker and dry bulk ships in its fleet, we present it as the one with the highest number of ships. The green investing portfolio consists of 7 tanker and 10 dry bulk stocks, whereas the non-green investing portfolio consists of 10 tanker and 9 dry bulk stocks.

Stock Exchange	Company Name	Market Cap	LGI (Nr. of Scrubbers)	Subsector
The Green Investing Portfolio				
OSL	Hunter Group ASA	0.19	100% (4)	Tanker
NAQ	Star Bulk Carriers Corp.	2.32	98% (122)	Dry Bulk
NAQ	Eagle Bulk Shipping Inc.	0.62	92% (49)	Dry Bulk
NYQ	Scorpio Tankers Inc.	0.75	76% (100)	Tanker
KSC	KSS Line Ltd.	0.23	48% (10)	Tanker
OSL	Frontline Ltd.	1.41	47% (34)	Tanker
NYQ	Safe Bulkers Inc.	0.46	45% (19)	Dry Bulk
CPH	Dampskibsselskabet Norden A/S	0.99	43% (16)	Dry Bulk
NAQ	Golden Ocean Group Ltd.	1.86	42% (42)	Dry Bulk
TYO	Meiji Shipping Co., Ltd.	0.26	40% (20)	Dry Bulk
TYO	Kyoei Tanker Co., Ltd.	0.08	40% (6)	Tanker
NYQ	Genco Shipping & Trading Ltd.	0.67	39% (17)	Dry Bulk
TOR	Algoma Central Corp.	0.51	31% (11)	Dry Bulk
SHH	Sincere Navigation Corp.	0.62	31% (4)	Tanker
HKG	Pacific Basin Shipping Ltd.	1.77	27% (32)	Dry Bulk
KSC	Pan Ocean Co., Ltd.	2.43	12% (37)	Tanker
SHH	Cosco Shipping Holdings Co., Ltd.	43.75	6% (25)	Dry Bulk
The Non-Green Investing Portfolio				
NYQ	Euronav NV	1.95	10% (6)	Tanker
NSI	The Great Eastern Shipping Co., Ltd.	0.65	10% (6)	Dry Bulk
NAQ	Seanergy Maritime Holdings Corp.	0.16	9% (9)	Dry Bulk
JPX	Idemitsu Kosan Co., Ltd.	8.24	4% (3)	Tanker
NYQ	Navios Maritime Partners L.P.	0.89	3% (4)	Dry Bulk
NYSE	Ardmore Shipping Corp.	0.12	0% (0)	Tanker
NAQ	Top Ships Inc.	0.03	0% (0)	Tanker
TAI	Wisdom Marine Lines Co.	2.20	0% (0)	Dry Bulk
NYQ	Tsakos Energy Navigation Ltd.	0.32	0% (0)	Tanker
KLS	Malaysian Bulk Carriers Bhd.	0.13	0% (0)	Dry Bulk
OSL	Jinhui Shipping and Transportation Ltd.	0.14	0% (0)	Dry Bulk
NYQ	Diana Shipping Inc.	0.33	0% (0)	Dry Bulk
NYQ	Teekay Tankers Ltd.	0.37	0% (0)	Tanker
OSL	Stolt-Nielsen Ltd.	0.83	0% (0)	Tanker
NYQ	KNOT Offshore Partners Ltd.	0.46	0% (0)	Tanker
OSL	Belships ASA	0.41	0% (0)	Dry Bulk
NYQ	Altera Infrastructure L.P.	0.02	0% (0)	Tanker
NAQ	Globus Maritime Ltd.	0.04	0% (0)	Dry Bulk
NYSE	Nordic American Tankers Ltd.	0.29	0% (0)	Tanker

4.2.3 The Sustainability Reporting and Non-Sustainability Reporting Portfolios

Table 2 presents descriptive statistics of the sustainability reporting and non-sustainability reporting portfolios. To construct the sustainability reporting and non-sustainability reporting portfolios, we restocked the 36 stocks based on whether they have published a sustainability report or not. To distinguish which companies report sustainability, we include companies that have continuos published one or several sustainability reports in the period between 2016 and 2022. We found the sustainability reports for the respective companies on the companies' websites, to use the same platform as potential investors. We checked every published sustainability report for reporting the efforts and measured toward SDG nr. 13 (see section 2.3).

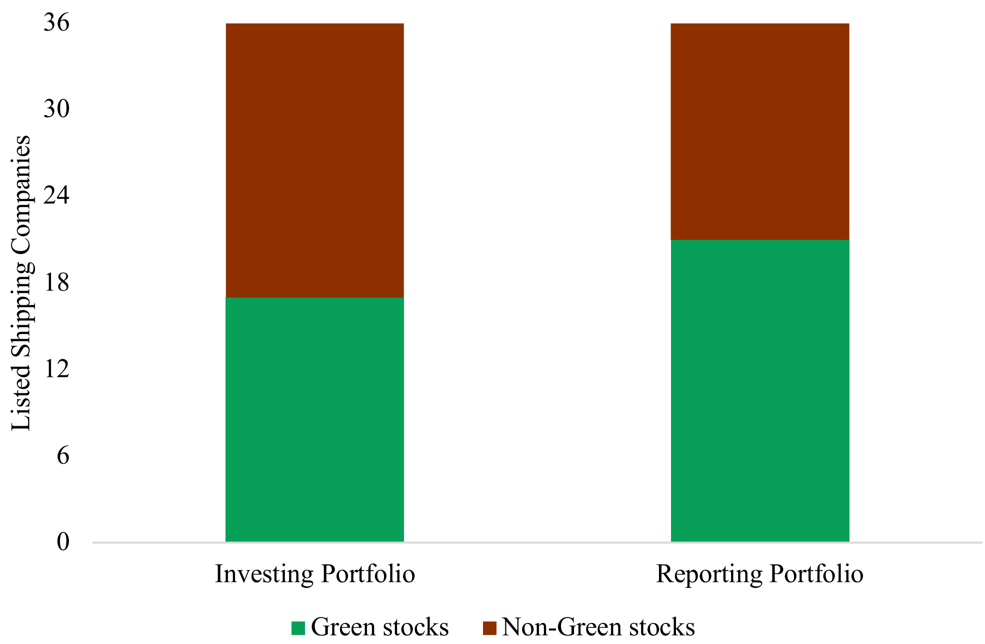
Table 2: Descriptive Characteristics, Sustainability Reporting and Non-Sustainability Reporting Portfolios

The table shows descriptive characteristics of 36 stocks distributed among 21 sustainability reporting and 15 non-sustainability reporting stocks. Stock Exchange presents the different stocks exchanges the stocks are listed on. The total 36 stocks present 13 different stock exchanges in Asia, Europe, and North America, and both portfolios have companies distributed on all three continents. The sustainability reporting investing/non-sustainability reporting portfolio has a 29%/40% geographic exposure to Asia, 23%/13% to Europa, and 48%/47% to North America. The geographic exposures = number of stock exchanges in respective continent/number of stock exchanges in the portfolio. Company Name presents the company name as written on the stock exchanges. Market Cap presents the market capitalization for each stock per December 2021 in billion USD. We retrieve the market cap from the Refinitiv Eikon database. LGI (Nr. of Scrubbers) presents the level of green investments in scrubbers (the number of scrubbers installed or ordered on their fleet). Subsector presents which subsector the respective stock belongs to based on its related activities. If a company has both tanker and dry bulk ships in its fleet, we present it as the one with the highest number of ships. The sustainability reporting portfolios consist of 10 tanker and 11 dry bulk stocks whereas the non-sustainability reporting portfolio consists of 7 tanker and 8 dry bulk stocks.

SE	Company Name	Market Cap	SR	Subsectors
The Sustainability Reporting Portfolio				
NAQ	Star Bulk Carriers Corp.	2.32	Yes	Dry Bulk
NYQ	Scorpio Tankers Inc.	0.75	Yes	Tanker
NAQ	Eagle Bulk Shipping Inc.	0.62	Yes	Dry Bulk
NAQ	Golden Ocean Group Ltd.	1.86	Yes	Dry Bulk
OSL	Frontline Ltd.	1.41	Yes	Tanker
HKG	Pacific Basin Shipping Ltd.	1.77	Yes	Dry Bulk
SHH	Cosco Shipping Holdings Co., Ltd.	43.75	Yes	Dry Bulk
NYQ	Safe Bulkers Inc.	0.46	Yes	Dry Bulk
NYQ	Genco Shipping & Trading Ltd.	0.67	Yes	Dry Bulk
CPH	Dampskibsselskabet Norden A/S	0.99	Yes	Dry Bulk
TOR	Algoma Central Corp.	0.51	Yes	Dry Bulk
KSC	KSS Line Ltd.	0.23	Yes	Tanker
SHH	Sincere Navigation Corp.	0.62	Yes	Tanker
NYQ	Diana Shipping Inc.	0.33	Yes	Dry Bulk
NYQ	Teekay Tankers Ltd.	0.37	Yes	Tanker
OSL	Stolt-Nielsen Ltd.	0.83	Yes	Tanker
NYQ	KNOT Offshore Partners Ltd.	0.46	Yes	Tanker
OSL	Belships ASA	0.41	Yes	Dry Bulk
NYQ	Altera Infrastructure L.P.	0.02	Yes	Tanker
NYQ	Euronav NV	1.95	Yes	Tanker
JPX	Idemitsu Kosan Co., Ltd.	8.24	Yes	Tanker
The Non-Sustainability Reporting Portfolio				
KSC	Pan Ocean Co., Ltd	2.43	No	Tanker
TYO	Meiji Shipping Co., Ltd.	0.26	No	Dry Bulk
TYO	Kyoei Tanker Co., Ltd.	0.08	No	Tanker
OSL	Hunter Group ASA	0.19	No	Tanker
KLS	Malaysian Bulk Carriers Bhd.	0.13	No	Dry Bulk
NSI	The Great Eastern Shipping Co., Ltd.	0.65	No	Dry Bulk
OSL	Jinhui Shipping and Transportation Ltd.	0.14	No	Dry Bulk
NAQ	Globus Maritime Ltd.	0.04	No	Dry Bulk
NYSE	Nordic American Tankers Ltd.	0.29	No	Tanker
NYSE	Ardmore Shipping Corp.	0.12	No	Tanker
NAQ	Top Ships Inc.	0.03	No	Tanker
TAI	Wisdom Marine Lines Co.	2.20	No	Dry Bulk
NYQ	Tsakos Energy Navigation Ltd.	0.32	No	Tanker
NYQ	Navios Maritime Partners L.P.	0.89	No	Dry Bulk
NAQ	Seanergy Maritime Holdings Corp.	0.16	No	Dry Bulk

The four constructed portfolios are based on the same 36 stocks, making it interesting to look at the distribution of green and non-green stocks in the investing and reporting portfolios (see figure 4.1). We see that the number of green stocks increases from 17 in the green investing portfolio to 21 in the sustainability reporting portfolio. Moreover, the number of non-green stocks decrease from 19 in the non-green investing portfolio to 15 in the non-sustainability reporting portfolio. This suggests that only looking at investments in scrubbers to measure environmental performance would ignore essential stocks that report environmental efforts, thus an environmental performance regardless of investments in scrubbers.

Figure 1: Distribution of Portfolios, Green and Non-Green Stocks



4.2.4 The Difference Portfolios

We use green investing, non-green investing, sustainability reporting, and non-sustainability reporting portfolios to make difference portfolios. To construct difference portfolios, we apply a net-zero investment strategy, taking a long-short position in the green and non-green portfolios, respectively. It is highly relevant to assess the results of the constructed difference portfolios to examine whether the green portfolios outperform the non-green portfolios.

4.3 The Fama-French Factors and the Alternative Market Factor

The Fama-French Factors are retrieved from Kenneth French's data library and cover the developed markets. As our portfolio consists of global stocks, we chose to proceed with the factors with the broadest geographical exposure (see table 14 in Appendix 3). The factors are constructed using six market-cap-weighted portfolios formed on size and book-to-market, size and operating profitability, and size and investment (French, 2021). The risk-free rates are also retrieved from Kenneth French's library and are based on the returns for a 1-month Treasury Bill (French, 2021). The risk-free rates are also retrieved for the developed markets, and all returns are in USD.

To assess the shipping market, we additionally retrieve a Shipping Market index as an alternative to the Fama-French market factor, namely the Solactive Global Shipping index (Solactive, 2022).

4.4 Data Biases

4.4.1 Sample Selection and Size

When analyzing the stock returns of the portfolios, it is essential to address the data sample's limitations. The main concern with the construction of the portfolios is the sample size. In consultation with Pareto Securities and Yara Marine Technologies, we make several assumptions to fit the data sample to our research question, related hypotheses, and the global shipping sector. Firstly, we choose to look at only the tanker and dry bulk subsectors (see subsection 2.1). Secondly, we decide to exclude all holdings and investment companies. Lastly, we chose a limited period to capture the effects of the IMO 2020 regulations and related sustainability report frameworks. All of these decisions have an impact on the sample size but are necessary to achieve portfolios with clear green and non-green outlooks for investors and capture the effect of relevant regulations and frameworks. As a result, the sample may be skewed due to selection bias.[10] The sample size is also essential for validity and is one of the most common challenges in statistical analysis. If the sample size is too small, it will not yield valid results and decrease the power of the test. The power of a study measures its ability to avoid type II errors, which occur when one fails to reject a false null hypothesis (Hayes, 2021).

4.4.2 Fama-French Factors

The chosen shipping stocks are distributed on 15 different stock markets in Europe, Asia, and North America (see tables 1 and 2). The developed markets cover both European countries, Asian countries, and United States (see table 14 in Appendix 3). The developed market factors cover countries that the portfolio stocks do not, making it difficult to achieve a perfect fit between the geographical exposure in the stock returns and the Fama-French factors. Although the developed market factors are the best fit for our global data sample, we may exclude some potential

[10] Selection bias is when the selection of data for analysis is done in such a way that randomization may not be achieved (Heckman, 2014).

significant risk exposures to geographical areas. This may lead to data bias in terms of not regressing the stock returns on the correct geographical risk exposures.

5 Empirical Analysis

In the following chapter, we present and discuss our findings from the empirical analysis. First, we present descriptive statistics and cumulative returns for the portfolios. We analyze the financial performance of the portfolios using the five-factor model, as described in the methodology chapter. We regress all portfolios on two market benchmarks: the Fama-French market factor (hereby FF market factor) and the Solactive Global Shipping Index (hereby the Shipping Market index). We also test subsector portfolios consisting of only tanker or dry bulk stocks for each of the hypotheses. We first present regressions result for the green investing portfolio (hereby referred to as "GI") and the non-green investing portfolio (hereby referred to "NGI"), as well as the related differences portfolios and subsector portfolios. Thereafter, we present regressions result for the sustainability reporting (hereby referred to as "SR") and non-sustainability reporting portfolios (hereby referred to as "NSR"), as well as the respective difference portfolios and subsector portfolios. Second, we perform tests to check the robustness of our results. In this section, we provide the results from the four-factor model and the OLS assumptions portfolio returns. Finally, this chapter presents a summary and discussion of the findings from the empirical analysis, as well as limitations and recommendations for future research.

5.1 Descriptive Analysis

5.1.1 Descriptive Statistics

Table 3 presents the descriptive statistics for the GI, NGI, SR, and NSR portfolios, the respective difference portfolios, and the market benchmarks. The statistics are based on monthly returns from January 2016 to January 2022. For descriptive statistics of subsector portfolios and the respective difference portfolios, see tables 15 and 16 in Appendix 4.

Table 3: Descriptive Statistics, GI, NGI, SR, NSR, and Difference Portfolios

The Sharpe ratio is the excess return (average return minus the average risk-free rate for the same period) per unit of risk. Mean return is the average return of the portfolio over the period. The min (max) return is the smallest (largest) return observed in a portfolio in the relevant period. For the difference portfolios, we have tested the mean return with a two-sample t-test to check whether the difference in mean return is statistically significant. None of the mean returns for the difference portfolios are statistically significant at the 1, 5, or 10 percent level using a two-sample t-test.

	Sharpe ratio (%)	**Mean return (%)**	**Standard Deviation (%)**	**Max (%)**	**Min (%)**
GI	0.156	1.312	8.424	22.566	-20.245
NGI	-0.042	-0.414	9.838	43.489	-18.96
Difference	0.250	1.652	6.595	12.890	-21.915
SR	0.135	1.075	7.937	20.244	-21.52
NSR	-0.05	-0.544	10.907	51.7	-20.531
Difference	0.215	1.545	7.18	13.7	-31.817
Market Benchmarks					
FF Market Factor	0.234	0.993	4.249	13.34	-13.77
The Shipping Market Index	0.144	1.129	7.835	25.249	-19.367

Table 3 indicates that the FF market factor has a higher Sharpe ratio than the GI and the NGI portfolios, indicating that the CAPM holds, as the market portfolio is the most optimal choice (Kenton, 2022). However, the GI portfolio has a higher Sharpe ratio than the Shipping Market index, which is not in line with the CAPM, only considering the shipping market. The standard deviations were higher for the GI and NGI portfolios than for both benchmarks. The GI and the NGI have more extreme maximum and minimum monthly returns than the FF market benchmark but are quite similar to the Shipping Market index. Nevertheless, the NGI portfolio stands out with a twice as high maximum level as the others.

None of the SR and the NSR portfolios has a higher Sharpe ratio than the market benchmarks, which is in line with the CAPM (Kenton, 2022). The standard deviation is the highest for the NSR portfolio, which also has the highest maximum level. The SR portfolio has almost the same standard deviation as the Shipping Market index.

The difference portfolio consisting of positions in the GI and NGI portfolios have a higher Sharpe ratio than both market benchmarks. But by using a two-sample t-test we did not find the mean return of the difference portfolio to be statistically significant at any level. Thus, we cannot draw a conclusion stating that the CAPM is violated based on mean returns. The remaining difference portfolio has a higher Sharpe ratio than the Shipping Market index, but not the FF market factor. Still, we got the same results from the two-tailed t-test in this case hence we cannot conclude from the mean return that CAPM is violated.

5.1.2 Cumulative Returns

In the following section, we present the cumulative returns for all the portfolios including the subsector portfolios. The cumulative return is the aggregate amount that an investment has gained or lost over time (Chen, 2020) and is calculated using the following formula.

$$CR_{p,t} = \sum_{t=1}^{T}[(1 + r_{p,t=1}) * (1 + r_{p,t}) - 1] \quad (7)$$

Where $CR_{p,t}$ is the cumulative return for the portfolio at time t, $r_{p,t=1}$is the return the first month in the period, and $r_{p,t}$ is the monthly return at time t.

Total Portfolios

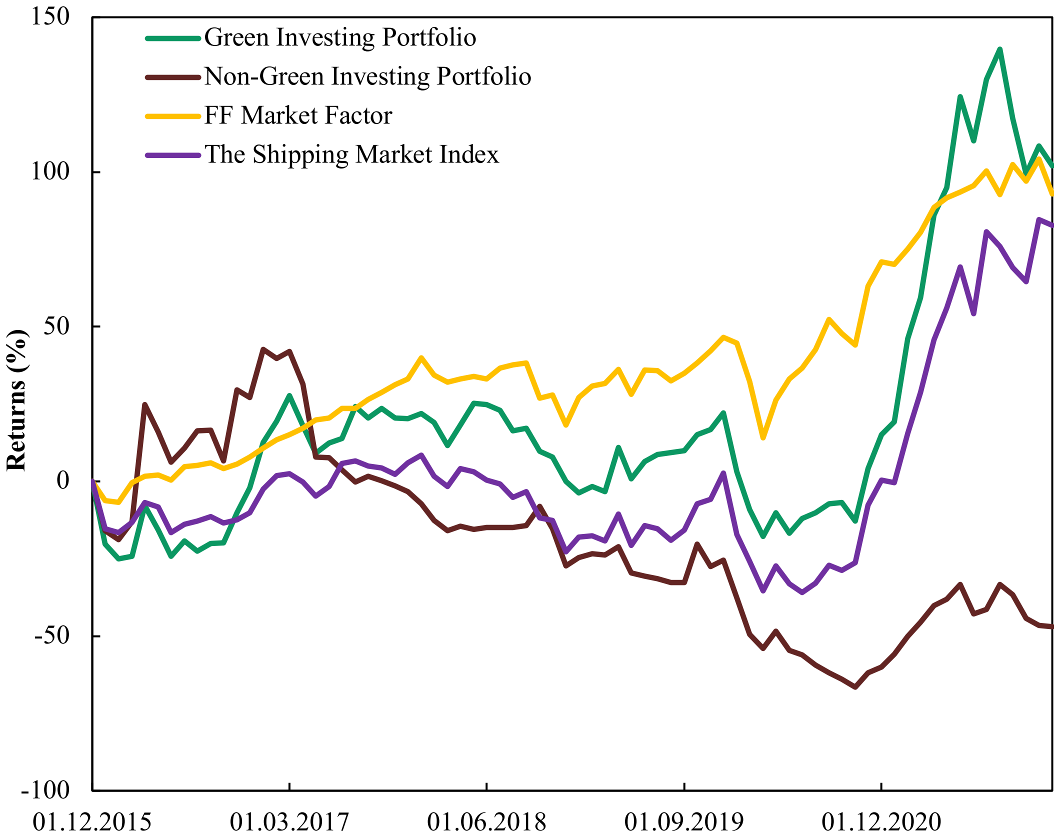
Figures 2 and 3 display the cumulative returns of the green and the non-green portfolios, respectively, for the total GI and the NGI portfolios, the total SR and the NSR portfolios, and the two market benchmarks. Given the correlation between the green investing and sustainability reporting companies, the cumulative returns develop, not surprisingly, mainly similarly.

The first remarkable finding is that figure 2 confirms the results in table 3, that the GI portfolio performs better than the Shipping Market index, specifically, between 2017 and 2022. However, we observe that the market exceeds the GI portfolio during the whole period, except for the first half of 2017 and the first half of 2021. Furthermore, the GI portfolio seems to follow the movements in both market benchmarks. It does, not surprisingly, seem more correlated with the trends in the shipping market.

Contrary to the GI portfolio, the NGI portfolio seems to destroy value compared to both market benchmarks, except for performing exclusively better during 2016 and the first half of 2017. The NGI portfolio yet appears to be correlated with the shipping sector.

It is essential to mention the VLSFO-HSFO spread when looking at the returns for the GI and NGI total portfolios. The spread rapidly decreased during the last months of 2019 and the first months of 2020 (see figure 7 in Appendix 5), probably due to a negative demand shock as a consequence of the Covid-19 pandemic (among other external factors). This may explain the down warding GI returns in the same period, as a decreasing spread makes it less profitable to invest in scrubbers. From 2020 until today, the spread has generally increased, which can explain the down warding NGI returns, as a VLSFO price increase makes it more expensive for the companies without scrubbers.

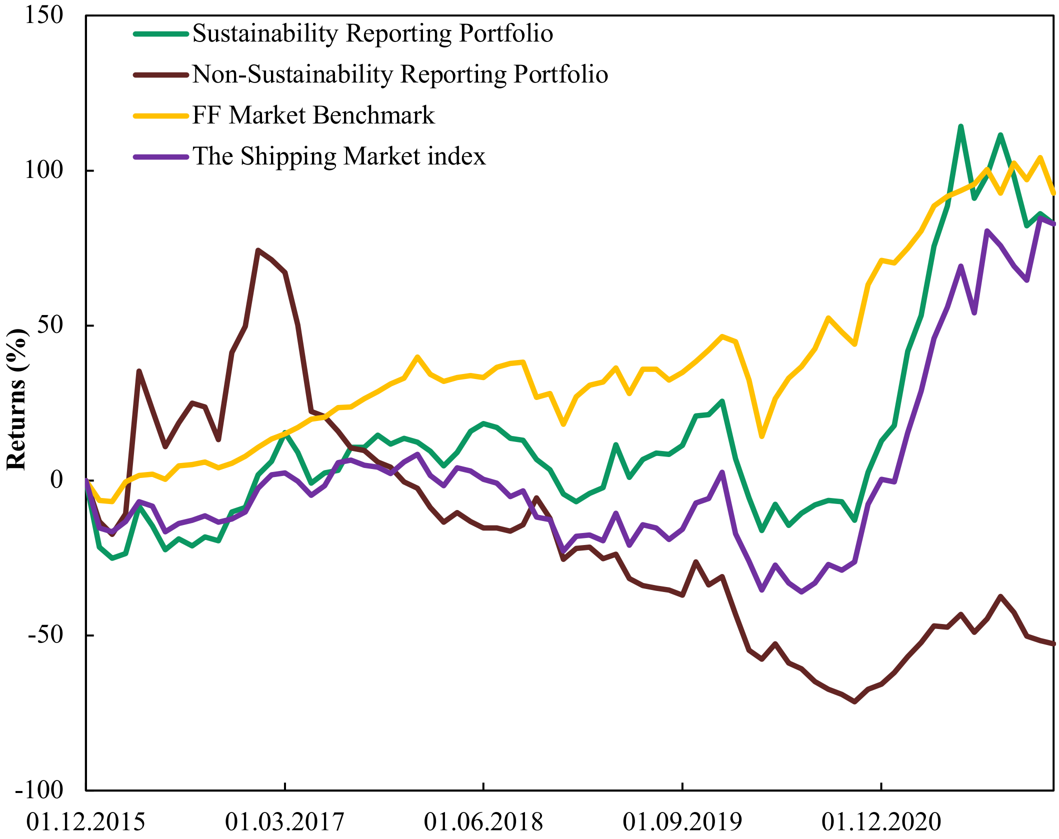
Figure 2: Cumulative Returns, GI and NGI Portfolios, 2016-2022



The SR portfolio is correlated with the Shipping Market index and seems to outperform it almost the whole period. However, this is contrary to the finding in table 3, where the Shipping Market index has a higher Sharpe ratio than the SR portfolio. Figure 3 confirms that the FF market benchmark has a higher Sharpe ratio than the SR portfolio, as the SR portfolio is outperformed throughout the whole period.

The NSR portfolio peaks the first year before it becomes outperformed by the SR portfolio and the market benchmark throughout the period, not surprisingly confirmed in table 3.

Figure 3: Cumulative Returns, SR and NSR Portfolios, 2016-2022



Subsectors Portfolios

To further explain the cumulative return of the green and non-green portfolios, we look at the cumulative returns for each subsector. Figure 4 shows the green tanker portfolios' cumulative returns towards the non-green tanker portfolios and the two market benchmarks. The most striking finding is that the GI tanker portfolio performs better than the SR tanker portfolio and even outperforms the Shipping Market index during some times. None of the green tanker portfolios seem to outperform the FF market factor throughout the period. The NGI tanker portfolio seems to have a poorer performance than the NGI total portfolio. This also seems to be the case for the NSR tanker portfolio. Both non-green tanker portfolios seem to underperform compared to the FF market factor and the Shipping Market index throughout the period.

Changes in the oil price are found to have a significant and negative financial impact on the tanker subsector as the oil demand mainly drives the tanker sector (Mohanty et al., 2021). From 2016 to 2022, oil prices have been volatile but generally increasing (Trading Economics, 2022a), and this can explain the poorer performance of the non-green tanker portfolios compared to the non-green portfolios.

Figure 4: Cumulative Returns, Tanker Portfolios, 2016-2022

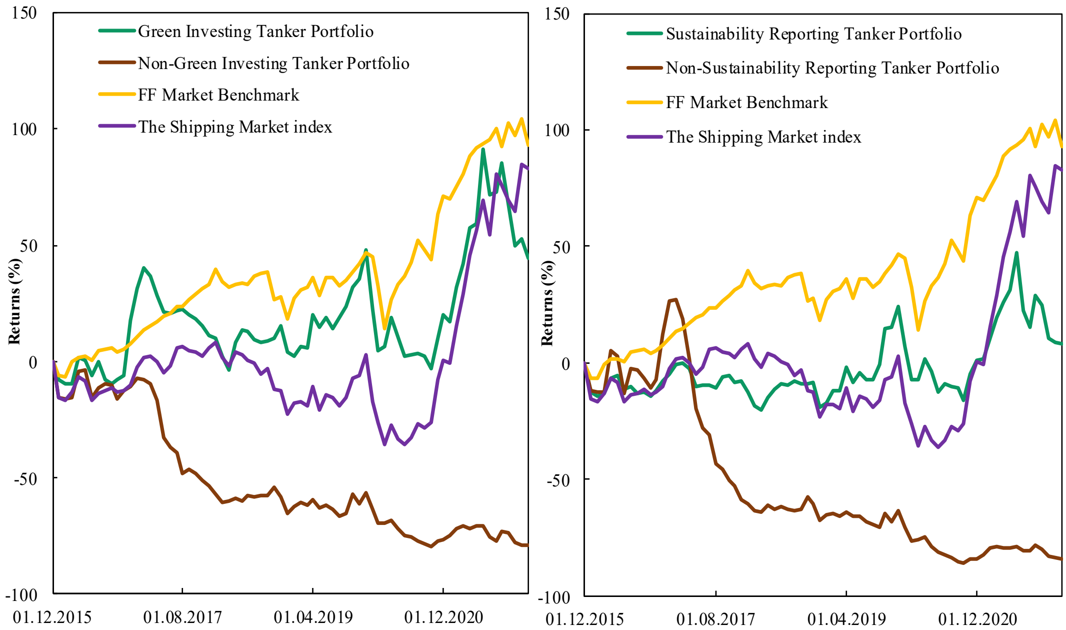
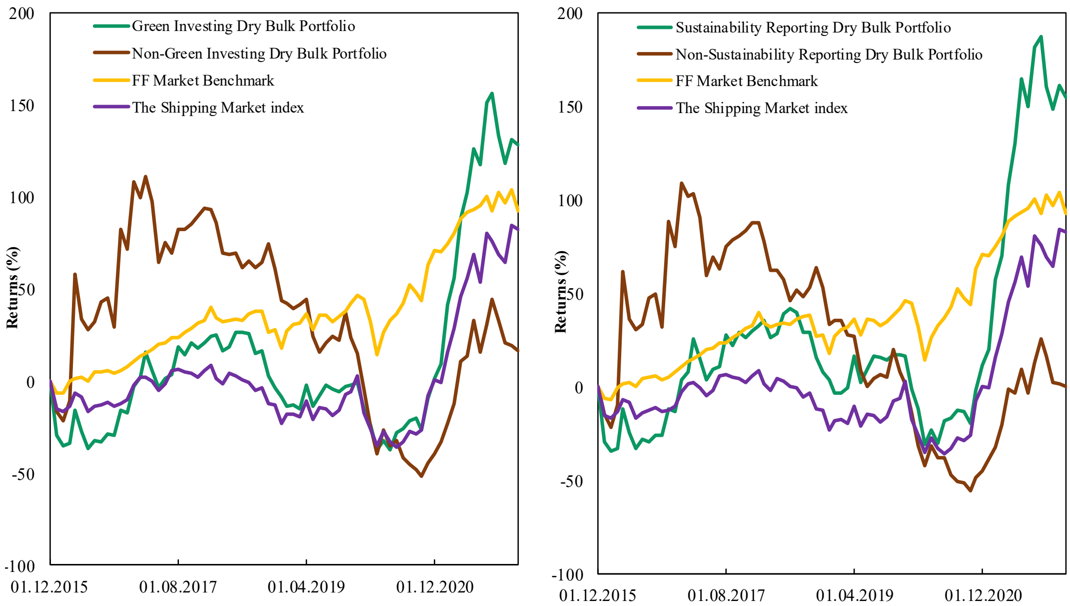


Figure 5 shows the green dry bulk portfolios' cumulative returns towards the non-green dry bulk portfolios and the two market benchmarks. The cumulative returns of dry bulk portfolios seem more volatile than those of the tanker portfolios. While the green and non-green tanker cumulative returns seem to diverge, the green and non-green dry bulk cumulative returns look correlated. Nevertheless, the non-green dry bulk cumulative returns are substantially more volatile than the green dry bulk cumulative returns.

Interest rates are also shown to affect shipping stock returns. More specifically, interest rates are significantly and positively correlated with stock returns in the dry bulk sector (Mohanty et al., 2021). Interest rates (here, US interest rates) have consistently risen from 2016 to 2020. In 2020, the Covid-19 pandemic hit the economy, and interest rates fell drastically (Trading Economics, 2022b). Figure 5 show that dry bulk cumulative returns have a strong correlation with interest rates, increasing until 2020, before falling considerably, and rising throughout 2021.

Figure 5: Cumulative Returns, Dry Bulk Portfolios, 2016-2022



5.2 Regression Results

In this section, we present the regression result from analyzing the GI, NGI, SR, and NSR portfolios with respective subsector and difference portfolios using the five-factor model. We perform the regressions using the FF Market Factor and the Shipping Market index as benchmarks. All results cover the period from January 2016 to January 2022.

5.2.1 GI and NGI Portfolios

Table 4: Regressions Results: GI, NGI, Difference Portfolios

This table presents regression results from the Fama-French five-factor model analyzing portfolio returns of the GI, NGI, and difference portfolio from January 2016 to January 2022. The GI portfolio consists of shipping companies that have a level of green investments above 30%, or have invested in 20 or more scrubbers. The NGI portfolio consists of shipping companies that have a level of green investments of 10 percent or lower. The GI portfolio and NGI portfolio consists of 17 and 19 shipping stocks respectively. The stocks are listed on stock exchanges located in Asia, Europe, and North America. The difference portfolios are constructed by a zero-net investment strategy taking a long position in the GI portfolio and a short position in the NGI portfolio. We regress all portfolios on two different market benchmarks, the FF market factor and the Shipping Market index. The Shipping Market index is the Solactive Global Shipping Index (see section 4.3). SMB is the size premium by investing in small cap stocks compared to large cap stocks. HML is the value premium by investing in value stocks compared to growth stocks. RMW is the profitability premium by investing in stocks compared to stocks with weak profitability. CMA is the investment premium by investing in stocks with conservative investments compared to stocks with aggressive investments. Alpha is the abnormal return (see section 3.1.1.) and is provided in % and monthly terms. Below each estimate, we report the standard error in parentheses. For the significance levels, *** 1%, **5%, *10%. The Adjusted R^2 is the model's explanatory power and represents the proportion of the variance of portfolio returns that is explained by the risk factors adjusted by the number of factors.

	α	β_{MKT}	β_{SMB}	β_{HML}	β_{RMW}	β_{CMA}	**Adj. R2**
The Shipping Market Index							
GI	0.049	0.834***	0.200	-0.081	0.061	0.052	**58.1%**
	(0.139)	(0.088)	(0.126)	(0.148)	(0.119)	(0.143)	
NGI	-0.335**	0.567***	0.046	0.362*	-0.271	-0.140	**37.7%**
	(0.177)	(0.111)	(0.159)	(0.188)	(0.152)	(0.180)	
Difference	0.520***	-0.228*	0.080	-0.300	0.343**	-0.833	**9.0%**
	(0.188)	(0.11)	(0.169)	(0.199)	(0.162)	(0.192)	
FF Market Factor							
GI	0.068	0.681***	0.223	0.311	-0.039	-0.230	**25.3%**
	(0.188)	(0.148)	(0.168)	(0.187)	(0.160)	(0.186)	
NGI	-0.330*	0.493***	0.059	0.625***	-0.341**	-0.332*	**25.1%**
	(0.196)	(0.154)	(0.175)	(0.195)	(0.167)	(0.194)	
Difference	0.549***	0.103	0.090	-0.180	0.322*	-0.162	**4.6%**
	(0.195)	(0.15)	(0.17)	(0.194)	(0.166)	(0.192)	

Table 4 show positive alphas for the GI in all market benchmarks and factor models. As neither alpha is significant, we cannot reject the null hypothesis that the GI portfolio will not outperform the market benchmark. Contrary, the NGI portfolio presents negative alphas independent of market benchmarks. The alphas for the NGI portfolios are significant at the 10 and 5 percent levels. Furthermore, the alphas for the difference portfolio are positive and statistically significant at the 1 percent level. These results are consistent regardless of the market benchmarks used and suggest that we can reject the null hypothesis stating that the GI portfolio does not outperform the NGI portfolio.

Regarding the risk factors, we observe that the respective portfolios are mainly exposed to the market factor regardless of the market benchmark. The portfolios' market exposures are higher to the Shipping market than to the FF market factor (0.830 and 0.567 versus 0.681 and 0.493, respectively), and statistically significant. Furthermore, the NGI portfolio is significantly exposed to the value, profitability, and investment factors. The exposure to the value factor is positive (0.362 and 0.625), looking at the FF market factor and the Shipping market, respectively. This may suggest that the NGI portfolio invests in stocks with high book-to-market ratios rather than stocks with low book-to-market ratios. The exposure to the profitability and investment factors are negative when using the FF market factor (-0.341 and -0.332, respectively). This suggests that the NGI portfolio invests in stocks with weak profitability and aggressive investments. The NGI portfolio seems to receive some value premium but destroy value toward the profitability and investment factor. Like the NGI portfolio, the difference portfolio is significantly exposed to the profitability factor at the 10 percent level. However, this positive exposure indicates that the difference portfolio receives the profitability premium.

The explanatory power varies depending on the market benchmarks. When regressing on the Shipping Market index, the models explain the excess returns of both portfolios better than with the FF market factor.

5.2.2 GI and NGI Portfolios by Subsectors

Table 5: Regressions Results: GI, NGI, Difference Portfolios, Tanker

This table presents the regression results from the Fama-French five-factor model analyzing portfolio returns of the GI, NGI, and difference tanker portfolios from January 2016 to January 2022. The GI tanker portfolio consists of tanker companies that have a level of green investments above 30% or have invested in 20 or more scrubbers. The NGI tanker portfolio consists of tanker companies that have a level of green investments of 10% or lower. The GI tanker portfolio and NGI tanker portfolio consists of 7 and 10 stocks respectively. The stocks are listed on stock exchanges in Asia, Europe, and North America. The difference portfolio is constructed with a zero-net investment strategy taking a long position in the GI tanker portfolio and a short position in the NGI tanker portfolio. We regress all portfolios on the FF market factor and the Shipping Market index. SMB is the size premium by investing in small cap stocks compared to large cap stocks. HML is the value premium by investing in value stocks compared to growth stocks. RMW is the profitability premium by investing in stocks compared to stocks with weak profitability. CMA is the investment premium by investing in stocks with conservative investments compared to stocks with aggressive investments. Alpha is the abnormal return and is provided in % and monthly terms. Below each estimate, we report the standard error in parentheses. For the significance levels, *** 1%, **5%, *10%. The Adjusted R^2 is the model's explanatory power and represents the proportion of the variance of portfolio returns that is explained by the risk factors adjusted by the number of factors.

	α	**β_{MKT}**	**β_{SMB}**	**β_{HML}**	**β_{RMW}**	**β_{CMA}**	**Adj. R2**
The Shipping Market Index							
GI	0.040	0.641***	-0.006	0.048	-0.034	-0.093	**39.2%**
	(0.157)	(0.098)	(0.141)	(0.166)	(0.134)	(0.16)	
NGI	-0.487***	0.457***	-0.027	0.264	-0.409***	0.123	**32.1%**
	(0.176)	(0.110)	(0.159)	(0.186)	(0.151)	(0.179)	
Difference	0.606***	0.171	0.082	-0.231	0.474***	-0.147	**16.1%**
	(0.169)	(0.106)	(0.152)	(0.179)	(0.145)	(0.173)	
FF Market Factor							
GI	-0.0040	0.448***	0.0160	0.357**	-0.1060	-0.311	**12.7%**
	(0.190)	(0.149)	(0.169)	(0.189)	(0.161)	(0.180)	
NGI	-0.488**	0.416***	-0.019	0.473**	-0.468***	-0.031	**23.8%**
	-0.1880	(0.148)	(0.167)	(0.187)	(0.159)	(0.186)	
Difference	0.631***	0.064	0.092	-0.142	0.459***	-0.206	**13.1%**
	(0.174)	(0.137)	(0.155)	(0.173)	(0.148)	(0.172)	

Table 6: Regressions Results: GI, NGI, Difference Portfolios, Dry Bulk

This table presents the regression results from the Fama-French five-factor model analyzing portfolio returns of the GI, NGI, and difference dry bulk portfolios from January 2016 to January 2022. The GI dry bulk portfolio consists of dry bulk companies that have a level of green investments above 30, or have invested in 20 or more scrubbers. The NGI dry bulk portfolio consists of dry bulk companies that have a level of green investments of 10% or lower. The GI dry bulk portfolio and NGI dry bulk portfolio consists of 10 and 9 stocks respectively. The stocks are listed on stock exchanges in Asia, Europe, and North America. The difference portfolio is constructed with a zero-net investment strategy taking a long position in the GI dry bulk portfolio and a short position in the NGI dry bulk portfolio. We regress all portfolios on the FF market factor and the Shipping Market index. SMB is the size premium by investing in small cap stocks compared to large cap stocks. HML is the value premium by investing in value stocks compared to growth stocks. RMW is the profitability premium by investing in stocks compared to stocks with weak profitability. CMA is the investment premium by investing in stocks with conservative investments compared to stocks with aggressive investments. Alpha is the abnormal return and is provided in % and monthly terms. Below each estimate, we report the standard error in parentheses. For the significance levels, *** 1%, **5%, *10%. Adjusted R^2 is the explanatory power and represents the proportion of the variance of portfolio returns that is explained by the risk factors adjusted by the number of factors.

	α	β_{MKT}	β_{SMB}	β_{HML}	β_{RMW}	β_{CMA}	Adj. R2
The Shipping Market Index							
GI	0.048	0.832***	0.157	0.067	0.067	-0.079	**50.4%**
	(0.167)	(0.105)	(0.149)	(0.176)	(0.143)	(0.169)	
NGI	-0.119*	0.578***	0.266	0.238	-0.192	-0.094	**27.9%**
	(0.211)	(0.133)	(0.189)	(0.224)	(0.181)	(0.215)	
Difference	0.204	0.014	-0.043	-0.010	0.069	-0.088	**-6.7%**
	(0.231)	(0.146)	(0.209)	(0.246)	(0.199)	(0.236)	
FF Market Factor							
GI	0.068	0.681***	0.223	0.311	-0.039	-0.230	**23.1%**
	(0.188)	(0.148)	(0.168)	(0.187)	(0.160)	(0.186)	
NGI	-0.330*	0.493***	0.059	0.625***	-0.341**	-0.332*	**15.2%**
	(0.196)	(0.154)	(0.175)	(0.195)	(0.167)	(0.194)	
Difference	0.161	0.166	-0.054	-0.020	0.056	-0.090	**-5.5%**
	(0.233)	(0.183)	(0.207)	(0.231)	(0.198)	(0.230)	

To address the matter of subsectors within the portfolios, we divide the GI and NGI portfolios by tanker and dry bulk portfolios and run separate regressions. This is to expose the possible difference in results solely based on the respective subsectors.

Table 5 presents the results for the tanker portfolios and table 6 for the dry Bulk portfolios. None of the alphas are statistically significant for the GI portfolio. For the NGI portfolios, the alpha is negative and significant, suggesting that the NGI portfolios might destroy value compared to the market. However, we see that the alpha is more significant and negative for the tanker subsector than it is for the dry bulk subsector. The alphas for the difference portfolios are only statistically significant when looking at the tanker subsector. This suggests that the GI tanker stocks outperform their respective NGI peers.

Considering risk factors for the NGI tanker portfolios, they are significantly exposed to the value and profitability factor when using the FF market factor but only the profitability factor when using the Shipping market as a benchmark. The exposure is positive for the value factor and negative for the profitability factor.

We find significant risk exposures for the NGI dry bulk portfolio when using the FF market factor as the market benchmark. The NGI dry bulk portfolio is here positively exposed to the value factor and negatively exposed to the profitability factor. The explanatory power is better for the tanker portfolios than it is for the dry bulk portfolios, and when using the Shipping Market index as a market benchmark.

5.2.3 SR and NSR Portfolios

Table 7: Regressions Results: SR, NSR, Difference Portfolios

This table presents the regression results from the Fama-French five-factor model analyzing portfolio returns of the SR, NSR, and difference portfolios from January 2016 to January 2022. The SR portfolio consists of stocks that have continuously published one or several sustainability reports during the period. The NSR portfolio consists of peers that have not published sustainability reports. The SR portfolio and NSR portfolio consist of 21 and 15 shipping stocks respectively. The stocks are listed on stock exchanges in Asia, Europe, and North America. The difference portfolio is constructed with a zero-net investment strategy taking a long position in the SR portfolio and a short position in the NSR portfolio. We regress all portfolios on two different market benchmarks: the FF market factor and the Shipping Market index. The Shipping Market index is the Solactive Global Shipping Index (see section 4.3). SMB is the size premium by investing in small cap stocks compared to large cap stocks. HML is the value premium by investing in value stocks compared to growth stocks. RMW is the profitability premium by investing in stocks compared to stocks with weak profitability. CMA is the investment premium by investing in stocks with conservative investments compared to stocks with aggressive investments. Alpha is the abnormal return (see section 3.1.1.) and is provided in % and monthly terms. Below each estimate, we report the standard error in parentheses. For the significance levels, *** 1%, **5%, *10%. The Adjusted R^2 is the model's explanatory power and represents the proportion of the variance of portfolio returns that is explained by the risk factors adjusted by the number of factors.

	α	β_{MKT}	β_{SMB}	β_{HML}	β_{RMW}	β_{CMA}	Adj. R^2
The Shipping Market index							
SR	0.120	0.725***	0.202	0.011	-0.105	0.051	**50.2%**
	(0.147)	(0.093)	(0.132)	(0.156)	(0.126)	(0.15)	
NSR	-0.385**	0.591***	0.212	0.337*	-0.244	-0.116	**38.7%**
	(0.181)	(0.114)	(0.163)	(0.197)	(0.155)	(0.185)	
Difference	0.389**	0.086	-0.175	-0.261	0.271*	-0.169	**5.3%**
	(0.188)	(0.118)	(0.169)	(0.199)	(0.161)	(0.192)	
FF Market Factor							
SR	0.135	0.599***	0.221	0.351*	-0.193	-0.194	**24.1%**
	(0.184)	(0.144)	(0.164)	(0.182)	(0.156)	(0.181)	
NSR	-0.369*	0.473***	0.229	0.616***	-0.315*	-0.316	**23.9%**
	(0.204)	(0.160)	(0.181)	(0.202)	(0.173)	(0.201)	
Difference	0.359*	0.181	0.181	0.223	0.253	0.196	**6.6%**
	(0.189)	(0.149)	(0.169)	(0.188)	(0.161)	(0.187)	

As for the SR portfolio, table 7 shows that the model deliver positive, but nonsignificant alphas. Still, the alphas are rather small and insignificant. Hence, we cannot reject the null hypothesis that the SR portfolio will not outperform the market. The NSR portfolio represents negative but significant alphas independent of the market benchmark. The alphas are in relevant absolute size (-0.385, -0.369) and statistically significant at the 10 percent level using the Shipping market and 5 percent using the FF market factor as benchmark. This suggests that the NSR portfolio might destroys value compared to the market. The alphas delivered for the SR are always greater than for the NSR portfolio, confirmed by the difference portfolio, suggesting that the difference in abnormal returns is significantly positive at 10 and 5 percent levels considering the Shipping Market index and the FF market factor, respectively. This indicates that the null hypothesis can be rejected, suggesting that the SR portfolio outperforms the NSR portfolio.

Concerning the risk factors, both portfolios are significantly exposed to the stock market benchmarks with a higher exposure towards the Shipping Market index than the FF market factor (0.725 and 0.591 versus 0.599 and 0.473, respectively). For the remaining risk factors, the NSR portfolios are exposed to the value and profitability factors. The latter, only when considering the FF market factor as benchmark. The exposure towards the value factor is positive and suggests that it receives some of the value premium by investing in stocks with high book-to-market ratios compared to stocks with small book-to-ratios. The negative exposure to the profitability factor indicates that the NSR portfolio invests in stocks with weak profitability. In addition, the SR portfolio shows a slightly positive exposure towards the value factor when using the FF market factor as a benchmark, indicating that the SR portfolio also invests in value stocks rather than growth stocks, hence receiving some of the value premium.

The explanatory power of the models depends on which market benchmark is used. For the SR and the NSR portfolios, the Shipping Market index explains the variance in excess returns better than the FF market factor.

5.2.4 SR and NSR Portfolios by Subsectors

Table 8: Regressions Results: SR, NSR and Difference Portfolio, Tanker

This table presents the regression results from the Fama-French five-factor model analyzing portfolio returns of the SR, NSR, and difference tanker portfolios from January 2016 to January 2022. The SR portfolio consists of tanker stocks that have continuously published one or several sustainability reports during the period. The NSR portfolio consists of peers that have not published sustainability reports. The SR tanker portfolio and NSR tanker portfolio consist of 11 and 7 tanker stocks respectively. The stocks are listed on stock exchanges in Asia, Europe, and North America. The difference portfolio is constructed with a zero-net investment strategy taking a long position in the SR tanker portfolio and a short position in the NSR tanker portfolio. We regress all portfolios on the FF market factor and the Shipping Market index. SMB is the size premium by investing in small cap stocks compared to large cap stocks. HML is the value premium by investing in value stocks compared to growth stocks. RMW is the profitability premium by investing in stocks compared to stocks with weak profitability. CMA is the investment premium by investing in stocks with conservative investments compared to stocks with aggressive investments. Alpha is the abnormal return and is provided in % and monthly terms. Below each estimate, we report the standard error in parentheses. For the significance levels, *** 1%, **5%, *10%. The Adjusted R^2 is the model's explanatory power and represents the proportion of the variance of portfolio returns that is explained by the risk factors adjusted by the number of factors.

	α	β_{MKT}	β_{SMB}	β_{HML}	β_{RMW}	β_{CMA}	Adj. R^2
The Shipping Market Index							
SR	-0.037	0.509***	0.019	0.043	-0.172	0.096	**27.0%**
	(0.165)	(0.104)	(0.149)	(0.175)	(0.142)	(0.169)	
NSR	-0.607***	0.471***	0.196	0.238	-0.390**	0.161	**28.3%**
	(0.195)	(0.123)	(0.176)	(0.207)	(0.167)	(0.199)	
Difference	0.688***	-0.071	-0.284*	-0.207	0.227	-0.245	**8.2%**
	(0.186)	(0.117)	(0.167)	(0.196)	(0.159)	(0.189)	
FF Market Factor							
SR	-0.003	0.336**	0.040	0.291	-0.227	-0.077	**7.9%**
	(0.187)	(0.147)	(0.167)	(0.186)	(0.159)	(0.185)	
NSR	-0.577***	0.319*	0.214	0.466**	-0.442**	0.001	**17.2%**
	(0.213)	(0.167)	(0.189)	(0.211)	(0.180)	(209)	
Difference	0.662***	0.029	-0.292	-0.250	0.229	-0.220	**7.7%**
	(0.188)	(0.148)	(0.168)	(0.187)	(0.159)	(0.186)	

Table 9: Regressions Results: SR, NSR, Difference Portfolios, Dry Bulk

This table presents the regression results from the Fama-French five-factor model analyzing portfolio returns of the SR, NSR, and difference dry bulk portfolios from January 2016 to January 2022. The SR portfolio consists of dry bulk stocks that have continuously published one or several sustainability reports. The NSR portfolio consists of peers that have not published sustainability reports. The SR dry bulk portfolio and NSR dry bulk portfolio consists of 21 and 15 shipping stock, respectively. The stocks are listed on stock exchanges in Asia, Europe, and North America. The difference portfolio is constructed with a zero-net investment strategy taking a long position in the SR dry bulk portfolio and a short position in the NSR dry bulk portfolio. We regress all portfolios on the FF market factor and the Shipping Market index. SMB is the size premium by investing in small cap stocks compared to large cap stocks. HML is the value premium by investing in value stocks compared to growth stocks. RMW is the profitability premium by investing in stocks compared to stocks with weak profitability. CMA is the investment premium by investing in stocks with conservative investments compared to stocks with aggressive investments. Alpha is the abnormal return and is provided in % and monthly terms. Below each estimate, we report the standard error in parentheses. For the significance levels, *** 1%, **5%, *10%. The Adjusted R^2 is the model's explanatory power and represents the proportion of the variance of portfolio returns that is explained by the risk factors adjusted by the number of factors.

	α	β_{MKT}	β_{SMB}	β_{HML}	β_{RMW}	β_{CMA}	Adj. R^2
The Shipping Market index							
SR	0.104	0.796***	0.272*	-0.067	-0.005	0.088	**4.4%**
	(0.178)	(0.112)	(0.160)	(0.188)	(0.153)	(0.182)	
NSR	-0.219	0.596***	0.148	0.241	-0.279	-0.132	**29.4%**
	(0.209)	(0.132)	(0.189)	(0.222)	(0.179)	(0.214)	
Difference	0.417*	0.171	-0.121	-0.261	0.249	-0.014	**0.0%**
	(0.229)	(0.143)	(0.206)	(0.243)	(0.195)	(0.233)	
FF Market Factor							
SR	0.118	0.663***	0.293	0.305	-0.102	-0.181	**19.9%**
	(0.215)	(0.169)	(0.192)	(0.213)	(0.183)	(0.212)	
NSR	0.194	0.447***	0.167	0.526***	-0.348*	-0.334	**15.4%**
	(0.232)	(0.182)	(0.207)	(0.230)	(0.197)	(0.229)	
Difference	0.419*	0.144	-0.117	-0.181	0.229	-0.070	**-1.8%**
	(0.232)	(0.182)	(0.207)	(0.230)	(0.197)	(0.229)	

Tables 8 and 9 present results from the subsector-based SR, NSR, and the respective Difference regressions. The NSR portfolios generate significant negative alphas only for the tanker subsector but not for the dry bulk subsector. For the difference portfolios, the alphas are positive and significant for the tanker and the dry bulk subsectors. These results imply that the NSR portfolio underperforms compared to the SR portfolio.

As for the risk factors, both subsectors' SR and NSR portfolios are mainly exposed to the market benchmarks. The tanker portfolios have a higher exposure toward the Shipping Market index than the FF market factor, while the dry bulk portfolios have higher exposure to both market benchmarks. Considering the remaining risk factors, the NSR tanker portfolios give the most empirical evidence having significant exposures towards the value and the profitability factors. These are positive and negative, respectively, indicating that the NSR tanker portfolio receives a value premium.

The explanatory power is better for the tanker regressions than for the dry bulk regressions, and better when considering the Shipping Market index.

5.3 Robustness Check

We conduct several tests to check the results' robustness. First, we apply the four-factor model where the regression results confirm the results from the five-factor model. After that, we test the portfolio returns for three OLS assumptions:

heteroscedasticity, autocorrelation, and non-normality. We find that none of the assumptions are violated.

5.3.1 The Carhart Four-Factor Model

Table 10: Robustness Regression Tests: NG, GI, SR, NSR, Difference Portfolios

This table presents the regression results from the Carhart (1997) four-factor model analyzing portfolio returns of the GI, NGI, SR, and NSR and the respective difference portfolio from January 2016 to January 2022. The GI portfolio consists of shipping companies with a level of green investments above 30% or have invested in 20 or more scrubbers. The NGI portfolio consists of shipping companies with a level of green investments of 10% or lower. The GI and NGI portfolios consist of 17 and 19 shipping stocks, respectively. The SR portfolio consists of stocks that have continuously published one or several sustainability reports. The NSR portfolio consists of peers that have not published sustainability reports. The SR and NSR portfolios consist of 21 and 15 shipping stocks, respectively. Each portfolio has stocks on stock exchanges in Asia, Europe, and North America. The difference portfolio is constructed with a zero-net investment strategy taking a long position in the green portfolios and a short position in the non-green portfolios. We regress all portfolios on two different market benchmarks, the FF market factor and the Shipping Market index. The Shipping Market index is the Solactive Global Shipping Index (see section 4.3). SMB is the size premium by investing in small cap stocks compared to large cap stocks. HML is the value premium by investing in value stocks compared to growth stocks. RMW is the profitability premium by investing in stocks compared to stocks with weak profitability. CMA is the investment premium by investing in stocks with conservative investments compared to stocks with aggressive investments. Alpha is the abnormal return (see section 3.1.1.) and provided in % and monthly terms. Below each estimate, we report the standard error in parentheses. For the significance levels, *** 1%, **5%, *10%. The Adjusted R^2 is the model's explanatory power and represents the proportion of the variance of portfolio returns that is explained by the risk factors adjusted by the number of factors.

	α	β_{MKT}	β_{SMB}	β_{HML}	B_{MOM}	Adj. R^2
The Shipping Market Index						
GI	0.036	0.853	-0.046	-0.050	0.067	**57.2%**
	(0.143)	(0.089)	(0.138)	(0.142)	(0.124)	
NGI	-0.405**	0.589***	-0.152	0.216	0.272*	**39.0%**
	(0.778)	(0.112)	(0.172)	(0.177)	(0.154)	
Difference	0.529***	0.257**	-0.009	-0.322	0.191	**5.4%**
	(0.194)	(0.122)	(0.188)	(0.194)	(0.169)	
FF Market Factor						
GI	0.058	0.678***	0.126	0.228	-0.011	**22.0%**
	(0.194)	(0.154)	(0.183)	(0.186)	(0.167)	
NGI	-0.381*	-0.436***	-0.027	0.408**	0.332*	**21.9%**
	(0.206)	(0.161)	(0.192)	(0.194)	(0.173)	
Difference	0.552***	0.148	0.053	-0.236*	0.157	**12.6%**
	(0.202)	(0.159)	(0.191)	(0.183)	(0.173)	
The Shipping Market Index						
SR	0.091	0.721***	0.012	0.004	-0.109	**49.2%**
	(0.150)	(0.094)	(0.145)	(0.149)	(0.130)	
NSR	-0.452***	-0.618***	-0.087	0.222	-0.214	**37.0%**
	(0.185)	(0.116)	(0.179)	(0.184)	(0.161)	
Difference	0.417***	0.074	-0.140	-0.344**	0.044	**1.4%**
	(0.194)	(0.122)	(0.188)	(0.193)	(0.169)	
FF Market Factor						
SR	0.114	0.559***	0.161	0.241	-0.178	**28.4%**
	(0.189)	(0.149)	(0.179)	(0.181)	(0.162)	
NSR	-0.418**	0.426***	-0.050	0.426***	-0.282	**18.6%**
	(0.213)	(0.169)	(0.201)	(0.204)	(0.183)	
Difference	0.387**	0.180	-0.132	-0.323**	0.059	**2.8%**
	(0.195)	(0.155)	(0.184)	(0.187)	(0.167)	

Table 10 presents the result from the four-factor regression models analyzing the green and non-green portfolios, and the respective difference portfolios. The explanatory power for the four-factor regressions is mainly similar as for the five-factor model, indicating that the two factor models explains the variance in portfolio excess returns just as well.

As for the alphas, the four-factor regression model deliver positive but non-significant alphas for the green portfolios but negative and significant alphas for the non-green portfolios. For the difference portfolios, the alphas are positive and significant. This confirms the five-factor regression results, implying that there is evidence that the green portfolio outperforms the non-green portfolio.

Regarding the market factors, the four-factor model confirms the Fama-French model results, finding a higher exposure toward the Shipping Market index than for the FF market factor. Regarding the momentum factor, only the NGI portfolio has significant and positive exposure. This implies that the NGI portfolio invests in stocks with high historical returns and hence receives some momentum premium.

5.3.2 Testing OLS Assumptions

The OLS regression method builds on five assumptions to hold to be able to trust the result: i) zero conditional mean, ii) homoscedasticity, iii) linear parameters, iv) no autocorrelation, and v) no perfect collinearity. If assumptions i)-iv) hold the estimators determined by OLS are the best linear unbiased estimators (Brooks, 2019). In our analysis, we tested the assumptions we think may be violated in our data: homoscedasticity, non-autocorrelation, and normality.

We test for normality by running a Jarque-Bera test on the portfolio returns. Also, if the error terms are heteroskedastic and autocorrelated, they can bias the regression results and invalidate inference (Brooks, 2019). We test for heteroscedasticity and autocorrelation by conducting the White's tests and the Breusch-Godfrey tests on the five-factor regressions. The data sample used in this thesis is homoscedastic, not autocorrelated, and normally distributed (see tables, 17, 18, and 19 in Appendix 6).

5.4 Summary and Discussion

This thesis addresses the financial implications of listed shipping companies' environmental performance by assessing whether green shipping stocks outperform the market and their non-green peers. In this chapter, we will discuss the abnormal findings from our empirical analysis. The analysis does not reject the null hypothesis that the green shipping portfolios do not outperform the market. However, we find that the non-green portfolios underperform compared to the market benchmarks. This suggests that we reject the null hypothesis stating that green portfolios do not outperform the non-green portfolios.

When discussing these findings, it should be considered that an alpha deviating from zero could suggest a pricing error, not abnormal returns. Our findings presented in table 11 will be discussed while noting that there may exist variables, we have not controlled for that could potentially cause abnormal returns.

Table 11: Summary of the Alphas

The table presents the alphas delivered by the Fama-French five-factor regressions for the Shipping Market index (SMI) and the FF market factor (FFMF). The alphas are presented in monthly terms and percent for the GI, NGI, SR, and NSR, as well as the respective difference and subsector portfolios. The GI portfolio consists of shipping companies with a level of green investments above 30%, or have invested in 20 or more scrubbers. The NGI portfolio consists of shipping companies with a level of green investments in scrubbers of 10% or lower. The GI and NGI portfolios consist of 17 and 19 shipping stocks, respectively. The SR portfolio consists of stocks that have continuously published one or several sustainability reports. The NSR portfolio consists of peers that have not published sustainability reports. The SR and NSR portfolios consist of 21 and 15 shipping stocks, respectively. The difference portfolio is constructed with a zero-net investment strategy taking a long position in the green portfolios and a short position in the non-green portfolios Each portfolio has stocks listed on stock exchanges in Asia, Europe, and North America. For the significance levels, *** 1%, **5%, *10%.

Portfolio	**Market Benchmarks**	
Total	**SMI**	**FFMF**
GI	0.049	0.068
NGI	-0.335*	-0.330*
Difference	0.520***	0.549**
Tanker		
GI	0.040	-0.004
NGI	-0.487***	-0.488**
Difference	0.606***	0.631***
Dry Bulk		
GI	0.048	0.068
NGI	-0.119*	-0.330*
Difference	0.204	0.161
Total		
SR	0.120	0.135
NSR	-0.385**	-0.369*
Difference	0.389**	0.359*
Tanker		
SR	-0.037	-0.003
NSR	-0.607***	-0.577***
Difference	0.688***	0.662***
Dry Bulk		
SR	0.104	0.118
NSR	-0.219	0.194
Difference	0.417*	0.419*

The lack of significant alphas for the green portfolios, including the green investing and sustainability reporting portfolios, indicates that being a forerunner will not generate a risk premium compared to the market. This contradicts what we expected. Our findings suggest that increased environmental performance in the shipping sector leads to superior returns to investors rather than just being a burden, as stated by Friedman (1970). Capital structure characteristics such as high leverage ratios, asset specificity, and the long lifetime of a ship might cause quick investment decisions to be cumbersome and costly. This may confirm that environmental performance diminishes stock returns, limiting the effects of increased asset value and competitive advantage (Cohen et al., 1998; Walley & Whitehead, 1994).

A potential explanation for the non-significant alphas for the green investing portfolios might be the lower risk associated with investing in scrubbers. Forerunners that invest to meet the sulfur regulations mitigate their risk exposure towards a decreasing VLSFO-HSFO spread. The traditional risk-return theory would then suggest that investors take less risk when investing in green companies, hence requiring a lower return.

A significant contribution to the abnormal returns delivered by the difference portfolios is the negative alphas for the non-green portfolios. A potential explanation for the negative abnormal returns when investing in the non-green portfolios is current investor scrutiny in the shipping sector because of the expanding regulatory structures. The results confirm that investors may play a role in moving their funds from non-green stocks to green stocks, causing a declining return for the non-green portfolios (Ammann et al., 2019).

The findings in table 5.9 indicate that non-green tanker stocks mainly drive the negative alphas for the non-green portfolios, hence the abnormal returns for the difference portfolios. The recent oil price has negatively impacted the tanker market. Regardless, it is a fair assumption that the “brown” aspect of the subsector also drives poor financial performance. The tanker subsector is brown in terms of the operations which are driven by oil, gas, and chemicals. The performance of the non-green tanker portfolios is consistent with that investors are found to divest in fossil fuel stocks (Halcoussis & Lowenberg, 2019).

Disregarding the non-significant alphas of the green portfolios, positive alphas for the difference portfolios could indicate that green shipping companies bear regulatory, investment, and technology risks. Uncertainty about regulations and compliance costs seems to shape the shipping sector in the coming years, making it riskier to be a forerunner in green investments and less risky to be careless. According to the risk-return theory, investors require a higher return which might contribute to the outperformance by the green portfolios. Nevertheless, the outperformance by the green portfolios seems to be driven by the downside risk the non-green companies are subject to. We imply that these companies, particularly the non-green investing companies, are subject to regulatory and reputational risk related to potential reluctant behavior that can destroy shareholders' perception. Investors may answer this behavior by moving their funds toward regulation-compliant companies, as they consider the regulatory risk too high. Let us also take the disputed aspect of scrubbers into account. The non-green investing portfolio may instead be defined as a "non-regulatory compliant" portfolio that could destroy value compared to the market because of downside regulatory risk. In this case, the results from the non-sustainability reporting portfolio become even more interesting. The alpha for this portfolio is more significant and negative than the non-green investing portfolio. This indicates that choosing not to incorporate sustainability and climate goals in the business model destroys even more value due to inferior reputation and competitive advantage. More importantly, it causes the non-green companies to be outperformed by those who focus on sustainability and climate goals.

5.5 Limitations and Recommendations for Future Research

It is essential to address that the results and discussion above should be carefully interpreted due to limitations (see sections 3.2 and 4.4). The results can be viewed as an approximation of reality, which one should be aware of when concluding.

There are also some limitations with the choice of empirical analysis. Given the lack of large data samples on stock returns in the shipping sector, another approach could be assessing corporate financials. Therefore, one suggestion for future research is to valuate a specific shipping company at the corporate level to assess its environmental performance. Also, an empirical analysis including macroeconomic factors in a regression model could help us assess whether some of the generated abnormal returns are significantly explained by oil price, interest rate, or other macroeconomic factors.

In this thesis, we have looked at green investments in the form of scrubber installations and the publishing of sustainability reports. An alternative performance measure could be to look at ESG scores or sustainability ratings and see if this has any financial implications for shipping companies. Nonetheless, we conclude that these measures are not widespread enough in the shipping sector, but this may as well change over the following years.

Additionally, the IMO has introduced new measures to reduce GHG emissions in the maritime industry, which will take effect in 2023, whereas the goal is to minimize the carbon footprint in shipping. In June 2021, the IMO adopted extensive new carbon regulations applicable to existing ships, specifically the Carbon Intensity Indicator (CII) requirements. The CII aims to measure how efficiently a ship transports goods or passengers and is an advancement of the earlier Energy Efficiency Existing Ship Index (EEXI), a one-time certification targeting design parameters. In contrast, the CII addresses actual emissions from operations. Based on the CII measure, the ship is given an annual rating ranging from A to E. The rating thresholds will become increasingly rigorous towards 2030 (DNV, 2022). Such ratings and related investments in green technologies would be an interesting measure to look at long-term, to spot the financial implications of environmental performance in the shipping sector.

6 Conclusion

This thesis examines whether investing in green forerunners in the shipping sector pays off by answering the research question: *What are the financial implications of listed shipping companies' environmental performance?* To answer this research question, we have performed regression analyses on green, non-green, and difference portfolios based on shipping stocks from the tank and dry bulk subsectors. We compare the performance of green portfolios with the global stock market, the shipping stock market, and non-green peers by assessing the abnormal returns delivered by four- and five-factor regression models.

Our results find no significant evidence that green stocks outperform the shipping stock market or the global stock market. Thus, we cannot conclude that it will pay off to invest in green stocks. The empirical analysis delivered positive abnormal returns for all green portfolios, except the sustainability reporting portfolio considering the dry bulk subsector. Yet, the abnormal returns are small and non-significant. Still, the difference portfolios deliver significant and positive returns indicating that the green portfolios outperform the non-green portfolios. Considering the shipping stock market, the difference in abnormal returns indicates that the green investing portfolio outperforms the non-green investing portfolio with 0.520 percent and that the sustainability reporting portfolio outperforms the non-sustainability reporting portfolio with 0.389 percent.

The green portfolios' outperformance is mainly driven by the value-destroying performance of the non-green portfolios. The analysis of the non-green portfolios delivers significant and negative abnormal returns, except for the sustainability reporting portfolio looking solely at the dry bulk subsector. Considering the shipping stock market, the regression model provides -0.335 percent and -0.385 percent abnormal returns respectively for the non-green investing and non-sustainability portfolios. The abnormal returns are larger in absolute size considering the tanker market, where the models deliver -0.487 and -0.607 percent abnormal returns for non-green investing and non-sustainability reporting portfolios, respectively. This suggests that investing in green portfolios will be profitable compared to non-green due to the non-green tanker portfolios' value-destroying performance.

In the light of the research question, environmental performance for listed shipping companies does not generate abnormal returns. Still, investors may punish the lack of environmental performance. This is consistent with our expectations, stating that the market presumes that companies comply with regulations and frameworks. The negative abnormal returns for the non-green portfolios vary between -0.335 and -0.607 percent. These results drive the positive returns delivered by the difference portfolios, ranging from 0.389 to 0.688 percent. We conclude that investing in green shipping stocks will result in higher returns than investing in non-green stocks, suggesting a positive financial impact on environmental performance in the shipping sector. Still, considering the expanding regulatory structures and increasing investor scrutiny, we emphasize the need to continue studying the financial implications of environmental performance in shipping in the years to come.

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Appendix

Appendix 1 – Key Figures for the Shipping Sector

Table 12: Key Figures, World Fleet, 2019 – March 2022

Numbers in this table are received from Clarksons Research in April 2022.

World Fleet	Number of ships, end of year				m, Gross Ton (GT), end of year			
	2019	2020	2021	22-Mar	2019	2020	2021	22-Mar
Total Fleet	100,152	101,419	102,899	103,161	1,400	1,440	1,485	1,495
Growth (ytd)	1.70%	1.30%	1.50%	0.30%	4.00%	2.80%	3.20%	0.70%
Fleet Value ($bn)					994	950	1,310	1,418

Table 13: Key Figures, Subsectors, 2019 – March 2022

Numbers in this table are received from Clarksons Research in April 2022.

World Fleet by sector	Number of ships, nd of year				m, Gross Ton (GT), End of Year			
	2019	2020	2021	22-Mar	2019	2020	2021	22-Mar
Tankers	15,656	15,897	15,983	16,019	361	371	377	379
Dry Bulk	11,979	12,326	12,702	12,790	486	504	522	526
Container	5,384	5,442	5,589	5,616	245	253	263	265

Appendix 2 – Sustainability Reporting Frameworks in Shipping

Figure 6: ESG Reporting Guidelines – GRI, SDGs, and SASB

Figure, Internal analysis, based on ESG reporting from the Norwegian Ship Assosiation and DNV (2017; 2021).

Appendix 3 – The Kenneth French's Continent Division

Table 14: Kenneth French's Division of Countries into Continent

Retrieved from Kenneth French (2021).

Country	Developed	Developed ex US	Europe	Japan	Asia Pacific ex Japan	North America
Australia	X	X			X	
Austria	X	X	X			
Belgium	X	X	X			
Canada	X	X				X
Switzerland	X	X	X			
Germany	X	X	X			
Denmark	X	X	X			
Spain	X	X	X			
Finland	X	X	X			
France	X	X	X			
Great Britain	X	X	X			
Greece	X	X	X			
Hong Kong	X	X			X	
Ireland	X	X	X			
Italy	X	X	X			
Japan	X	X		X		
Netherlands	X	X	X			
Norway	X	X	X			
New Zealand	X	X			X	
Portugal	X	X	X			
Sweden	X	X	X			
Singapore	X	X			X	
United States	X					X

Appendix 4 – Descriptive Statistics for the Subsector Portfolios

Table 15: Descriptive Statistics, Subsectors, GI ,and NGI portfolios

All statistics are based on the period 2016-2022. The Sharpe ratio is the excess return (average return minus the average risk-free rate for the same period) per unit of risk. Mean return is the average return of the portfolio over the period. The min (max) return is the smallest (largest) return observed in a portfolio in the relevant period. For the difference portfolios, we have tested the mean return with a two-sampled t-test to check whether the difference in mean return is statistically significant. None of the mean returns for the difference portfolios are statistically significant at the 1, 5, or 10 percent level.

	Sharpe Ratio	Mean Return	Standard Deviation	Max	Min
Total					
Green Investing	0.156	1.312	8.424	22.566	-20.245
Non-Green Investing	-0.042	-0.414	9.838	43.489	-18.960
Difference	0.250	1.652	6.595	12.890	-21.915
Tanker					
Green Investing	0.103	0.787	7.645	24.960	-17.238
Non-Green Investing	-0.208	-1.754	8.451	24.263	-19.209
Difference	0.347	2.468	5.543	2.468	-17.42
Dry Bulk					
Green Investing	0.159	1.680	10.554	29.472	-29.256
Non-Green Investing	0.075	1.075	14.364	77.172	-19.209
Difference	0.056	0.531	9.545	17.365	-49.350
Market Benchmarks					
FF Market Factor	0.234	0.993	4.249	13.341	-13.771
The Shipping Market Index	0.144	1.129	7.835	25.249	-19.367

Table 16: Descriptive Statistics, Subsectors, SR and NSR portfolios

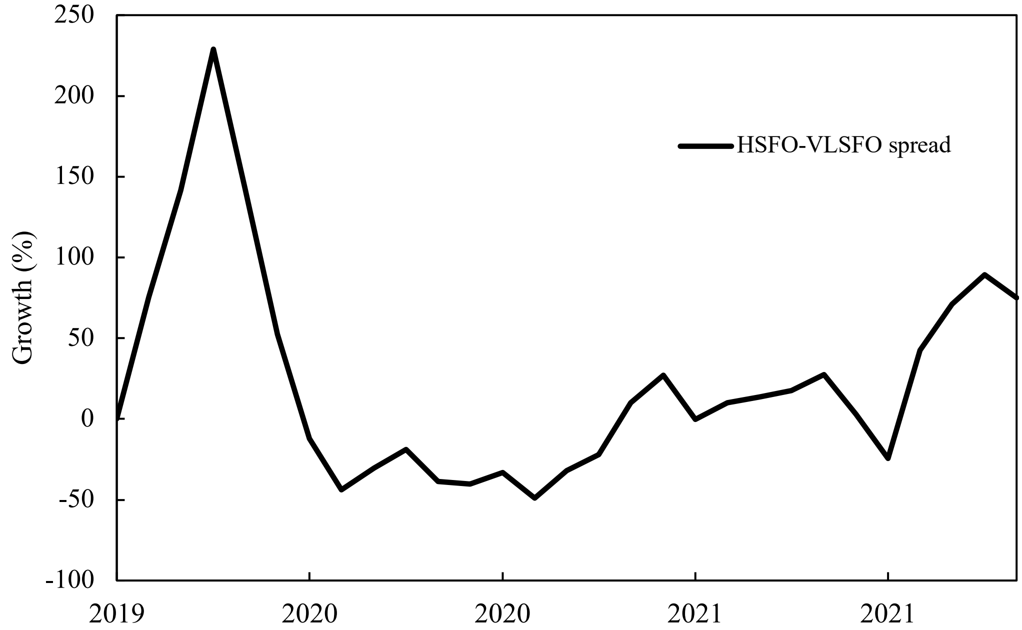
All statistics are based on the period 2016-2022. The Sharpe ratio is the excess return (average return minus the average risk-free rate for the same period) per unit of risk. Mean return is the average return of the portfolio over the period. The min (max) return is the smallest (largest) return observed in a portfolio in the relevant period. For the difference portfolios, we have tested the mean return with a two-sampled t-test to check whether the difference in mean return is statistically significant. None of the mean returns for the difference portfolios are statistically significant at the 1, 5, or 10% level using a two-sample t-test.

	Sharpe Ratio	Mean Return	Standard Deviation	Max	Min
Total					
Sustainability Reporting	0.135	1.075	7.937	20.244	-21.52
Non-Sustainability Reporting	-0.050	-0.544	10.907	51.700	-20.531
Difference	0.215	1.545	7.1800	13.700	-31.817
Tanker					
Sustainability Reporting	0.039	0.258	6.570	15.191	-16.717
Non-Sustainability Reporting	-0.212	-2.088	9.867	20.769	-21.173
Difference	0.328	2.273	6.925	16.467	-16.121
Dry Bulk					
Sustainability Reporting	0.165	1.818	11.055	30.779	-29.66
Non-Sustainability Reporting	0.056	0.808	14.502	79.276	-20.836
Difference	0.091	0.937	10.262	19.266	-48.507
Market Benchmarks					
FF Market Factor	0.234	0.993	4.249	13.340	-13.77
The Shipping Market Index	0.144	1.129	7.835	25.249	-19.367

Appendix 5 – The VLSFO-HSFO spread

Figure 7: The VLSFO-HSFO Spread, 2019-2022

The spread is calculated based on the VLSFO and HSFO price between September 2019 and January 2022, retrieved from Pareto Securities in April 2022, by taking the price of VLSFO minus the HSFO price and calculating the monthly growth.



Appendix 6 – Testing OLS Assumptions

Table 17: White's Test for Homoscedasticity

This table presents the results of White's test for homoscedasticity. We test for homoscedasticity for the GI, NGI, SR, and NSR portfolios using the five-factor model. The test statistics represent a chi-squared distributed test statistics, where the null hypothesis is that the error variances are all equal, i.e., that the data is homoscedastic. The p-values above 0.05 (5 % significance level implicate that we cannot reject the null hypothesis stating that the data is homoscedastic (Brooks, 2015).

	P-value	Test Statistic
GI	0.201	24.951
NGI	0.251	23.921
SR	0.941	4.112
NSR	0.422	20.661

Table 18: Breusch-Godfrey Test for Non-Autocorrelation

This table presents the results of the Breusch-Godfrey test for autocorrelation. We test for homoscedasticity for the GI, NGI, SR, and NSR portfolios using the five-factor model. The null hypothesis is that there is no autocorrelation in the portfolios, and low test statistics and high p-values indicate that we cannot reject any null hypothesis (Brooks, 2015). Thus, we conclude that there is no autocorrelation in our data set.

	P-value	Test Statistic
GI	0.887	5.051
NGI	0.679	7.492
SR	0.942	4.108
NSR	0.796	6.216

Table 19: Jarque-Bera Test for Normality

This table presents the results of the Jarque-Bera tests for normality. The null hypothesis state that the data set are normally distributed, and a low test statistics and p-values above 0.05 (5% significance level) indicate that we cannot reject any null hypothesis (Brooks, 2015). Thus, we conclude that our data are normally distributed.

	P-value	Test Statistic
GI	0.663	0.882
NGI	0.057	5.697
SR	0.387	0.824
NSR	0.052	6.042