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Abstract

The shipping industry transports 90% of world trade, according to the International Chamber of Shipping. As climate change and sustainability becomes increasingly more topical, this industry's pollution levels are now being carefully monitored. In recent years, regulation such as IMO 2020 has been passed, forcing shipowners to make costly modifications to their ships, or use more expensive fuels. This thesis analyses how these types of environmental policies and regulations affect dry bulk freight rates. We used the residuals from the return of green stock portfolios regressed on the return of a stock market index as a proxy to measure environmental policy stringency (EPS). From this we estimated impulse responses by the method of local projection. We found that an increase in EPS leads to an increase in dry bulk freight rates. Our results suggest sticky prices and that the effect is persistent up to a horizon of 24 months. The shock in EPS affects shipowners' variable costs in terms of increased fuel and crew costs, and fixed costs through increased shipbuilding and scrapping costs.

Key Words: Environmental Policy Stringency, EPS, Shipping, Dry Bulk, Freight Rates, Transportation, Sea Freight, Bulk Shipping

Abbreviations:

EPS: Environmental Policy Stringency

BDI: Baltic Dry Index

ETF: Exchange Traded Funds

IRF: Impulse Response Functions

IMO: International Maritime Organisation

ESG: Environmental, Social and Governance

VAR: Vector Autoregression

LNG: Liquefied Natural Gas

NO_x: Nitrogen Oxides

Terms used interchangeably:

- Shipping rates, shipping prices, freight rates, transport costs, Baltic Dry Index
- Shipping industry, maritime transport industry, dry bulk industry
- Environmental policy stringency, environmental regulation
- ETF, fund, portfolio

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1. Introduction

According to the International Chamber of Shipping (ICS), the shipping industry transports almost 90% of world trade, making it the main transport for global trade due to low cost and relatively low pollution when carrying large volumes of goods (ICS, 2022). The shipping industry involves large industry agents with high bargaining power that generates large amounts of profits while maintaining sustainably low costs. All this takes place, without facing severe repercussions from emissions caused by the industry.

The International Maritime Organization (IMO) is the one responsible for regulating the industry in terms of maritime safety, maritime security, legal affairs, maritime environment, and everything surrounding the global maritime industry. As climate effects and sustainability become increasingly more topical, the visibility of the International Maritime Organization and active local governments increases, as their main target is to reduce the extreme CO_2 emissions caused by the shipping industry.

On January 1. 2020, the International Maritime Organization (IMO) implemented a new regulation that required all ships to adhere to a 0.5% limit on sulphur oxide content in ship's fuel oils to "improve air quality, preserve the environment and protect human health" (IMO, 2020). The alternatives used to adhere to these regulations are widely discussed, with the most common being NO_x scrubbers, low sulphur fuel oil, liquified natural gas (LNG) fuel, or costly innovation in motorised sails and hydrogen. This measure is the first of many, as IMO member states agreed upon a strategy to reduce at least 50% of emissions in the industry by 2050. Regulations such as these have already yielded large industrial processes to combat pollution in the shipping industry.

Stricter environmental policy regulations are believed to increase the costs of seafaring transport, and this thesis analyses how this happens and if there is any apparent causal effect of environmental policy regulation and shipping costs.

The first part of this thesis discusses the environmental effects of dry bulk shipping, as well as the current global trends in the market that affects the shipping industry. The thesis considers the shipowners point of view, and how they respond to the challenges that occur today, also explaining the shipping cycle and the timing of investment decisions. Furthermore, this thesis discusses how freight rates are determined by different variables, and how these variables channel out through variable and fixed costs for shipowners. The empirical section of our thesis analyses how environmental policy stringency (EPS) proxied by the returns on green stock portfolios, affect shipping prices by using the procedure of local projection.

2. The Economics of the Dry Bulk Freight Market

2.1 Environmental Effects of Shipping

The deep-sea freight transport market has proven to be relatively more volatile in recent years compared to before the 2000s. This is illustrated in Figure 1 and might be caused by global economic instability and oil price volatility, as oil prices heavily affect shipping prices through variable costs. Figure 1 shows the Baltic Dry Index, a widely used index in the deep-sea dry bulk freight industry.

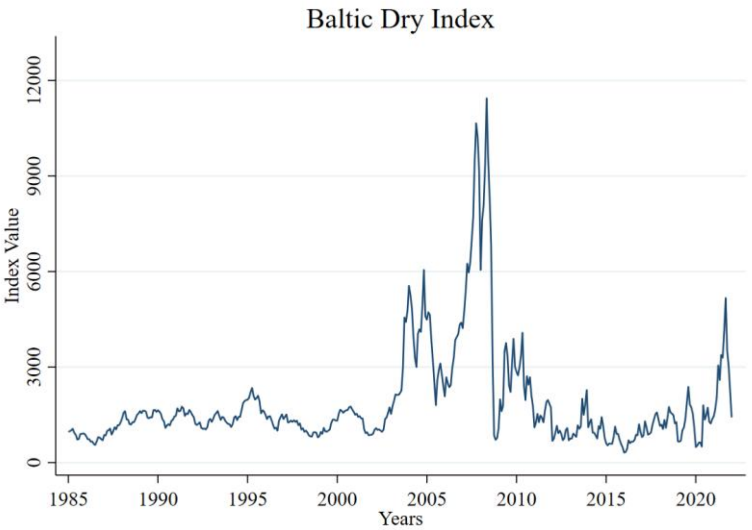

Figure 1 (Bloomberg L.P., n.d.a)

As environmental policy and sustainability are rising to become a necessary focus area, all industries will try to minimize their carbon footprint. Reducing emissions is more feasible in some industries than others, as some might endure great research and development costs for new technologies. The transport sector is of this category, because the decarbonization of this industry requires extensive amounts of capital. According to Wang et al. carbon dioxide emissions from the transportation sector are linked to a country's growth in GDP (Wang et al., 2011, p. 5912). This is illustrated in Figure 2.

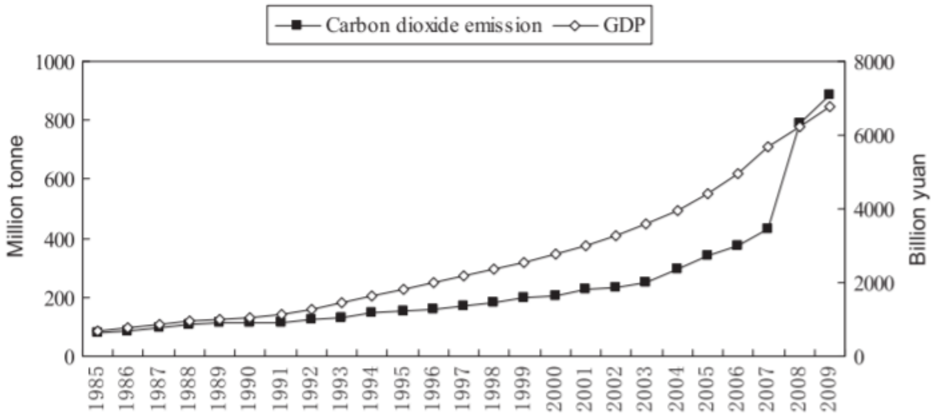

Fig. 1. Trend of transport sector CO_2 emissions and GDP in China.

Figure 2 – From "Using LMDI method to analyze transport sector CO2 emissions in China", by Wang et al., 2011, Energy, 36, p. 5912 (https://doi.org/10.1016/j.energy.2011.08.031). Copyright 2011 by Elsevier Ltd.

This might raise a concern with developing countries, as CO_2 emissions together with physical production and trade are traditionally required to achieve economic growth. Industrialised countries have passed this phase and are trying to lead the way to find more sustainable solutions for all industries. This green change compels the industry to develop cheaper, more profitable solutions. Organisations and governments also incentivize this change in the form of penalties, taxes, fees, and incentives in regulatory changes, hereafter denoted as environmental policy stringency (EPS). The Norwegian government for instance recently passed an amendment to the regulation for visiting foreign cruise ships. It specified requirements for the reduction of sulphur and sewage in Norwegian fjords and increasing the use of NO_x scrubbers (Norwegian Maritime Authority, 2019). These regulations force shipping companies to adhere to new regulations or stop visiting Norwegian fjords. This is a measure that is less likely to occur in developing countries, as it could result in fewer visiting ships, thereby reducing tourism income.

This thesis aims at researching whether these types of regulations leave any apparent direct or indirect effects on the international sea-freight rates, mainly in the dry bulk sector. It is well documented that a deciding factor of deep-sea freight and dry bulk freight rates are oil prices and crew costs, both of which determine the largest variable costs for ships. Other factors of freight rates are port efficiency, infrastructure, and location (Wilmsmeier & Hoffmann, 2008). These factors are all supply variables, but demand also contributes to the freight rates. Business cycles that determine the global economy with peaks and troughs greatly affect demand for goods and services globally, which in turn affects demand for shipping. The driving factors for shipping prices are further discussed in the literature review.

2.2 Anticipations About Future Shipping Trends

The concept behind this thesis is founded on environmental regulations imposed by organisations and governments that force shipowners to reduce their emissions and carbon footprint. This forces the shipowners to rethink how they can still operate and earn profits, in spite of contributing to great amounts of pollution.

In a horizon that spans over 20-30 years, the technological advances that might come out of regulations could help reduce marginal costs and emissions. In economic terms, this means a right-ward shift in the supply curve, which yields a lower price. These technological advances require vast amounts of capital and will be a large cost for shipbuilders. Large international companies such as IKEA, Amazon, and Unilever promise by 2040 to phase out non-zero emission transportation. These measures benefit the companies' climate profile and makes them favourable towards environmentally conscious consumers, although it might reduce its profitability due to increased transportation costs (IKEA, 2022), (Amazon, 2022), (Unilever, 2022).

The main demand drivers of the dry bulk markets are coal, iron ore, grain and agricultural goods, and other minor bulk (Kavussanos & Visvikis, 2013). Given that natural resources are generally very inelastic in demand due to their importance, Kavussanos and Visvikis suggest looking at the elasticity of demand to understand the need for transportation when prices change.

The same thoughts are expressed in a UN report that analyses how IMO 2020 regulations affected the price of grain seeds. The regulation that came into effect on the 1st of January 2020 made shipowners face a steep but moderate increase in fuel costs, but the deteriorating economic markets quickly seemed to neutralise this price effect (Karavaytsev & Turkin, 2020). Transport prices surprisingly fell below pre-2020 levels by April 2020, suggesting that there is a short-term effect through marginal costs, but no real long-term effect of the regulation.

Although it is unclear how the freight market will develop in the long term, a potential theory is that shipping companies and the market will have factored in future policy changes. Large and influential companies have given indications about their future transportation emission goals. This focus is surely observed by shipowners, and business practices in the shipping industry might be revised and changed accordingly. The revision of practices might lead to increased rates today for shipbuilders to invest in greener technologies in the future.

Trends in new technology and production facilities are by far the most popular topic of discussion for shipowners and politicians as there is a future value related to the production and usage of new ships. However, there comes a point where a vessel no longer brings value to the firm and is considered a liability instead of an asset. Historically, the working conditions under which vessels have been scrapped has been extremely poor, with sickness and death being brought upon workers in emerging economy countries. This problem has been considered and attempted to be regulated by IMO and other countries' regulators, however, there is still a very long way to go. Through a renewable future with a higher social responsibility focus, costs of scrapping will only increase as it is expected to see rises in salaries, working conditions, and methods of recycling old materials. Increased cost to scrapping will contribute to increasing the fixed costs of sea-born transportation (SDIR, 2022).

2.3 The Shipping Cycle

Although not famously coined by anyone, the concept of shipping cycles is, according to Martin Stopford, credited to the Dutch economist Jan Tinbergen, who noticed this notion of shipping cycles in the 1930s. Today, the shipping cycle explains how the market is clearly out of sync when it comes to supply and demand given the time new ships can be brought to market, and how quickly demand changes (Stopford, 2009). This concept is necessary to understand the general supply and demand for the maritime transportation industry. The shipping cycle is a continuous cycle based upon the basic supply and demand for shipping. When there is an over-supply of vessels in relation to demand, rates, and asset-values fall. This leads to fewer orders of new ships and old ones being scrapped. As the market balances, and there seems to be an increase in demand, a sense of optimism among shipowners drives a new influx of ship orders. The supply-side of the sector continuously lags one period behind due to the long period it takes to construct ships. Because it takes up to two years to build a ship, supply lags behind, and by the time all ships are delivered, there is again an over-supply of ships, continuing the cycle (Miller, 2021). During periods of low demand for maritime transportation, the supply of vessels decreases. As shipping markets are driven by freight rates, markets can move up or down as freight rates changes.

With the fear of future decarbonization rules and economic uncertainty, shipowners are careful and uncertain about which propulsion systems they should choose, as investing in the wrong propulsion system could cause premature obsolescence of newly built ships. Greg Miller of Freightwaves [1] suggests the Environmental, Social and Governance (ESG) movement is likely to push prices of bulk commodities upwards in the future. Miller uses the example of escalating housing demand and barriers to constructing new buildings, to compare what happens to freight rates when research and development cost increases, namely, increased cost of production (Miller, 2022). Shipowners have with these huge risks involved in their decisions to order new ships of different types. To combat this, the industry has been advised and agreed to split the risk between charterers and vessel owners through the introduction of time charter contractual clauses (Kyriakides, 2022).

2.4 Stopford’s Supply Curve

The world economy influences the shipping cycles and its fluctuations. Shipowners are responsible for operating their shipping companies to benefit from these fluctuations. One example is to hedge against future fluctuations in the oil price, securing a lower fuel price for a limited period. This protects the shipowners against some risks of the market. According to Martin Stopford, the key influences that affect demand and supply for shipping can be simplified into ten factors.

[1] Freightwaves is a leading supply chain intelligence platform. The incorporation provides supply chain organizations with fundamental data and context that can help benchmark the global freight market.

Demand	Supply
The World Economy	World Fleet
Seaborn Commodity Trades	Fleet Productivity
Average Haul	Shipbuilding Production
Random Shocks	Scrapping and Losses
Transport Costs	Freight Revenue

Table 1 - Ten variables in the shipping market model. From "Maritime Economics", by Martin Stopford, 2009, London Routledge (3rd ed., p. 136). Copyright Martin Stopford 2009.

Stopford argues that while cargo shippers are central in the demand module through decisions on raw material, the shipping investors are important for the supply module by ordering and scrapping ships. Any differences appearing between supply and demand directly feed into the freight market. And freight rates constantly adjust in response to changes in the balance between supply and demand. As seen in this model, and confirmed by Karavaytsev & Turkin (2020), the world economy is very dominant in both determining the supply and demand, but also for all controlling factors. This is important to emphasize when discussing supply and demand, and the lifetime of shipping cycles.

The relationship between speed and freight rates is often seen as a proxy for the industry's supply curve. S is optimal speed measured in miles per day, R is voyage freight rate, p is price of fuel, k is ships fuel efficiency coefficient, and d is distance. Equation (1) defines the supply curve used in page 161 of Stopford's book "*Maritime Economics*", and shows that supply increases as ships speed up. In other words, speed here is a proxy for supply.

Equation (1)

$$S = \sqrt{\frac{R}{3\, p.k.d}}$$

Equation 1 - From "Maritime Economics", by M. Stopford 2009, 3rd Edition., p.162)

The shape of the supply curve is determined by this function, and the shipowners maximize their profit by operating the vessels at the speed at which marginal cost equals the freight rate. EPS affects this equation through both variable and fixed channels. The price of fuel is according to Stopford, ”the single most important item in voyage cost, accounting for 47% of the total cost” (Stopford, 2013, p. 233). A ship’s design and considerations are not solely dependent on forced regulations, but also on changes in the market and costs. Such as when the price of fuel surged in the 70s and 80s, shipowners needed new engine designs to lessen fuel consumption.

EPS can be seen through this supply curve with variable costs and fixed costs. Environmental policy stringencies are likely to increase the fixed costs needed to research and develop innovative solutions needed for newer vessels that comply with new regulation standards. The same applies to scrapping old ships that are no longer efficient for transportation, as we discussed in section 2.2. The largest variable costs are fuel and crew costs. By implementing new policies, shipowners are now required to purchase a more environmentally friendly fuel than previously, which in turn is more expensive. With this intuition, EPS will increase the price of fuel. The same goes for crew costs because IMO is continuously reviewing and improving working conditions aboard ships. This also contributes to increasing the prices of the variable crew costs.

2.5 Oil Prices and Oil Price Shocks’ Effect on Shipping

A key factor in freight rates is oil prices. Ships today run on fuel-oil that has been refined and processed and made into heavy fuel oil (HFO), however, ships can also run on crude oil with just some coarse filtering needed. As mentioned previously, the oil price therefore significantly affects the marginal costs of shipowners. It is safe to state that a positive shock in oil prices causes an increase in shipping costs, as variable fuel costs are one of the main contributors to total voyage costs (Fritt-Rasmussen et al., 2018). David Howdon proposes that an individual tanker owner cannot control long-run profitability in the industry, just by altering their investment decisions. Especially at times when oil companies tie their investment decisions based on market anticipations (Hawdon, 1978). In a consulting report from 2018, McKinsey and Company believed skippers would switch from residual bunker fuel (Heavy fuel oil) to marine gasoil. Marine gasoil requires greater amounts of crude oil to refine than residual bunker fuel. This increase in demand for gasoil will pressure the price of global crude oil (Billing et al., 2022).

Oil is said to have a fairly low elasticity of demand, which means that oil demand does not heavily change when the price for it changes. The global economy has for a long time been very dependent on this resource, and with increased international transportation of goods and people, demand for oil has remained stable, despite surging prices at times. As Brancaccio et al. discuss in their paper on the impact of oil on world trade, "as fuel costs decline, trade becomes less responsive to further decline in fuel costs", indicating that trade remains relatively stable considering the change in price (Brancaccio et al., 2021). For naval transportation, that means demand does not necessarily depend on the price of oil, but rather on the world economy.

Furthermore, one can use the prices of airline tickets to explain the inelasticity of oil demand. Jet fuel (Jet A/A-1), refined from crude oil is a large contributor to the price of airline tickets, and although there are large increases in the prices of oil, people still travel, and people still purchase airline tickets on large scales during summer periods. Although plane ticket prices are very dependent on the price of oil, there are other factors such as hedging of oil and airline fuels that contribute to determining the price of airline tickets. Gayle & Lin suggest that correct hedging can contribute to either reducing the price of airline tickets or increasing the margins of airline companies (Gayle & Lin, 2020). This concept can be applied to the dry bulk ships too, such that shipowners can plan against future changes in oil price when stocking up on fuel.

The average sailing speed of ships and air speed of aircraft have gone down over the last decades leading to longer average travelling times of goods and people than ever (Vidal, 2010). The sailing speed of many cargo ships and tankers are now so low that the effect of the famous *bow bulb* is counterproductive as it is designed to give the ship a longer profile to allow for a higher economical speed. At lower speeds the bow bulb is counterproductive as the ideal pressure wave around the ship is no longer aligned to the hull length in the water line. Slowing down will regardless save fuel, but for new builds it would in many cases be beneficial to drop the bow bulb altogether, provided one decided never to need the increased speed again (which may not be realistic so shipbuilders will probably keep it).

Looking at airline travel there is a clear profit in slightly reducing the air speed as fuel consumption is dramatically lowered. Subsequently, most airline flights today take a longer time today than they did several decades ago (McGuire, 2019).

2.6 Greenflation

With the transition to green energy, a type of inflation called greenflation is causing an increase in the prices of materials used in green and environmentally friendly products. Most green technologies use different minerals than non-green technologies. Minerals like copper, cobalt, and lithium have experienced a significant positive demand shock, leading to increased prices. Off-shore wind farms use seven times more copper than conventional land-based gas plants, and electric vehicles use six times more minerals than non-electric vehicles (Schnabel, 2022).

Demand increases as supply is constrained for these minerals, causing increased prices, which is greenflation. The price of lithium has risen by over 1000% since January 2020. Lithium is used in lithium-ion batteries, which is the most common battery type to be used in electric vehicles and ships. Demand for this metal will likely increase in the coming years as more cars and ships switch to lithium-ion batteries. Greenflation could therefore cause a permanent increase in fixed costs through ship construction. Aida Cruises for example has ordered a battery pack with a capacity of 10 MWh to supply electrical energy for cabins, kitchens, shops, and entertainment facilities (Randall, 2019). This allows for the main fossil fuel propulsion system to run at a reduced rate and improves the ship's efficiency.

It is debated, however, how much of a real impact greenflation has on a long-term scale, with Isabel Schnabel (2022), who is a member of the executive board of the European Central Bank arguing the effect is only subtle.

3. Research Question

The determinants of freight rates are remarkably interesting to understand, and there have been done numerous studies to research this topic. What we want to examine, however, is how environmental regulation and laws affect these rates.

Our research question, therefore, becomes, "*What is the effect of governmental and organisational environmental policy stringency on dry bulk freight rates?"*.

There exist research articles on how shipping is a large contributor to carbon emissions, but we could not find many research articles on quantifying the effects of EPS and how environmental policy affects the prices of shipping. This is one of the reasons why we want to conduct this research. We did however find relevant research that will be explained more carefully in the literature review.

The topic of research was chosen by us due to our desire to gain more knowledge on the global maritime industry and its challenges concerning climate regulation. The field of shipping is highly relevant in today's macro environment, and thus, it creates motivation to be able to study and learn more about this topic while writing our thesis. The industry is driven by world demand for goods and supplies, while it serves the majority of the world population. Moreover, the shipping industry has been one of the main contributors to globalisation, by connecting world economies. This very structure increases the motivation to study the industry further from a macro perspective.

3.1 Expectations from our Regressions

We hypothesise that the effect of increased EPS will increase the prices of shipping raw materials and goods in the short-term. We believe this is due to a shock in the supply side of maritime transportation. The supply shocks will lead to increased prices in the supply of transportation as shipowners and shipbuilders must conduct research and development to comply with environmental regulations set by IMO and governments.

Our thoughts are based on the concepts of supply and demand. We believe there will be a negative shock to the supply side of the industry. This leads to a "bottleneck" and an increase in prices due to higher variable costs for shipowners caused by stricter environmental policy. As the "product" becomes more expensive to produce, it is fair to assume that this will transfer over to the consumer. Additionally, the study completed by Karavaytsev and Turkin (2020) uncovered that the IMO 2020 regulation seemingly increased the price in the short-term, before it declined, only providing effects in the short-term, and none in the long-term. However, this is not entirely valid as the news of this regulation was released more than ten years before implementation, and the rise of the COVID-19 pandemic had large effects on world supply and demand. Another major disruption to the industry happened in March 2021, as the container ship "*Ever Given"* got stuck and blocked the Suez Canal for six days, causing an enormous bottleneck effect.

In the long run, we expect the market to adapt to the new regulations, and that the prices will go back down to pre-regulation changes. We believe that the market will account for the price of the change in regulation, with the reason being that eventually, the market must adapt to changes in regulation to continue as normal. There could be a persistent effect on prices due to greenflation, but as mentioned previously this effect is believed to be subtle.

4. Literature review

As this thesis analyses how freight rates change with a set of binding regulations, the literature review examines mostly the determinants of freight rates. This section will shortly and concisely examine earlier and recent research on determinants of shipping prices, and how the industry previously has reacted to changes.

When thinking about transportation rates, one would assume that method of transportation, and the distance travelled is key to determining the price.
As Micco & Perez stated in 2002:

> *"The obvious and most studied determinant of transport cost is geography, particularly distance. The greater the distance between two markets, the higher the expected transport cost for their trade.* (Page 4)"

This notion is supported by the widely academically cited *Gravity Equation*, used in a paper by Bergstrand (1985). That paper explains how the coefficient for distance in the basic gravity equation has a negative sign, meaning that an increase in distance increases the price.

More recent studies by Micco & Pérez in "Determinants of Maritime Transport Costs", agrees with the traditional view that the distance travelled by vessels is a leading factor in the price (Micco & Pérez, 2002). However, the pair suggests that there are more factors to freight rates than just distance. They analyse how port efficiency and environmental factors in South America affect freight rates and find that by improving port efficiency, shipping costs can be reduced by up to 12%, which equates to 8000km in distance for an average ship. The same goes for the location of the port. Another variable that affects the shipping prices in that article is the level of competition-based regulation from the government. Some regulation is found to be more effective, like reducing monopoly power or incentivizing competition, although too much regulation can be damaging.

Along with Micco & Perez, Wilmsmeier & Hoffman (2008) also agrees that distance travelled affects freight rates through variable costs. However, factors such as the infrastructure and connectivity in the ports also play a role in determining the freight rates, and more than the distance travelled in this study. Another highly significant variable in determining rates in this study was the number of shipping companies providing direct service between routes, which in this paper's case was intra-Caribbean routes. The more companies that operate equates to a lower price. This confirms the simple notion of supply and demand, and when there is an influx of supply, prices go down. These papers only research South America and intra-Caribbean trade routes, and thereby raises the question of whether these findings can be applied to global freight routes and rates. Although the results come only from those areas, we believe the logic and reasoning are sound and valid. Infrastructure and connectivity will affect efficiency and therefore costs.

Bustgaard & Snekkenes' thesis from (2021) discusses that shipowners are likely to change strategy to navigate around rules and regulations. Such that scrubber vessels are likely to sail faster than non-scrubber vessels to make up for lost time at the dock after the IMO 2020 regulation came into effect. This thesis discusses that shipowners are likely to strategically manoeuvre around rules and regulations to increase profits.

Michail and Melas (2021) discuss risks around shipping companies and decision making in the industry. They focus on the future expectations of the shipowners on the supply-side and how this affects the price of shipping.
The authors discuss how sentiment or market expectations has a significant

impact on the supply of vessels, utilising both newly built ships and vessels in the dock. They agree with the consensus that according to economic theory, there is a positive relationship between supply and price, and a negative relationship between demand and prices. The pair criticise themselves for their usage of data, and the lack of data on the demand side of the industry (Michail and Melas, 2021).

Although the literature quantifying the effects of environmental regulations on dry bulk freight rates is relatively thin, we have managed to collect a variety of studies related to the main factors behind freight rates through fixed and varied cost channels.

5. Description of Data

This section aims to present the different sources of statistical data we have utilized in our analysis. We make use of data on Baltic Dry Index vessels in combination with green exchange-traded funds (ETF) to study the effect of environmental policy changes on freight rates.

The data is collected mainly through Bloomberg markets terminals and to some extent through the supplier of the data's website.

5.1 Baltic Dry Index

The Baltic Dry Index (BDI) measures the demand for transportation versus the supply of carriers. We apply the index as a proxy for dry bulk freight rates due to its widespread usage by global organisations and investors. We believe this is a sufficient and fair measure of global dry bulk shipping prices due to the market share covered by BDI Vessels. The index is a composite of the ship's sizes, namely Capesize, Panamax, and Supramax time-charter averages, and is a leading indicator of global demand for commodities and raw materials (BalticExchange, 2022).

During times of growth and high demand for raw materials and commodities, the BDI increases, and the opposite is when demand decreases and the markets contract. A positive supply shock will cause the BDI to decrease, and vice versa with a negative supply shock. This simple mechanism helps us describe the general freight rates through supply and demand. The data is extracted from Bloomberg markets.

Figure 1 illustrates the Index from its introduction until today. After ca. 2003, the index seems to have become, and remain much more volatile than before 2003. This is likely due to the oil price also becoming, and remaining much more volatile after 2003, as illustrated in Figure 1.

5.2 iShares Global Clean Energy ETF (ICLN)

To proxy the changes in environmental policy, we use the iShares' *Global Clean Energy* fund (hereafter GCE), which is a green ETF comprised of green energy companies and some emerging market funds and securities. The fund was created in 2008 and has roughly 70 companies in the green energy sector in North America, Europe, and Asia, thereby making the fund well diversified. We use this fund to obtain a proxy to EPS, and the data is downloaded from iShares' website. Figure 3 is an illustration of the GCE fund and the S&P500 stock market index.

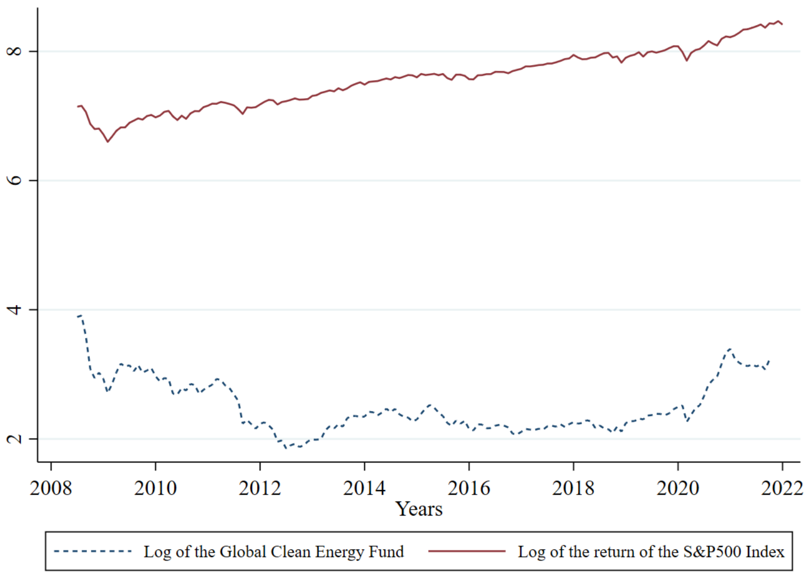

Figure 3 (Bloomberg L.P., n.d.c) & (BlackRock, Inc, 2021)

Table 2. shows the top 10 largest holdings of the GCE fund, with Enphase Energy Inc being the most heavily weighted company as of 2021. Two noticeable names on this list are those in the Information Technology sector. Enphase Energy Inc. helps users of solar panels to safely make, use, save, sell, and own their energy.

The organisation aims to replace fossil fuels all together through an intelligent microchip device (Enphase, 2022). SolarEdge technologies Inc. provide solutions that optimise power harvesting and storage, while reducing the cost of energy (SolarEdge, 2022). Beyond these, the list is dominated by firms in the utilities sector, meaning firms that operates with providing basic amenities, such as electricity in this list.

Name	Sector	Weight (%)	Location	Exchange
Enphase Energy Inc	Information Technology	9,61	United States	NASDAQ
Vestas Wind Systems A/S	Industrials	6,64	Denmark	Omx Nordic Exchange Copenhagen A/S
Plug Power Inc	Industrials	6,30	United States	NASDAQ
SolarEdge Technologies Inc	Information Technology	5,61	United States	NASDAQ
Consolidated Edison Inc	Utilities	5,29	United States	NYSE
Ørsted A/S	Utilities	5,22	Denmark	Omx Nordic Exchange Copenhagen A/S
Iberdrola SA	Utilities	3,87	Spain	Bolsa De Madrid
EDP Energias de Portugal SA	Utilities	3,55	Portugal	Nyse Euronext - Euronext Lisbon
Sunrun Inc	Industrials	3,48	United States	NASDAQ
SSE PLC	Utilities	3,40	United Kingdom	London Stock Exchange

Table 1 - MSCI Global Clean Energy Fund Top 10 Holdings 2022 (BlackRock, Inc, 2021)

5.3 Invesco MSCI Sustainable Future ETF (ERTH)

As an alternative proxy, we use the *Sustainable Future* fund (hereafter SF), which is an ETF from the American investment company Invesco. The fund is based on the MSCI Global Environment Select Index, and 90% of the fund is invested in this index. The fund is comprised of companies that contribute positively to environmental and social aspects through offering products and services that use green technology or power with efficient use of resources. The fund was created in 2006, and is well diversified with companies from America, Europe, and Asia. Companies included in the fund are also in many industries, like commodities, real estate, energy, IT, and utilities.

We include this fund as robustness to our iShares GCE ETF. In the econometric models, we will repeat the regressions where we use the GCE fund with the SF fund. This gives a higher degree of certainty and gives us more confidence that the results are valid. The ticker symbol of the fund is ERTH.

Figure 4 shows the SF fund up against the S&P500 stock market index.

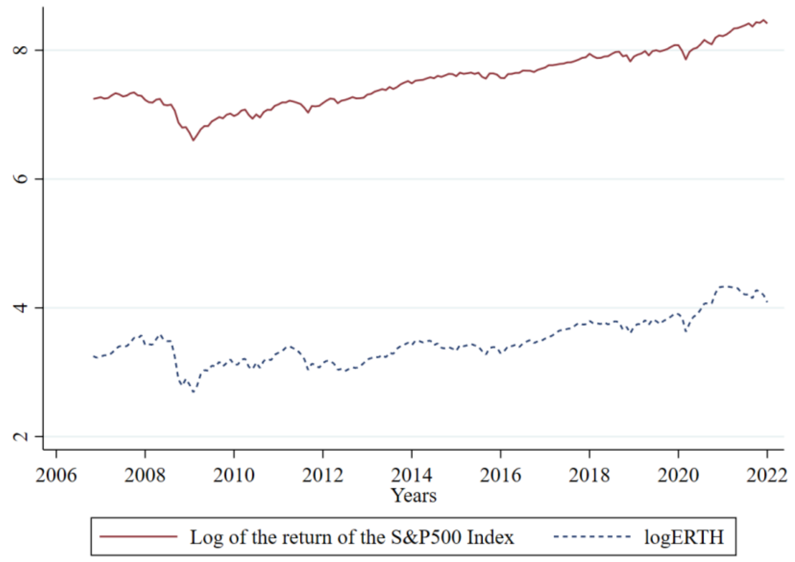

Figure 4 (Bloomberg L.P., n.d.d.) (Invesco Ltd, 2022)

Table 3 shows the top 10 largest holdings of the SF fund, with Digital Realty Trust Inc being the most heavily weighted company as of 2022. Again, there are organisations in the Information Technology sectors that dominates the top spots. Digital Realty Trust inc. is an investment trust supporting data centres and colocation with focus on cloud and IT services in various sectors. The incorporation issues green bonds in the data centre industry (DigitalReality, 2022). In addition to these, the list is dominated by firms in the industrials sector with focus on more environmentally friendly solutions, such as electrical cars.

Name	Sector	Weight %	Location	Exchange
Digital Realty Trust Inc	Information Technology	5,49	United States	NYSE
Vestas Wind Systems A/S	Industrials	4,76	Denmark	NASDAQ Copenhagen
Enphase Energy Inc	Information Technology	4,69	United States	NASDAQ
Central Japan Railway Co	Industrials	4,07	Japan	Tokyo Stock Exchange
Tesla Inc	Industrials	4,05	United States	NASDAQ
NIO Inc	Industrials	3,62	China	NYSE
SolarEdge Technologies Inc	Information Technology	2,93	Israel	NASDAQ
Li Auto Inc	Industrials	2,90	China	NASDAQ
Darling Ingredients Inc	Agriculture	2,75	United States	NYSE
Kingspan Group PLC	Construction	2,65	Ireland	London Stock Exchange

Table 2 - Invesco Sustainable Future Fund Top 10 Holdings 2022 (Invesco Ltd, 2022)

5.4 WTI Crude Oil Price (West Texas Intermediate)

We use the WTI (West Texas Intermediate) crude oil price as a proxy for world oil price due to its close correlation with Brent and OPEC prices (Robiyanto, 2018). We do this confidently as numerous studies and researchers have done the same. Table 4 is a correlation matrix between WTI, North Sea Brent, and OPEC oil prices.

		WTI	OPEC	BRENT
WTI	Pearson Correlation	1	0.921**	0.747**
	Sig. (2-tailed)		0.000	0.000
	N	153	153	153
OPEC	Pearson Correlation	0.921**	1	0.794**
	Sig. (2-tailed)	0.000		0.000
	N	153	153	153
BRENT	Pearson Correlation	0.747**	0.794**	1
	Sig. (2-tailed)	0.000	0.000	
	N	153	153	153

**. Correlation is significant at the 0.01 level (2-tailed).

Source: https://www.eia.gov/ and http://www.opec.org/basket/basketDayArchives.xml, processed

Table 3 - Oil price correlation matrix. From "The Dynamic Correlation between ASEAN-5 Stock Markets and World Oil Prices", by Robiyanto, 2018 , Jurnal Keuangan dan Perbankan, 22, p. 201. (https://doi.org/10.26905/jkdp.v22i2.1688). CC License.

We include monthly growth in global oil price as a control in our regression on the Baltic Dry Index. This is done when a variable could heavily influence the results of a regression if it is not included in the regression as a control variable. Oil price will affect the Baltic Dry Index because it determines one of the largest variable costs of shipping. It also correlates with our green ETFs because news of oil prices will affect ESG firms. We, therefore, include it as a control to examine the relationship between the dependent (BDI) and independent (green ETFs) variables.

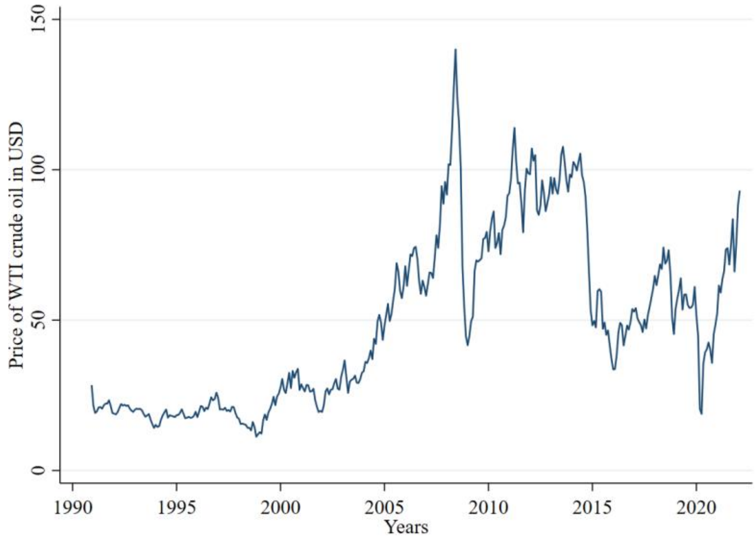

Figure 5 - West Texas Intermediate Crude Oil Price in USD

Figure 5 shows the historical oil price from 1990 to 2022. The price is much more volatile after 2003 compared to earlier periods.

6. Research Methodology

The method which is used in this paper to analyse dynamic effects through impulse responses is called *Local Projection* (Jordà, 2005).

6.1 Using ESG ETFs as a Proxy for Environmental Policy Stringency

The measurement of EPS is complex and ambiguous, especially on a worldwide scale. Policy implementation is different and diverse across countries, sectors, and environmental issues (GGKP, 2015). Therefore, in academic literature and environmental reports, it is normal to use external instruments and indicators as proxies. For example, The Green Growth Knowledge Platform (GGKP) in partnership with UNEP, OECD, and The World Bank used nine different indicators to proxy the measurement of environmental action and policy stringency in developed and developing countries. Some of the indicators were private abatement expenditures, measures of international environmental cooperation, environmental performance indicators, and aggregate indices of policy response and impact measures.

Other recent academic literature that analyses the measurement of EPS uses proxies in the form of pollution abatement and control expenditures (PACE) (Rubashkina et al., 2015). Brunel & Levinson (2013) propose an index that surveys how regulated firms emit less compared to the industry standard. The idea is that where actual emissions exceed predicted emissions, environment stringency is less than average, and vice versa. Nesta, Vona & Nicolli (2014) use product market regulation (PMR) and a renewable energy policy (REP) index to measure EPS. The REP is based on a dataset by the International Energy Agency and provides information about OECD countries' renewable energy policies. The latter is similar to our approach using environmentally focused exchange-traded funds, particularly since one of our two ETFs contains only green energy companies.

We use green ETFs where only firms with excellent ratings where environmental, social, and governance factors are included. These funds are also denoted socially responsible investment (SRI) funds and include companies that focus on sustainable solutions, positive ripple effects on communities, employee well-being, business ethics, transparency, and low polluting records. These funds also exclude companies that invest in nuclear power, weapons, alcohol, tobacco, genetically modified organisms (GMO), and adult entertainment. Therefore, all companies that contribute to a negative social impact in any way are excluded.

Companies included are therefore considered to be green, and a viable choice for an environmentally and socially conscious investor. As Serafeim & Yoon (2022) mentioned in their findings on ESG news; the market reacts positively to positive ESG news and negatively to negative ESG news from individual companies. In other words, they found that ESG ratings proxy market expectations and stock returns.

By economic intuition, one can presume that if a government imposes a regulation or law that inflicts negatively on companies with low ESG scores, the companies with higher scores will be perceived as relatively more favourable. The stock price of companies with higher regard for ESG will then increase. This will in turn make the indices with only green companies increase. By this logic, when new environmental regulation (e.g., a higher tax on carbon emissions) is passed, the index funds with green companies will increase, thereby making green ETFs our proxy for environmental policy change.

Our paper, therefore, builds upon Eugene Fama's (1970) hypothesis that the capital markets are efficient, meaning that prices in the market "fully reflect" all available information. Prices will then react positively to positive news and vice versa, as mentioned above.

Although the focus on ESG is relatively new in the shipping industry, it is becoming increasingly more important, as stakeholders demand stricter ESG monitoring and reporting requirements (PwC, 2020). These requirements include better welfare and wellbeing of crew, stricter health & safety standards, reduced environmental pollution levels and a better protection of marine ecosystems. It is natural to presume that those ESG requirements are contributing to higher operating costs for the shipping companies. This notion correlates with our hypothesis that stricter regulation increases shipping rates, thereby further justifying our use of ESG funds as proxies for environmental policy.

6.2 Model

The econometric methodology will be divided into two steps. First, we will regress the monthly return of the ETFs on the stock market index. We do this to control for systematic movements in the stock market. These systematic movements, among other things, are reflectors of global demand. The ETFs we use are as previously mentioned the iShares *Global Clean Energy* fund and *Sustainable Future* fund by Invesco. For the market index, we use the *Standard & Poor's 500 index*. Second, we regress the shipping prices on the residuals from the first regression, while controlling for oil-price growth. We do this because as stated in section 2.5, the oil price directly affects shipping rates through variable costs. Furthermore, higher oil prices and climate change also increase the demand for green energy. Third, we estimate local projections based on the second regression with different lag lengths.

6.2.1 Green ETFs Regressed on Stock Market Index

All variables are logged, and we create monthly growth (log-differenced) variables of these.This transformation of the data was repeated for all the series used in the first analysis.
We first estimate the following model by ordinary least squares (OLS).

Equation (2)

$$r_t^{Green\ stocks} = \alpha + \beta r_t^M + \varepsilon_t,$$

Where t denotes month, β denotes the stock market beta of our green ETF, and $r_t^m$is the return of the S&P500 stock market index. The residual/idiosyncratic return we are after will be the ε.

To obtain our residuals, we regress the return of our green ETFs on the return of the market index (S&P500), and the estimated effects are shown in table 5

Return of the Green ETFs Regressed on the Return of the stock market index

	(1)	(2)
ETF Variant	Global Clean Energy Fund	Sustainable Future Fund
Coefficient	1.540***	1.342***
	(0.113)	(0.057)
Constant	-0.017***	-0.004
	(0.005)	(0.003)
Observations	160	183
R-squared	0.539	0.753
Controlled for oil price	YES	YES

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4 - Log-differenced return from green ETFs regressed on log-differenced return from market index

The first (1) regression shows a β coefficient of 1.54 and indicates that our green ETF has a market $\beta > 1$, and it is significant with a P-value under 0.01. This means that if the market index increases by 1%, the fund increases by more than one percent. The second regression (2) has a slightly lower β coefficient of 1.342 and a lower standard error. This ETF is also statistically significant, as the P-value is less than 0.01.

We then predict the residuals of these regressions.

6.2.2 Baltic Dry Index Regressed on Residuals from Green ETFs

We next regress the Baltic Dry index on the residuals from equation (1). The following model is used.

Equation (3)

$$\ln p^S_{t+h} - \ln p^S_{t-1} = \alpha_h + \gamma_h \varepsilon_t + \delta x_t + u_{t,h},$$

For $h = 0,1,2, \dots 24$. $\ln p$ is the logged Baltic Dry Index. When $h = 0$, $\ln p^S_t - \ln p^S_{t-1}$ = monthly price growth. For $h = 1$, $\ln p^S_{t+1} - \ln p^S_{t-1}$ = two-month price growth. For $h = 5$, $\ln p^S_{t+5} - \ln p^S_{t-1}$ = six-month price growth, and $h = 11$ equals the 12-month price growth. The controls in x_t strengthen the causal interpretation of the γ coefficients. x_t is the one-month oil price changes, where we use WTI (West Texas Intermediate) as our world oil price.

Equation 2 is an impulse response function (IRF) that we will estimate using the method of local projection (Jordà, 2005). Table 6 shows the estimated effect for $h = 5$.

Six-Month Growth of Baltic Dry Index Regressed on Residuals of Green ETFs

	(1)	(2)
Residuals from ETF Variant	Global Clean Energy Fund	Sustainable Future Fund
Coefficient	2.056***	2.902*
	(0.777)	(1.548)
Constant	0.001	-0.016
	(0.050)	(0.050)
Observations	158	178
R-squared	0.057	0.0249
Controlled for oil price	YES	YES

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5 - Jordà regression for horizon $h = 5$

Used here is a six-month price growth in the Baltic Dry Index. The first (1) regression on the residuals from the GCE ETF gives a magnitude of the coefficient of 2.056 and has a standard error of 0.777. This could indicate a significant positive relationship between the Baltic Dry index and the Clean Energy ETF. The monthly price growth of oil is also included for robustness. Furthermore, the t-statistic of the residuals is 2.65 which indicates that the coefficient of the residuals is significant at the 95% confidence level. In addition to this, the P-value is 0.009 which indicates significance at the 99% level.

For the sake of robustness, we repeated the process, using the SF ETF and obtained relatively similar results in the second regression (2). It has a higher coefficient of 2.902, but also a higher standard error of 1.548, and a P-value of less than 0.1. As with the previous regression, the SF fund also shows a positive correlation with the Baltic Dry Index.

6.2.3 Local Projections

With a local projection, we estimate impulse responses by a sequence of projections of the dependent variable that in turn is shifted forward onto its respective lags. Projections are local to each forecast and more robust to misspecification of the unknown data generating process (DGP) (Jordà, 2005).

Because of this, local projection is preferable to Vector Autoregression (VAR) when the object of interest is to calculate impulse responses. Also, local projections are more robust to misspecifications and can accommodate experimentation with strongly nonlinear and flexible specifications that can be impractical in a multivariate context. We estimate the local projections with and without controlling for oil-price growth, with different lags on both the variables and the main regressor itself.

6.2.4 Newey-West Standard Errors

In the model, we use Newey-West standard errors. This is a method of producing standard errors for coefficients estimated by OLS. The Newey-West standard errors are used in our model because they correct for autocorrelation (serial correlation) and heteroskedasticity in the error terms.

7. Results

Our empirical results are twofold: (1) We find a significant *positive* effect of environmental policy stringency proxied via the idiosyncratic returns of green ETFs on shipping prices. (2) Environmental policy stringency has a more *persistent* effect on shipping prices than what our initial hypothesis anticipated.

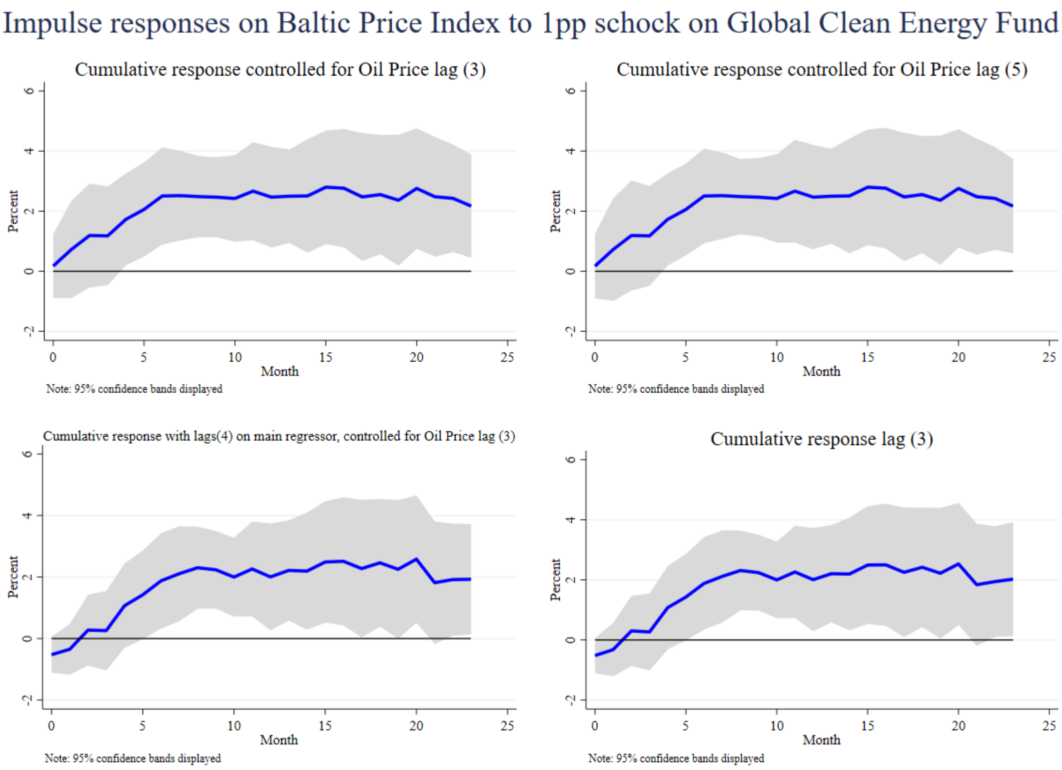

Figure 6 - Local Projections Global Clean Energy Fund.

Figure 6 illustrates the effect of a shock to EPS on dry bulk shipping prices, using the GCE fund as a proxy. The different graphs represent different parameters for which the IRFs were estimated. The first graph shows the cumulative response of the BDI where oil-price growth is controlled for, with a lag length of three. The second graph shows the cumulative response of the BDI where oil-price growth is controlled for, with a lag length of five. The third graph shows the cumulative response of the BDI with four lags on the main regressor, with control for oil-price growth and a lag length of three. The fourth graph shows the cumulative response of the BDI without controlling for oil-price growth with a lag length of three. Despite the different specifications, our results all give a clear indication of an obvious and noticeable positive shock on shipping prices when EPS increases. The x-axis shows our horizon in months, which is 24 (two years), the y-axis shows effect in percentage points and the grey area represents the 95% confidence band. The local projection with lags on the main regressor and controlled for oil-price growth, and the one without controlling for oil-price growth seems to have an immediate negative effect. The immediate effect is rather negligible, however, after six months, the effect is significant and robust. The shock seems to be rather stable from six to 24 months. Apart from this initial negative effect, all graphs display the same results, namely that there is a *positive* and *persistent* effect on the shipping prices.

All the graphs show a rather slow build-up of the effect on shipping rates. This could indicate sticky prices, which is the resistance of market prices to quickly change in the event of an economic shock.

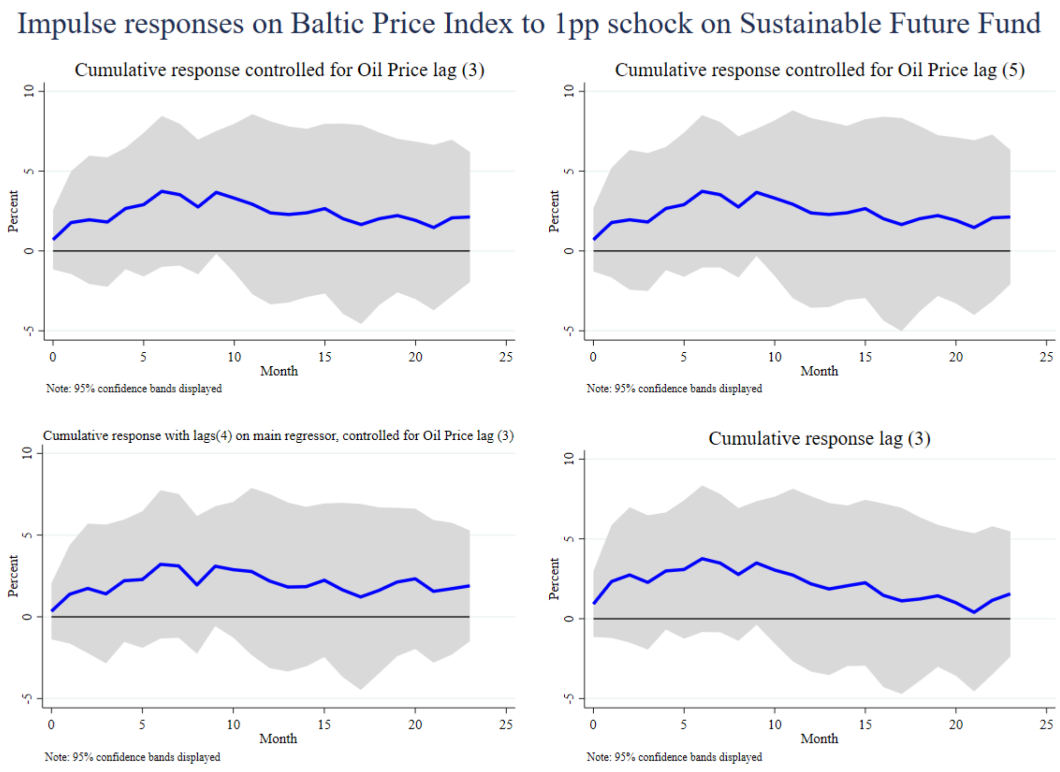

Figure 7 - Local Projections Sustainable Future Fund.

Figure 7 illustrates the same graphs and specifications as figure 6, with the only difference being that the SF fund is used. Figure 7 shows comparable results as figure 6, albeit with a slightly less permanent effect. The shock seems to react more quickly than in the previous figure, with some positive immediate effects. Despite this, there seems to also be some element of price stickiness. The slight convexity of the response to the BDI implies that the shocks seem to dampen out and converge towards the starting point. The prices never really converge fully back to the starting point, but the fourth graph without controlling for oil-price growth and a lag length of three comes close to it.

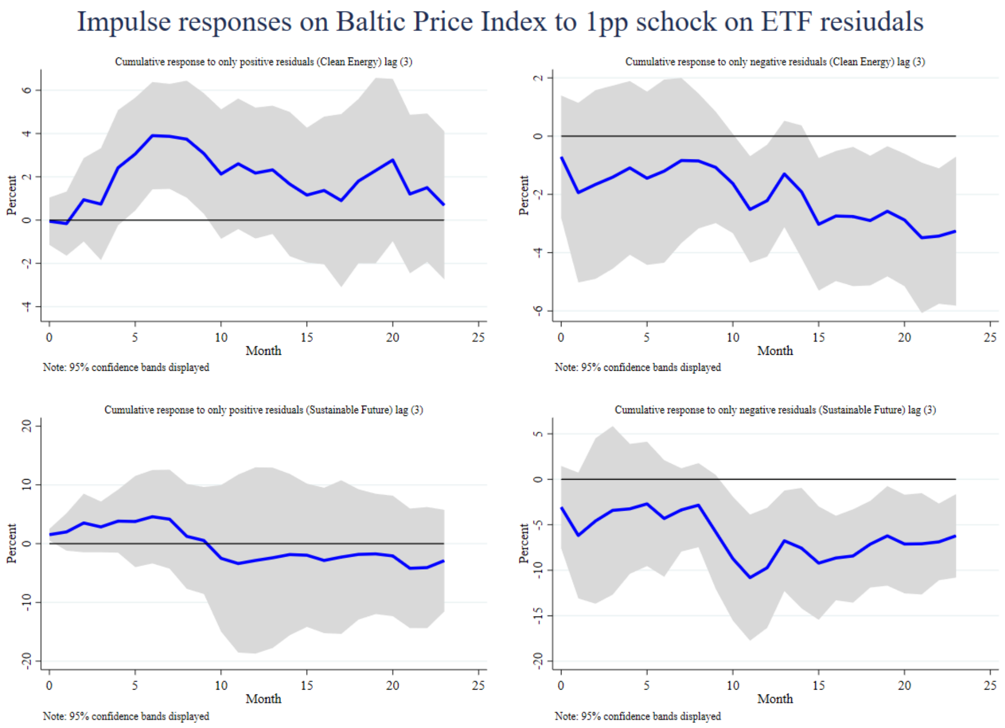

Figure 8 - Local Projections to both ETFs, only positive and negative residuals.

Figure 8 shows the cumulative response to the BDI where we control for oil-price growth with a lag length of three, but with shocks to only the positive and negative residuals from the regression with the return of green ETFs on the return of the stock market index ETF. These effects vary, but they support the results from figures 6 & 7, this time with a shock to positive residuals reacting positively (higher shipping prices), and a shock to negative residuals reacting negatively (lower shipping prices). These IRFs however are significantly more unstable and less robust, as the graphs seem to be more volatile. The first graph shows a shock to the positive residuals on the GCE fund and has little immediate effect but remains positive and volatile for a permanent period. The second graph shows a shock to the negative residuals of the GCE fund and has a slightly immediate negative effect and remains negative and volatile. The third graph shows a shock to the positive residuals from the SF fund, and starts slightly positive, but the falls beneath the starting point and remains negative. The fourth graph shows a shock to the negative residuals of the SF fund, and has an immediate negative effect, which fluctuates, but remains negative across all 24 horizons.

Graph number two and four have had the y-axis inverted in order to illustrate and reflect the negative shocks. Both negative shocks remain negative, but the shock to the SF fund has a greater effect when looking at the values of the y-axis, with the price of shipping falling by 10 percentage points at most, compared with falling four percentage points.

7.1 Discussion

Our empirical results were surprisingly stronger and more persistent than what we anticipated before doing the analysis. Our previous expectations were largely based on the outcome of the IMO 2020 regulation. That regulation had an immediate and small positive effect on the shipping prices, but no lasting permanent change. On the contrary, after a few months, prices fell below the starting point of January 1st, 2020. This may have been caused by unstable and deteriorating economic markets due to the COVID-19 pandemic, according to researchers. Our results, however, include data from a period of 16 years (2006-2022), and therefore supply more information than just the IMO 2020 regulation.

There is an economic intuition behind our results that we believe are credible. The stricter environmental policy entails increased variable costs through increased fees and taxes on maritime fuel. They also mean that crew costs will increase, as improvements in health and safety (HSE) could mean the crew cannot work the long hours they do now, and transporters may have to employ more crew to satisfy these conditions. In the long run crew members may fall as a result of automation and/or changes to work practises – however, in the short term more stringent HSE regulations means more crew and/or more frequent replacements (turnarounds). That will increase personnel cost as crew changes generally means expensive international flights. Furthermore, shipowners will take EPS into account, and invest more in more efficient and sustainable ships, with the increased fixed costs that come with this. In the future, when ships are due for scrapping, there will also likely be an increased cost affiliated with this for scrappers to comply with human rights for their workers. All these factors combined, result in increased variable and fixed costs for the shipowners, which in turn results in increased prices for transportation by sea.

Greenflation could also be a contributing factor to our results, mainly as they are far more persistent than we anticipated. As we discussed in section 2.6, increased demand for certain products and minerals while supply lags behind as new mines take several years to open can cause a permanent increase in prices. This would in future terms lead to increased fixed costs when constructing ships. Although intuitive, this is speculative and lacks empirical evidence on our behalf.

Of our two funds, we also want to emphasise that we are more interested in the results from figure 6, where the GCE fund was used. We believe the return of this fund is the better proxy for EPS of the two funds. This is due to the holdings in the fund, which has a focus on only green energy industry, whereas the SF fund is exposed to many industries, albeit still with a green focus.

Although we interchangeably use shipping prices and dry bulk shipping prices, we think the same mechanics and affected channels are influenced by EPS in other seafaring shipping sectors too. Our results only use data on prices in dry bulk shipping, but the channels through which EPS affects these prices in the dry bulk sector will be the same in the liquid bulk sector or container shipping sector. Those industries will experience the same increase in variable costs through fuel and crew, as well as increased fixed costs that comes through more expensive shipbuilding and scrapping.

The results may have some limitations, however. Despite controlling for global demand via S&P500 and oil prices, there could be omitted variables that affect both the BDI and the residuals. We cannot rule out that omitted variables such as inflation, unemployment or housing prices could affect global supply or demand, and thereby the BDI or our residuals. Our interpretations are therefore with the caveat that such omitted factors are secondary.

8. Conclusion

Studies with a traditional view have shown that shipping costs are heavily influenced by distance traversed, and more recent studies show that the costs are influenced also by more indirect factors, such as port efficiency, supply, demand, competition, and business/shipping cycles. Our paper supplements these more recent studies, where we found empirical evidence that suggests that environmental policy stringency (EPS) also influences the price of dry bulk shipping positively.

To our knowledge, this is the first paper to implement sustainable and green exchange-traded funds (ETF) as a proxy for measuring EPS, and then analysing how shipping prices are affected by it by using the method of local projection.

Our results indicate a positive correlation between EPS proxied by the returns on green stock portfolios and dry bulk shipping prices. A stricter policy implemented by governments and organisations causes permanently increased shipping prices, and a lenient policy implemented by governments and organisations causes a permanent decrease in shipping prices.

The channels through which dry bulk rates are affected by EPS are mainly variable costs through increased fuel costs and crew costs. We believe fixed costs also are affected long-term through more expensive shipbuilding costs, as well as increased costs affiliated with the scrapping of the ships.

9. References

Amazon. (2022). Delivering Shipment Zero. Sustainability - US. Retrieved 17 February 2022, from https://sustainability.aboutamazon.com/environment/sustainable-operations/shipment-zero.

Baltic Exchange. (2022). *Dry*. Baltic Exchange Consumer. Retrieved 4 February 2022, from https://www.balticexchange.com/en/data-services/market-information0/dry-services.html.

Bergstrand, J.H. (1985). The Gravity Equation In International Trade: Some Microeconomic Foundations And Empirical Evidence. *The Review of Economics and Statistics, 67*(3), p. 474-81. https://doi.org/10.2307/1925976

Billing, E., Fitzgibbon, T., & Shankar, A. (2022). *IMO 2020 and the outlook for marine fuels*. McKinsey.com. Retrieved 2 March 2022, from https://www.mckinsey.com/~/media/McKinsey/Industries/Oil%20and%20Gas/Our%20Insights/IMO%202020%20and%20the%20outlook%20for%20marine%20fuels/IMO-2020-and-the-outlook-for-marine-fuels.pdf.

BlackRock, Inc. (2021). [BlackRock iShares' Global Clean Energy ETF monthly data 2008Q2 – 2021Q4 in USD] [data set]. Retrieved November 15, 2021, from https://www.ishares.com/us/products/239738/ishares-global-clean-energy-etf

Bloomberg L.P. (n.d.a) [BalticExchange Baltic Dry Index monthly data 1985Q1 – 2022Q1 in USD] [data set]. Retrieved January 15, 2022, from BI Norwegian Business School Bloomberg Terminal.

Bloomberg L.P. (n.d.b) [MSCI KLD400 Index monthly data 1990Q2 – 2022Q1 in USD] [data set]. Retrieved January 15, 2022, from BI Norwegian Business School Bloomberg Terminal.

Bloomberg L.P. (n.d.c) [Standard & Poor's 500 S&P500 Index monthly data 1988Q4 – 2022Q1 in USD] [data set]. Retrieved January 15, 2022, from BI Norwegian Business School Bloomberg Terminal.

Bloomberg L.P. (n.d.d) [Invesco MSCI Sustainable Future ETF monthly data 2006Q4 – 2022Q1 in USD] [data set]. Retrieved March 30, 2022, from BI Norwegian Business School Bloomberg Terminal.

Brancaccio, G., Kalouptsidi, M. & Papageorgiou, T. (2021). *The Impact of Oil Prices on World Trade* (Boston College Working Papers in Economics 1030, Boston College department of Economics). https://ideas.repec.org/p/boc/bocoec/1030.html

Brunel, C. & Levinson, A. (2013). *Measuring Environmental Regulatory Stringency* (OECD Trade and Environment Working Papers No. 2013/05). https://doi.org/10.1787/5k41t69f6f6d-en

Bustgaard, M. & Snekkenes, M.E. (2021). *Has IMO 2020 changed bulk shipping?* [Master's thesis, Norwegian School of Economics]. NHH Brage. https://hdl.handle.net/11250/2774801.

DigitalReality. (2022). *Funding projects that benefit the environment.* www.DigitalReality.com. Retrieved 8 June 2022, from https://www.digitalrealty.com/about/sustainability/green-bond.

Enphase. (2022). *Discover our journey to global renewable energy leader | Enphase*. Enphase.com. Retrieved 8 June 2022, from https://enphase.com/about-us.

Fama, E. F. (1970). Efficient Capital Markets: A Review of Theory and Empirical Work. *The Journal of Finance*, *25*(2), page 383-423. https://doi.org/10.2307/2325486

Fritt-Rasmussen, J., Wegeberg, S., Gustavson, K., Sørheim, K., Daling, P., & Jørgensen, K. et al. (2018). Heavy Fuel Oil (HFO). *Temanord*. https://doi.org/10.6027/tn2018-549

Gayle, P., & Lin, Y. (2020). COST PASS-THROUGH IN COMMERCIAL AVIATION: THEORY AND EVIDENCE. *Economic Inquiry*, *59*(2), 803-828. https://doi.org/10.1111/ecin.12949.

GGKP. (2015). *MEASURING ENVIRONMENTAL ACTION AND ECONOMIC PERFORMANCE IN DEVELOPING COUNTRIES.* Green Growth Knowledge Platform. https://sustainabledevelopment.un.org/content/documents/2096GGKP_Trade_Measuring_Environmental_Action.pdf?fbclid=IwAR0hQtv26aWeen23SaYdn12YYkVqIPIAkSYTokziFhEU1x10kjSBhHjuYvw

Hawdon. (1978). Tanker freight rates in the short and long run. *Applied Economics*, *10*(3), 203–218. https://doi.org/10.1080/758527274.

ICS. (2022). *Shipping and World Trade: Global Supply and Demand for Seafarers*. Ics-shipping.org. Retrieved 13 March 2022, from https://www.ics-shipping.org/shipping-fact/shipping-and-world-trade-global-supply-and-demand-for-seafarers/.

IKEA. (2022). *Zero emission fuels for ocean shipping*. About.ikea.com. Retrieved 19 February 2022, from https://about.ikea.com/en/newsroom/2021/10/18/zero-emission-fuels-for-ocean-shipping.

IMO. (2020). *IMO 2020 – cutting Sulphur oxide emissions*. Imo.org. Retrieved 4 January 2022. https://www.imo.org/en/MediaCentre/HotTopics/Pages/Sulphur-2020.aspx

Invesco Ltd. (2022). *Invesco MSCI Sustainable Future ETF*. Invesco Ltd. https://www.invesco.com/us/financial-products/etfs/product-detail?audienceType=Investor&ticker=ERTH

iShares. (2022). *iShares Global Clean Energy ETF.* iShares.com. https://www.ishares.com/us/products/239738/ishares-global-clean-energy-etf

Jordà, Ò. (2005). Estimation and Inference of Impulse Responses by Local Projections. *American Economic Review*, *95*(1), 161-182. https://doi.org/10.1257/0002828053828518

Karavaytsev, A. & Turkin, B. (2020). *Assessing the impact of IMO 2020 on grains and oilseeds freight costs* (Article no. 51, Newsletter no. 86, Second quarter 2020). United Nations Conference on Trade and Development, Transport and Trade Facilitation Newsletter. https://unctad.org/news/assessing-impact-imo-2020-grains-and-oilseeds-freight-costs

Kavussanos, & Visvikis, I. D. (2013). *The International handbook of shipping finance: theory and practice* (pp. 39, 430). Palgrave Macmillan.

Kyriakides, H. (2022). *IMO 2020 APPROACHES 2021 – HAS THE SHIPPING INDUSTRY ADAPTED TO THE 0.5% SULPHUR CAP?*. Legal500. Retrieved 2 April 2022, from https://www.legal500.com/developments/thought-leadership/imo-2020-approaches-2021-has-the-shipping-industry-adapted-to-the-0-5-sulphur-cap/

McGuire, C. (2019). *Flights are longer now than they were in the 1990s because planes are flying more slowly*. TheSun.co.uk, retrieved 13 June 2022, from https://www.thesun.co.uk/travel/6247384/flights-longer-now-plane-slower/

Micco, A. & Pérez, N. (2002). Determinants of Maritime Transport Costs. *IDB Working Paper*, *371*, pages N/A. http://dx.doi.org/10.2139/ssrn.1817241

Michail, N. and Melas, K., (2021). Sentiment-Augmented Supply and Demand Equations for the Dry Bulk Shipping Market. *Economies*, *9*(4), p.171.

Miller, G. (2021). *What is the shipping cycle – and can it ever be tamed?*. American Shipper. Retrieved 21. March 2022, from https://www.freightwaves.com/news/what-is-the-shipping-cycle-and-can-it-ever-be-tamed?fbclid=IwAR3go2ZD7b10kXG4JAVhZZ2d86koQTA9eWUUZGkV13c4bXMpSUgyHXvUi-A.

Miller, G. (2022). *ESG 'green' push has ship owners seeing green(backs)*. FreightWaves. Retrieved 17. February 2022, from https://www.freightwaves.com/news/esg-green-push-has-ship-owners-seeing-greenbacks.

MSCI. (2022, January 14). *MSCI USA ESG Select Index*. MSCI. https://www.msci.com/our-solutions/indexes/usa-esg-select-index

Nesta, L., Vona F. & Nicolli, F. (2014). Environmental policies, competition and innovation in renewable energy. *Journal of Environmental Economics and Management*, *67*(3), pages 396–411. https://doi.org/10.1016/j.jeem.2014.01.001

Norwegian Maritime Authority. (2019). *Endring av forskrift om miljømessig sikkerhet for skip og flyttbare innretninger* [Amendments to the Regulations on environmental safety for ships and mobile offshore units] (RSR -2 - 2019) [Circular]. https://www.sdir.no/en/shipping/legislation/directives/amendments-to-the-regulations-on-environmental-safety-for-ships-and-mobile-offshore-units/

PwC. (2020, June 11th). *The importance of Environmental, Social and Governance (ESG) performance in accessing shipping finance - Insights from PwC Greece on the key steps for the shipping industry to start preparing for the future* [Press Release]. PwC Greece. https://www.pwc.com/gr/en/press-releases/assets/The%20increasing%20importance%20of%20ESG%20factors%20in%20shipping%20financing_%CE%95%CE%9D.pdf

Randall, C. (2019). *Aida plans to use battery systems on cruise ships.* Electrive.com. https://www.electrive.com/2019/08/21/aida-plans-to-use-battery-systems-on-cruise-ships/

Robiyanto, R. (2018). The Dynamic Correlation between ASEAN-5 Stock Markets and World Oil Prices. *Jurnal Keuangan dan Perbankan*, 22(2), Pages 198-210. https://doi.org/10.26905/jkdp.v22i2.1688

Rubashkina, Y., Galeotti, M. & Verdolini, E. (2015). Environmental regulation and competitiveness: Empirical evidence on the Porter Hypothesis from

European manufacturing sectors. Energy Policy, 83(N/A), pages 288-300. https://doi.org/10.1016/j.enpol.2015.02.014.

Schnabel, I. (2022). *A new age of energy inflation: climateflation, fossilflation and greenflation.* European Central Bank. https://www.ecb.europa.eu/press/key/date/2022/html/ecb.sp220317_2~dbb3582f0a.en.html

SDIR. (2022). *Scrapping of ships*. Sdir.no. Retrieved 22 May 2022, from https://www.sdir.no/en/shipping/vessels/environment/scrapping-of-ships/.

Serafeim, G. & Yoon, A. (2022). Stock price reactions to ESG news: the role of ESG ratings and disagreement. *Review of Accounting Studies*. https://doi.org/10.1007/s11142-022-09675-3

SolarEdge. (2022). *SolarEdge Fact Sheet.* Solaredge.com. Retrieved 8 June 2022, from https://www.solaredge.com/sites/default/files/se-fact-sheet.pdf.

Stopford, M. (2009). *Maritime Economics 3e* (3rd ed., pp. 93-240). Taylor & Francis Group.

Unilever. (2022). *Greener logistics – the world has a lot further to travel*. Unilever. Retrieved 24 May 2022, from https://www.unilever.com/news/news-search/2019/greener-logistics-the-world-has-a-lot-further-to-travel

Vidal, J. (2010). *Modern cargo ships slow to the speed of the sailing clippers.* TheGuardian.com. Retrieved 13 June 2022, from https://www.theguardian.com/environment/2010/jul/25/slow-ships-cut-greenhouse-emissions

Wang, W.W., Zhang, M., Zhou, M. (2011). Using LMDI method to analyze transport sector CO2 emissions in China. *Energy*, *36*(10), pages 5909-5915. https://doi.org/10.1016/j.energy.2011.08.031.

Wilmsmeier, G. & Hoffmann, J. (2008). Liner shipping connectivity and port infrastructure as determinants of freight rates in the Caribbean. *Maritime*

economics & logistics, *10*(1-2), pages 130–151. Palgrave.
https://doi.org/10.1057/PALGRAVE.MEL.9100195