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The Principal-Agent Problem in Finance: Performance Clauses in Shipping Charterparties

The misalignment of incentives for performance between shipowners and charterers regarding 'Good weather conditions' in time charter contracts

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Abstract

This study investigates how definitions of ‘Good weather conditions’ influence speed and fuel consumption claims in dry bulk shipping time charter contracts. Using observed weather data, we simulate various definitions to model the relationship between ‘Good weather conditions’ and the expected number of good weather days. We examine the four key parameters defining a ‘Good weather day’ through a random forest model and assess the financial implications of varying these definitions through a case study.

The analysis shows that charterparties tend to define the threshold for what is considered ‘Good weather conditions’ too strict in relation to the intended threshold for weather so heavy that the warranted vessel speed and fuel consumption cannot be reasonably expected. Further, the results show that whether to allow for periods where the vessel is negatively influenced by currents (that is, a negative current factor) or not has the largest impact on the expected number of good weather days. Additionally, results suggest that a 2.4 m significant wave height limit is the optimal limit to use when intending to describe Douglas sea state 3 in conjunction with Beaufort limit 4. Alternatively, results show that a combined sea and swell limit of 3.25 m can resemble the same definition of weather conditions; however, we argue that the significant wave height is more precise in its ability to describe the weather that affects a vessel’s performance. Further, a case study suggests that the increasing practice of including the ‘no extrapolation’ wording in present charterparties significantly influences the financial implications of claims for underperformance. This trend makes the definition of ‘Good weather conditions’ even more critical for claim potential.

The study points to a misalignment of incentives between charterers and shipowners when setting good weather definitions in time charter contracts. This misalignment represents a principal-agent problem and can lead to speculative behaviour and less effective clauses. We argue that a more objective definition of good weather in performance clauses is more efficient for both shipowners, charterers, and the environment.

Keywords – Shipping economics, Principal-agent, Dry bulk timecharter, Performance clauses, Good weather quotations, Speed- and consumption claims

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1 Introduction

This chapter will first present the thesis's motivational background, explain why the research is relevant, and outline the theoretical frameworks. Secondly, our research questions are raised, and finally, the structure of the thesis is outlined.

The maritime industry stands as a long-considered lifeblood of international trade, connecting nations and economies across the globe. Today, the industry finds itself in a profound state of transformation. With rising concerns about climate change and the urgent need for a 'green transition', the industry has come under increased scrutiny for its efficiency and environmental impact.

Maritime cargo transportation is contracted between charterers and shipowners; such a contract is called a charterparty (CP). The two main types of charterparties are voyage charter contracts and time charter contracts. Voyage charter covers individual voyages; their price is quoted in $/ton of cargo transported. A time charter covers a specific period and is given in $/day (in shipping, this is called 'hire'). Under a time charter, the charterer, not the shipowner, is responsible for fuel costs (in shipping, this is called 'bunkers'), port costs and cargo claims; see, for instance, Stopford (2009, pp. 180–188). To reduce the uncertainty for the charterer regarding adherence to delivery schedules and fluctuating fuel costs, the time charter contract includes a performance clause. This clause quotes a warranty for the vessel's performance in terms of the vessel's sailing speed (measured in nautical miles (1.852 km) per hour; also called a knot) and fuel consumption (in metric tons per day).

However, the warranted vessel speed and fuel consumption are only applicable in certain weather conditions. Because of this, performance clauses include a clarification of the term 'Good weather conditions' (sometimes called 'Basis good weather'), usually with reference to marine weather measurements (e.g., Beaufort wind force). The clause determines thresholds for when a vessel's performance should be evaluated. Should she not perform at the warranted speed and/or fuel consumption, the charterer may raise a speed and/or consumption claim against the shipowner for underperformance.

Many disputes arise from these claims; for maritime arbitrators, one of the most common activities is to verify and negotiate vessel speed and fuel consumption claims (Makkar, 2006).

As a result, shipowners may want to define ‘Good weather conditions’ as advantageously as possible to avoid claims. If there are fewer established periods with good weather in a voyage, charterers will have less evidence to prove a potential underperformance in arbitration.

This research investigates if the typical definitions of ‘Good weather conditions’ reflect the sea conditions they are intended to or if a misalignment of incentives between shipowners and charterers could lead to unfair definitions of such ‘Good weather conditions’. This potential misalignment of incentives introduces a principal-agent problem. The principal-agent problem is a distinct example of what financial theory defines as a moral hazard. Mishkin and Eakins (2018, p. 187) describes this as a problem that arises when the agent is incentivised to participate in activities that are undesirable for the principal because the agent does not bear the entire risk. In time charter markets, the contractual dynamics resemble a typical principal-agent problem. Here, the shipowner (the operator of the vessel) is the agent who represents the interests of the charterer, the principal.

The hypothesis is that the shipowner (the agent) is not incentivised to comply with the warranted performance and sail at the speed instructed by the charterer (the principal). This is because the shipowner knows that if the weather conditions are such that the vessel’s performance cannot be evaluated, the probability of a claim is low. Then, the shipowner does not bear the entire risk of underperforming and can care more about, for example, the wear and tear of the vessel.

As a result, the shipowner is also incentivised to set strict thresholds for ‘Good weather conditions’ to reduce the risk of claims. If the latter is the case, charterers should be aware of this and consider that shipowners may be incentivised to define thresholds for ‘Good weather conditions’ that are structurally lower than the actual sea conditions where the vessel cannot be expected to perform as warranted. This leads to inefficient practices in the time charter segment of shipping.

To better understand the economic implications of this, the study aims to quantify how the wording of different performance clauses affects potential claims in hire, based on the definition of ‘Good weather conditions’.

The implications of this research have the potential to help enforce the intention of performance clauses, making it harder to evade consequences for poor vessel performance. Additionally, both parties can leverage these insights to enhance their understanding of the economic implications of contractual terms. This will increase transparency and contribute to levelling the power balance in charterparties.

1.1 Research question

To provide insights on how definitions of good weather translate into an expected amount of good weather days, and to discover more about how these definitions translate into potential claims, this thesis aims to pursue the following research questions:

(1) *What parameters should charterers aim to negotiate in the definition of 'Good weather conditions' in charterparties?*

(2) *How do varying definitions of 'Good Weather Conditions' financially impact a performance claim?*

1.2 Outline

The thesis is organised as follows: Chapter 2 presents the literature used to motivate our research questions and the background for further analysis. Chapter 3 delves deeper into performance clauses, how they are built, and how underperformance results in claims. In Chapter 4, we provide an overview of how data is collected and processed, in addition to descriptive statistics. Chapter 5 presents the methods used to investigate our research questions. In Chapter 6, the results of our random forest analysis are presented, and in Chapter 7, we conduct a case study to understand how different clause wordings impact the claim potential. Chapter 8 provides a discussion of our results, and finally, in Chapter 9, we conclude our research findings and provide recommendations for applying our results and further research.

2 Literature Review

This chapter reviews the literature pertinent to the topic, identifies the shortcomings relevant to this research and outlines the appropriate theoretical context.

Previous research has undertaken the analysis of charterparties to some extent. Pirrong (1993) investigated the rationale behind the joint existence of long-term and spot charter contracts in the dry bulk shipping sector. He pointed out that some characteristics, such as barriers to switching between contracts, result in more prolonged negotiations and wasteful strategic behaviour by both parties and that long-term contracts mitigate these inefficiencies. Through this, Pirrong's research examines the nature of charterparties and their possibilities for inefficient behaviour on a market level. A later contribution of Veenstra and van Dalen (2011) explored the opportunities for inefficient strategic behaviour at the individual level between the two parties of a contract, therefore applying the principal-agent problem as the theoretical foundation to the time charter contracting situation. Our analysis utilises this theory and goes further in examining this contractual behaviour. Additionally, there has been extensive research on how weather conditions impact vessel performance and efficiency, as well as how this relates to the environmental aspect of shipping. Finally, we delve into relevant legal precedence on the topic of speed and consumption claims in order to understand how performance clauses are enforced in practice.

2.1 Principal-agent model for performance quotations in time charter contracts

Veenstra and van Dalen (2011) offer a comprehensive examination of setting warranted vessel speed and fuel consumption in time charter contracts. Additionally, their paper introduces a principal-agent model for this type of contracting situation. In their research, Veenstra and van Dalen formulated hypotheses, ranging from shipowners deliberately warranting vessel speed and fuel consumption below the ship's design to how the ship's physical attributes (that is, age, size) and market variables (that is, bunker price) were related to the warranted vessel speed and fuel consumption.

The researchers formulated a conceptual model where these elements are tied to potential underperformance claims. This model is grounded in an empirical approach, relying on data from time charter fixtures to inform their analysis.

One of the paper's key findings is the identification of strategic behaviour by shipowners when negotiating time charter contracts. It reveals that shipowners often warrant a vessel speed that is systematically below the vessel's design speed and, similarly, fuel consumption levels above the vessel's design fuel consumption. This practice is not purely arbitrary but is influenced by several factors, such as the ship's age and the uncertainty surrounding bunker prices. This pattern holds across different vessel sizes. Notably, for the largest vessels (Capesize), the discrepancy between warranted and design fuel consumption was more pronounced than the smallest observed vessels (Handysize). Among all vessel sizes examined, Handymax was the only size where warranted fuel consumption was not consistently reported above design levels. Despite the differences across vessel sizes, the study also highlighted notable variations within the vessel size groups, emphasising the industry's complexity of practices.

The study's analysis indicates that the behaviour of shipowners when determining vessel speed and fuel consumption reflects a strategic response to market developments. This suggests that the quotations for vessel speed and fuel consumption in time charter contracts are merely technical or operational decisions but are also influenced by market conditions and strategic considerations.

In their paper, Veenstra and van Dalen introduce a principal-agent model for a time charter contract and its characteristics. Despite the nature of time charter contracts being about the rental of a ship, the researcher's model does not represent a standard rental problem. The unique aspect is that the shipowner serves as the agent, not the principal. This arrangement more closely resembles a conventional wage contract problem, where the principal (the charterer) pays the agent (the shipowner) for the rental of the vessel and for operating her on behalf of the charterer. Additionally, the charterer is responsible for the fuel costs during the rental period.

From this relationship, Veenstra and van Dalen have derived a fundamental time charter contracting model as a variant of the standard wage model developed by Holmström (1979). This model illustrates when the charterer will claim a reduction in hire due to underperformance, given the charterer's utility. According to the model, the shipowner might be incentivised to set the warranted vessel speed lower than the true speed the ship can achieve due to uncertainty about the vessel's actual capabilities. This can protect the shipowner against claims resulting from underperformance.

The model highlights that the principal-agent problem is more significant when the determination of the warranted vessel speed and fuel consumption depends on, for example, the freight rates (that is, the bargaining power one party has over the other). This happens because, in situations where the warranted vessel speed (and fuel consumption) is an element in the negotiation of the contract, the shipowner may behave more speculatively in their behaviour as a result of the asymmetric information.

In today's charterparties, the wording for 'Good weather conditions' is more subject to negotiation than the warranted vessel speed and fuel consumption. This emphasises the principal-agent problem's relevance in the case of defining good weather in performance clauses. The hypothesis that the shipowner is incentivised to set thresholds for 'Good weather conditions' that are as strict as possible, is thereby well-founded. This hypothesis, however, opens for a contradicting interpretation of the conclusion in Veenstra and van Dalen's model.

Related to the actual performance of the vessel vis-à-vis the warranted performance, the shipowners have more information about the actual performance and quality of a vessel than the charterer. Suppose the shipowner knows that setting strict thresholds for 'Good weather conditions' will make it near impossible for the charterer to claim anything post-voyage. In that case, the shipowner might be incentivised to oversell the vessel (that is, to set the warranted vessel speed higher than the actual speed the ship can achieve) to win contracts. This is the case even though the shipowner knows the vessel cannot sustain the warranted speeds for the entire voyage. Doing so would make underperformance more likely, but if the performance clause does not effectively punish underperformance, such overselling is a small risk to take for shipowners. If the shipowner structurally oversells each vessel in the fleet, this risk is even minimised due to the effect of diversification.

Furthermore, the charterer has no direct economic interest in the rented vessel; the primary consideration will be the transported cargo and voyage-related expenditures. However, since the shipowner is paid a daily fixed hire, the vessel's wear and tear can be more critical than fuel consumption. Since the shipowner is not rewarded for any overperformance, they have few incentives to do so. Hence, overselling the vessel to win contracts might be a calculated way to earn profit.

Although Veenstra and van Dalen's research goes far in describing the misalignment of incentives between shipowners and charterers in a time charter, their research is mainly related to the determination of warranted vessel speed and fuel consumption in performance clauses. Our analysis continues on Veenstra and van Dalen's research when introducing the same problem for the quotation of 'Good weather conditions' in performance clauses, building upon their principal-agent model for a time charter contractual situation.

2.2 Environmental impact of performance clauses

The environmental effect of the shipping industry is vastly documented, and reducing shipping emissions to net zero is among the industry's most important but complex challenges. With the implementation of various greenhouse gas emission reduction strategies, this challenge is also recognised by the International Maritime Organization (IMO) (2023). Within this study, the relevance of performance clauses becomes particularly significant as these are the only clauses in the charterparty directly concerning the vessel's fuel consumption.

Responsible for about 2.8 per cent of the global carbon dioxide emissions, commercial shipping is a significant contributor to climate change (Morante, 2022). To put this in context, if the commercial seaborn fleet were a country, it would have been the 6th most significant emitter of greenhouse gas, only beaten by the United States, China, Russia, India and Japan.

The negative environmental effect of shipping is diverse; from the various effects, atmospheric pollution, including greenhouse gas emissions, has gotten the most attention from IMO and the industry. The amount of atmospheric pollution caused by shipping further substantiates the relevance of performance clauses as an environmental tool since air pollution is directly linked with fuel consumption and the vessel's efficiency.

Performance clauses address the environmental challenges in shipping in two central ways. Firstly, it allows the charterers to choose the most fuel-efficient vessels possible. Besides saving fuel costs, cargo owners also prefer modern tonnage (Boonzaier, 2019). Though it could be argued that modern tonnage delivers a safer transport of goods, more important is the total CO2 footprint for the cargo owners, including cargo transport. Because of this, both the charterer and cargo owners prefer fuel-efficient vessels as the demand for sustainable supply chains grows. The performance clauses state this preference in writing.

Secondly, performance clauses are designed to punish underperformance, thereby incentivising vessel efficiency. However, strict definitions of 'Good weather conditions' make these clauses less effective in enforcing this punishment. Our study intends to shed light on how these definitions influence the evaluation of a ship's performance, aiming to make the performance clauses more efficient in rightfully incentivising adequate performance. With a transparent evaluation of performance, shipowners will be less incentivised to either underperform or claim that a vessel is more fuel-efficient than it is to win contracts.

2.3 Fuel-efficiency profitability

The analysis of differentiated markets resulting from variations in vessel efficiency has received some attention in the past, with an increased focus in recent years. Tamvakis and Thanopoulou (2000) provides an early analysis of whether a differentiated market exists within the bulk carrier segment based on the individual vessel's attributes. Using vessel age as their main variable, the researchers found no significant rate premium for younger vessels. Köhn and Thanopoulou (2011) continues this research, expanding the variables to also account for contract-specific aspects, such as delivery terms and fuel consumption. For Panamax time charter rates between 2003 and 2007, the results suggested that a quality premium is indeed present, particularly in market booms.

Agnolucci et al. (2014) provided an early analysis of how financial savings from energy-efficient vessels are distributed between the shipowners and charterers. Focusing on the Panamax segment between 2008 and 2012, the researcher found that, on average, only 40 per cent of the savings were credited to the shipowners.

A later contribution of Adland et al. (2017) offers an investigation of the economic viability of fuel efficiency in the dry bulk time charter market in their paper *'Does fuel efficiency pay? Empirical evidence from the dry bulk timecharter market'*. This research is particularly significant in the context of the principal-agent problem prevalent in this market, where shipowners' incentive to invest in energy-efficient ships is diminished as the benefits of reduced fuel costs accrue primarily to charterers.

The study analyses over 9,000 dry bulk vessel charters from 2001 to 2016, assessing factors affecting charter rates and the economic impact of fuel efficiency. It confirms the market rate's dominance while noting the influence of vessel age, fuel prices, delivery terms and deadweight tonnage (DWT). It also shows that only 14 – 27 per cent of fuel savings convert to higher rates in normal markets, with inefficient ships surprisingly earning higher rates during booms, contradicting established theories and thereby highlighting the complex market dynamics around fuel efficiency.

The paper also emphasises the need for a deeper understanding of fuel efficiency's economic impact and advocates for policies that bridge the gap between fuel efficiency investments and financial returns, underlining the role of regulatory frameworks in balancing economic and environmental goals.

2.4 Weather's influence on performance

Wave and wind conditions significantly influence a ship's resistance. However, its impact varies depending on the propeller and residual resistance, primarily influenced by waves and weather conditions. Interestingly, Carlton (2018) points out that waves and wind affect the vessel's fuel consumption substantially more than ocean currents. Typically, wind and waves hitting the bow and sides of the ship (known as beam wind or waves) heighten resistance and fuel usage, while wind and waves approaching from the stern can be advantageous.

The research conducted by Abebe et al. (2020) corroborates these observations. In their study, which utilises a machine learning model for predicting ship speeds, it is demonstrated that a ship's speed over ground (SOG) is more significantly affected by weather elements like wind speed and direction, along with wave height, direction, and period, than by the speed and direction of ocean currents.

This underscores the importance of how definitions of 'Good weather conditions' in performance clauses can impact the vessel's actual performance, indicating that allowing for more heavy waves and wind has more effect on performance than allowing for more adverse currents.

2.5 Legal precedence

Assessing past claims and statistics related to speed and fuel consumption can provide valuable insights into the nuances of performance clauses and the handling of such claims. Examining past legal disputes helps us understand these contractual elements' intricate dynamics and clarifies the resolution processes involved. Both Krikris (2021) and Kasi (2022) provide a practical perspective on this, with reference to relevant legal disputes.

The misinterpretations of performance clauses have led to several disagreements among charterparty participants. Many of these disputes are resolved by private arbitration, which is closed to the public. If treated in court, however, the verdict of such disputes forms precedence in the industry on interpreting and applying clauses. Examples of such cases are 'The Gas Enterprise' from 1993, 'The Ocean Virgo' from 2015 and 'The Divinegate' from 2022.

2.5.1 The Gas Enterprise

The case, Exmar NV v BP Shipping LTD (1993), known as 'The Gas Enterprise', concerned the interpretation of a speed and consumption claim in a time charterparty for a Liquefied Petroleum Gas (LPG) Tanker. The case's central issue revolved around the extrapolation of the vessel's performance in terms of speed and fuel consumption.

The parties argued whether the speed and consumption warranty should apply only during periods of good weather, or if the consumption warranty should apply at all times, including periods of heavy weather.

The court's decision established that charterers are entitled to compensation for losses incurred throughout the voyage, encompassing both good and heavy weather periods (Kasi, 2022). This ruling was based on the rationale that if a vessel underperforms during good weather conditions, it is also highly likely to underperform in heavy weather. However, the performance could only be evaluated in periods of good weather. This interpretation allows for extrapolating a vessel's underperformance in good weather periods to the entire voyage, providing a broader basis for assessing overall performance and calculating underperformance.

2.5.2 The Ocean Virgo

'The Ocean Virgo' case between Polaris Shipping Co Ltd v Sinoriches Enterprises Co Ltd (2015) dealt with what proportion of the day must be of 'Good weather conditions' to establish a 'Good weather day'. The central issue was whether a performance claim could be dismissed due to good weather periods lasting less than 24 consecutive hours. Polaris Shipping, the charterer, sought a deduction in the hire of $ 263,832, alleging a breach of performance warranties in a voyage performed by the Supramax bulk carrier 'Ocean Virgo' in 2013. The owners, Sinoriches Enterprises, contended that the good weather periods were too brief to establish any breach of warranties. The arbitrator initially agreed with the owners, requiring 24 consecutive hours of good weather conditions to be able to evaluate performance. From this, the entirety of the day must be of 'Good weather conditions' or '100% good weather' for a day to be a 'Good weather day'.

However, on appeal in 2016, the Commercial Court ruled against this limitation, noting the lack of a specific 24-hour wording in the performance clause in the charterparty. The case was remitted for revaluation, focusing on whether periods of 14 and 16 hours of good weather were adequate to assess performance (Standard Club, 2016). From this, only the majority of the day must be of 'Good weather conditions' or '51% good weather' for a day to be a 'Good weather day'.

This case underscores the need for clear terms in charterparties and concludes that without an explicit requirement of 24 consecutive hours in the performance clause, such a period is not legally binding.

2.5.3 The Divinegate

Referred to as 'The Divinegate', the case between Eastern Pacific Chartering Inc v Pola Maritime Ltd (2022) concerned a voyage performed by the bulk carrier 'Divinegate'. The owner, Eastern Pacific, initially claimed $ 99,982.79 for outstanding hire and bunkers from the charterer, Pola Maritime. As a result of the claim, Eastern Pacific arrested the Pola Maritime vessel 'Pola Devora' while awaiting the settlement of their claim. Pola

Maritime disputed the original claim, arguing they had rightfully held back hire as they could make deductions based on the underperformance of the voyage. As Pola Maritime claimed they had rightfully held back hire, they also claimed there was no basis for the arrest of ‘Pola Devora’, making their total counterclaim for both underperformance and the arrest \$ 59,129.25 in their favour.

Since the arrest claim results from the alleged underperformance, the heart of the matter lies in whether an underperformance could be established. Pola Maritime claimed an underperformance of 83.6 hrs, equivalent to \$ 93,074.55.

From the verdict, a total of 16 hrs of underperformance was established. Despite considerably less than Pola Maritime initially claimed, the verdict points out two general elements that can be used in future underperformance disputes:

The ‘Good weather method’ was established as the conventional approach to establishing a breach of performance clauses. Another approach, the ‘RPM method’, was discussed but deemed ‘untested’ and, therefore, less preferable than the ‘Good weather method’. The Pearl C decision also underbuilt this conclusion (M/V Pacific Pearl Co Ltd v Osios David Shipping Inc, 2022).

The effects of currents were also heavily discussed, with the verdict concluding that the owners are to have the effect of positive currents to their advantage if not expressively mentioned otherwise in the charterparty. This positive effect was also why Pola’s claim was cut short. Additionally, the verdict clearly states that periods of adverse current should be excluded from the ‘good weather’ definition. This means that good weather cannot be defined if there are adverse currents.

3 Performance Clauses, Weather Conditions and Claims

3.1 Performance clauses

As previously mentioned, time charter contracts include a performance clause stating the vessel's speed and fuel consumption capabilities. Typically, these clauses include four key elements:

i. **The vessel's warranted capabilities:** The performance clause typically specifies the vessel's performance in terms of 'Full speed' and 'Eco speed'. These terms are warranted, meaning they are formally guaranteed and subject to claim if not complied with. The use of the word 'about' is frequent in these quotations, implying a leeway of the vessel's capabilities, such that a claim is effectuated if the difference between the actual and warranted performance is larger than a reasonable margin. There is a widespread consensus among London Arbitratiors that the term 'about', in performance clauses, implies a leeway of 0.5 knots on the speed and 5 per cent of the fuel consumption in tons per day (West of England P&I Club, 2019).

ii. **Definition of 'Good weather conditions':** The performance clauses define conditions for what is considered good weather. This definition is essential, as it sets the standard for when the charterer can expect the vessel to perform at her warranted capabilities. Thus, the conditions also define when a potential underperformance can be calculated. In present performance clauses, the definition of 'Good weather conditions' typically includes three components: a quotation on a Beaufort limit, a Douglas sea state limit (often in conjunction with a significant wave height limit or combined sea and swell limit), and a disallowance, or allowance, for adverse current periods. In this thesis, the latter is referred to as the 'current factor condition'.

iii. **Definition of a 'Good weather day':** Performance clauses could also include words used to describe what proportion of the day (that is, a 24-hour period) must be of 'Good weather conditions' to be classified as a 'Good weather day'. Such a definition is, in this thesis, referred to as the good weather amount condition ('GW amount condition'). In present performance clauses, the most common wording regarding this condition is to explicitly state that 'good weather periods are to be for 24-hour periods'. This means that the entirety of the day must be of good weather conditions ('100% GW'). The alternative approach is not to state it at all; then, weather routing companies can interpret this as the majority of the day to be good weather conditions ('51% GW'). Some clauses also state that a weather day must be considered from noon-to-noon.

iv. **Extrapolation or no extrapolation:** Another central aspect of the performance clause is whether it allows extrapolation. Extrapolation involves predicting an unknown value by extending known data. In a performance claim, this means that an established underperformance in periods of 'Good weather conditions' can be used to extend that underperformance to periods outside those conditions.

In Figure 3.1 an example of a typical performance clause is provided.

FULL SPEED IN LADEN CONDITION: ABOUT 14 KNOTS ON ABOUT 29 MT,
MGO AT SEA ABOUT 0.2 MT.
FULL SPEED IN BALLAST CONDITION: ABOUT 14 KNOTS ON ABOUT 27.5 MT,
MGO AT SEA ABOUT 0.2MT.

ECO SPEED IN LADEN CONDITION: ABOUT 12 KNOTS ON ABOUT 22 MT,
MGO AT SEA ABOUT 0.2 MT.
ECO SPEED IN BALLAST CONDITION: ABOUT 12 KNOTS ON ABOUT 21 MT,
MGO AT SEA ABOUT 0.2 MT.

IN PORT GEAR WORKING ABOUT 4.5 MT IFO PLUS ABOUT 0.2 MT MDO.
IN PORT GEAR IDLE ABOUT 2.5 MT IFO PLUS ABOUT 0.2 MT MDO.

BALLAST PUMPS WORKING ABOUT 4.5 MT PER DAY.

SPEED/CONSUMPTION ALWAYS: BASIS WIND MAXIMUM BEAUFORT SCALE 4, AND SEA NOT EXCEEDING DOUGLAS SEA STATE 3 (SIGNIFICANT WAVE HEIGHT 1.25 M). GOOD WEATHER PERIODS TO BE FOR 24 HOUR PERIODS.

THE SPEED AND CONSUMPTION IS BASIS GOOD WEATHER CONDITION UP TO AND INCLUDING BEAUFORT 4, AND DOUGLAS SEA STATE 3 (SIGNIFICANT WAVE HEIGHT OF 1.25 M), AND NO ADVERSE CURRENTS. THE ASSESSMENT OF GOOD WEATHER TIME SHALL BASE ON ANY CONSECUTIVE 24 HORUS GOOD WEATHER PERFORMANCE. NO EXTRAPOLATIONS TO BE MADE FOR WEATHER CONDITIONS OTHER THAN THOSE DESCRIBED ABOVE.

ALL DETAILS ARE ABOUT AND ABOUT IS DEFINED AS +/− 0.5 KNOT ON THE SPEED AND +/− 5 % ON THE CONSUMPTION FIGURES.

Figure 3.1: Typical performance clause - An example

3.2 Marine weather measurements

Several metrics are used to measure and describe the weather conditions at sea. In this section, the metrics relevant to defining ‘Good weather conditions’, as well as a ‘Good weather day’ in performance clauses are presented.

3.2.1 Swell height

Swell height represents the average height of the highest one-third of the sea swell (that is, large rolling waves attributable to previous or distant winds). It is estimated by analysing the distribution of wave energy across different periods (that is, frequencies), identifying if there’s a distinct swell energy peak, and then selecting a frequency to distinguish between swell and wind waves. The swell height is computed from the wave energies below this chosen frequency (National Data Buoy Center, 2023).

3.2.2 Sea height

Sea height, sometimes referred to as wind wave height, is the average height of the top one-third of the wind waves (that is, fresh waves attributable to local wind conditions). It is estimated through the same procedure as under ‘Swell height’, except it is computed from the energies above the separation frequency (National Data Buoy Center, 2023).

3.2.3 Combined sea and swell

Combined sea and swell is a simple way to measure the state of the sea. Combining the sea height with the swell height at any time allows you to quote the sea conditions without quoting the sea and swell separately. Combined sea and swell are calculated from the separate sea and swell using Equation 3.1:

$$H_{\text{Combined}} = H_{\text{Sea}} + H_{\text{Swell}} \tag{3.1}$$

The combined sea and swell are typically used as a metric to state the limit of Douglas sea state 3 in present performance clauses.

3.2.4 Significant wave height

Significant wave height, also known as total wave height, is a more precise and modern way to describe the combined height of the sea and swell that mariners experience on open waters (Australian Bureau of Meterology, 2023).

The significant wave height equals the average height of the top one-third of the waves (measured from trough to crest). For significant wave height, there is no separation between sea (wind waves) and swell frequencies; instead, both wave types are measured as one. If both sea and swell waves are present, the significant wave height should equal the square root of the sum of the squares of the individual sea and swell heights (National Data Buoy Center, 2023). According to this definition, the significant wave height is calculated from the separate sea and swell heights using Equation 3.2:

$$H_{\mathrm{Sig}} = \sqrt{(H_{\mathrm{Sea}})^2 + (H_{\mathrm{Swell}})^2} \tag{3.2}$$

Like the combined sea and swell, the significant wave height can be used as a metric to quote the limit of Douglas sea state 3 in present performance clauses. Typically, one would use either one or the other, but in some cases, they are also used together.

3.2.5 Beaufort Wind Force Scale

One of the first scales to estimate wind speeds and their effects was created by the Royal Navy Admiral Sir Francis Beaufort. He created the Beaufort Wind Force Scale (BF) in 1805 to help sailors estimate wind speeds based on visual observations. The scale starts at 0 and goes up to a maximum force of 12. The Beaufort scale is commonly used today to estimate wind strengths.

Table 3.1 shows the Beaufort scale in its entirety.

Table 3.1: Beaufort Wind Force Scale (Britannica, 2023)

Force	**Description**	**Wind speed threshold**	**Sea condition**
0	Calm	<1 kt	Sea like a mirror.
1	Light air	1-3 kn	Ripples with appearance of scales are formed, without foam crests.
2	Light breeze	4-6 kn	Small wavelets still short but more pronounced; crests have a glassy appearance but do not break.
3	Gentle breeze	7-10 kn	Large wavelets; crests begin to break; foam of glassy appearance; perhaps scattered white horses.
4	Moderate breeze	11-16 kn	Small waves becoming longer; fairly frequent white horses.
5	Fresh breeze	17-21 kn	Moderate waves taking a more pronounced long form; many white horses are formed; chance of some spray.
6	Strong breeze	22-27 kn	Large waves begin to form; the white foam crests are more extensive everywhere; probably some spray.
7	Near gale	28-33 kn	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind; spindrift begins to be seen.
8	Gale	34-40 kn	Moderately high waves of greater length; edges of crests break into spindrift; foam is blown in well-marked streaks along the direction of the wind.
9	Strong gale	41-47 kn	High waves; dense streaks of foam along the direction of the wind; sea begins to roll; spray affects visibility.
10	Storm	48-55 kn	Very high waves with long overhanging crests; resulting foam in great patches is blown in dense white streaks along the direction of the wind; on the whole the surface of the sea takes on a white appearance; rolling of the sea becomes heavy; visibility affected.
11	Violent Storm	56-63 kn	Exceptionally high waves; small- and medium-sized ships might be for a long time lost to view behind the waves; sea is covered with long white patches of foam; everywhere the edges of the wave crests are blown into foam; visibility affected.
12	Hurricane	≥64 kn	The air is filled with foam and spray; sea is completely white with driving spray; visibility very seriously affected.

3.2.6 Douglas Sea Scale

Another Royal Navy Admiral, H.P. Douglas, devised the Douglas Sea Scale (DSS) in 1917 while he was head of the British Meteorological Navy Service. Its purpose is to estimate the sea's roughness for navigation.

The Douglas scale consists of two codes, one for estimating the sea height (wind waves) and the other for describing sea swell; both are expressed in one of 10 degrees. In Tables 3.2 and 3.3 the Douglas Sea Scale is detailed in its entirety, for both the sea and the swell.

Table 3.2: Douglas Sea Scale (Sea) (Drag device data base, 2023)

Degree	Height (m)	Description
0	No Wave	Calm (Glassy)
1	0 - 0.1	Calm (Rippled)
2	0.1 - 0.5	Smooth
3	0.5 - 1.25	Slight
4	1.25 - 2.5	Moderate
5	2.5 - 4	Rough
6	4 - 6	Very Rough
7	6 - 9	High
8	9 - 14	Very High
9	14+	Phenomenal

Table 3.3: Douglas Sea Scale (Swell) (Drag device data base, 2023)

Degree	Description
0	No Swell
1	Very Low (short and low wave)
2	Low (long and low wave)
3	Light (short and moderate wave)
4	Moderate (average and moderate wave)
5	Moderate rough (long and moderate wave)
6	Rough (short and heavy wave)
7	High (average and heavy wave)
8	Very high (long and heavy wave)
9	Confused (wave length and height indefinable)

Classification of Swell

Short wave: $< 100m$	Low wave: $< 2m$
Average wave: $100 - 200m$	Moderate wave: $2 - 4m$
Long wave: $> 200m$	High wave: $> 4m$

3.2.7 Current factor

The current factor estimates how the ocean currents affect a vessel, indicating whether the ocean currents negatively or positively influence the vessel's performance. The ocean current is measured by the northward- or eastward component of the seawater velocity in the region of the vessel at the time of the weather observation (Copernicus, n.d.).

The current factor is dependent on the relative angle of the ocean current direction to the vessel's sailing direction and is calculated based on the cosine of this relative angle. A negative value thus indicates adverse current factors which disrupt the vessel's performance. Positive values indicate favourable current factors that boost performance, and zero or near-zero current factors suggest a negligible current impact on the vessel.

This way of implementing the current factor for performance evaluation has been detailed in communication with one of the experts from the weather routing company StormGeo. Figure 3.2 illustrates how the current factor is derived (B. A. Townson, personal communication, 29 November 2023):

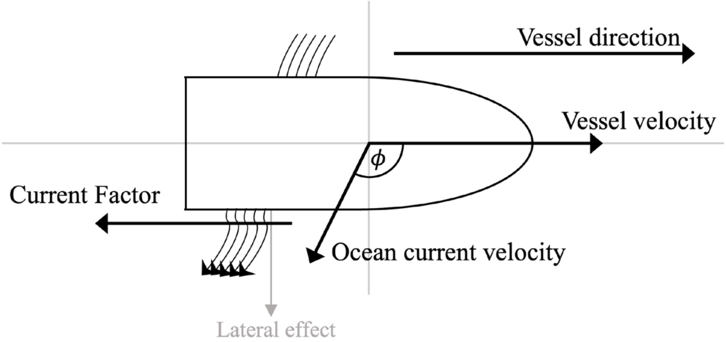


Figure 3.2: Current factor estimation

Equation 3.3 demonstrates the mathematical method employed to obtain the current factor, where CF is the current factor, V_{Current} is the ocean current velocity, and ϕ is the angle in degrees between the vessels sailing direction and the velocity direction of the ocean currents:

$$CF = V_{\text{Current}} \cos(\phi) \tag{3.3}$$

In present performance clauses, the current factor is typically quoted as a binary condition where the clause either states that 'Good weather conditions' cannot be periods where the vessel is influenced by adverse currents (that is, a negative current factor) or the clause states that the current factor has no implication in the determination of 'Good weather conditions'. Sometimes, the vessel's performance is also adjusted for the average current factor post-voyage.

3.3 Speed and consumption claims

The performance clause's relevance rests under the assumption that underperformance can be quantified into actual speed and consumption claims. A speed and consumption claim allows charterers to deduct from hire based on a vessel's underperformance vis-á-vis the warranted vessel speed and fuel consumption in the performance clause; see, for instance, West of England P&I Club (2019).

In time charter contracts, such underperformance is based on a time loss as a result of the ship sailing slower than the warranted CP speed or bunker overconsumption as a result of the vessel using more bunkers than she should in accordance with the warranted CP consumption. A claim can also be a combination of the two.

Time loss occurs when a vessel is spending more time on a voyage than what the warranted speed justifies. As performance clauses in reality allow for time loss in heavy weather, such weather is not in itself an explanatory factor for why time loss happens. Therefore, time loss must occur in good weather conditions. Overconsumption is measured in metric tons of fuel, and similar to time loss, overconsumption refers to the excess use of fuel based on what is warranted for the vessel. There are two primary reasons for time loss or overconsumption - incorrect warranted capabilities in the performance clause and issues related to the voyage itself. For the latter, such incidents can vary widely, including mechanical failures, bottom fouling, or other defects or breakdowns either prior to or during the voyage.

The specific cause of underperformance must be assessed on a case-by-case basis. This will determine whether an underperformance claim or an off-hire claim (or a combination) is appropriate. In an underperformance claim, the charterer claims due to a breach of the warranted capabilities in the performance clause. The vessel is only off-hire if the performance resulted from a defect or breakdown of the vessel during the charter. For this study, we will only consider underperformance claims.

If underperformance is established, the charterer calculates a claim, often through an independent weather routing company that provides a performance report for the specific voyage. It is important to note that there are no official standards for such calculations. Weather routing companies lean towards a more cautious approach when calculating claims, always interpreting the specific clause in favour of the vessel. Recent arbitration from commercial courts often sets the standard for potential claims in the future. A basic example helps understand the process and methodology for an underperformance claim.

Consider the clause in Figure 3.1. This vessel was contractually warranted to maintain a sailing speed of 14 kn using 29 mt of Marine Gas Oil (MGO) per day under 'Good weather conditions'. Unlike the clause in 3.1, we will now assume extrapolation to be allowed. Suppose an example where the voyage lasted for a period of 30 days. In the voyage, only one day experienced weather good enough to be classified as a 'Good weather day', all other days were of periods with heavy weather. Because of extrapolation, the vessel's performance will therefore be evaluated based on its performance during this single day of good weather. Post voyage, it is found that on this day, the vessel only achieved 13 kn and required 30 mt of MGO per day. This discrepancy indicates a breach of the contractual guarantee in terms of both reduced speed and increased fuel consumption. The achieved performance on the particular day of good weather suggests that these were the actual capabilities of the vessel at the time of delivery.

Throughout the charter, the vessel covered a total of 9,000 nm. If she had performed as warranted, it would have taken 642.86 hrs (approximately 26.8 $days$) to complete this distance ($9,000nm \div 14kn$), assuming good weather for the entire voyage. The fuel consumption under these ideal conditions would have been 777.2 metric tons of MGO ($26.8days \times 29mt$). However, with the vessel's actual performance in good weather, it would have required around 692.3 hours (about 28.85 $days$) to cover the same distance ($9,000nm \div 13kn$). Additionally, it would have required approximately 865.5 mt of MGO ($28.85days \times 30mt$), assuming optimal weather throughout the voyage.

Consequently, the charterer's loss amounts to 49.44 hrs ($692.3hrs - 642.86hrs$) and 86.5 mt ($865.5mt - 777.2mt$) of MGO. The total claim will consist of the time loss, converted into days, multiplied by the daily fixed hire from the CP and the overconsumption multiplied by the average bunker price that the charterer paid for the voyage.

According to Kasi (2022) several calculation methods are used to determine a speed and consumption claim. However, the above-outlined methodology closely aligns with the main principles of claim calculation. From the example above, with extrapolation allowed, the fundamental formulas can be articulated as follows:

$$\textit{Time loss (hrs)} = \frac{\textit{Total voyage distance (NM)}}{\textit{Warranted CP speed (kn)}} - \frac{\textit{Total voyage distance (NM)}}{\textit{Actual GW speed (kn)}} \tag{3.4}$$

$$\begin{aligned} \textit{Overconsumption (mt)} = {} & \frac{\textit{Total voyage distance (NM)}}{\textit{Warranted CP speed (kn)}} \times \textit{Warranted CP consumption (mt)} \\ & - \frac{\textit{Total voyage distance (NM)}}{\textit{Actual GW speed (kn)}} \times \textit{Actual GW consumption (mt)} \end{aligned} \tag{3.5}$$

$$\begin{aligned} \textit{Net underperformance claim} = {} & \textit{Time loss (days)} \times \textit{CP rate (\$/day)} \\ & + \textit{Overconsumption (mt)} \times \textit{Bunker price (\$/mt)} \end{aligned} \tag{3.6}$$

An interesting question is whether an overperformance in vessel speed (that is, a time gain) can cause an overconsumption of fuel. Theoretically, this is a relevant question, as the fuel consumption of commercial vessels increases exponentially with vessel speed; a small increase in speed can lead to a disproportionately large increase in fuel consumption, see for instance, GloMEEP (n.d.). This particular scenario operates under the premise that increased vessel speed is not attributed to favourable weather conditions, such as tailwind or downstream current since these conditions do not contribute to increased fuel consumption.

To realise a vessel's speed overperformance, the momentum must stem from engine output. A speed increase of this kind leads to a disproportionate escalation in fuel costs for the charterers. Concurrently, the shipowner is not rewarded for this increased performance; on the contrary, it potentially escalates the vessel's wear and tear. As a result, neither party is incentivised to achieve such increased performance, rendering the concept effectively theoretical in a practical context.

4 Data

This chapter outlines the data acquisition, sampling, and processing methodology, culminating in the presentation of descriptive statistics.

4.1 Data collection

4.1.1 Charterparty data

With support from the Norwegian dry bulk shipping company Western Bulk, we have accessed 48 performance clauses in textual form. These are time charter contracts ranging from 2012 until 2023. This data has been used to investigate how clauses have changed over the years and to understand how present clauses are formulated.

This data only provides insight into how clauses are typically outlined in old and present charterparties. Except for a descriptive analysis of keyword counts, no further analysis has been conducted on this data.

The clauses are written in variations of what is described in Chapter 3.1.

4.1.2 Weather data

Through the weather routing company StormGeo, in partnership with Western Bulk, we have accessed historical marine weather data compiled from observations across all of Western Bulk's commercially controlled vessels from 1 January 2019 until 19 October 2023. More specifically, we have accessed weather data from all voyages, with 2-6 hours between each observation, totalling between 3 and 8 weather observations per day, or 6 observations on average. In total, the data consists of 477,144 rows of individual weather observations, grouped into a total of 79,352 individual weather days.

Appendix A.1 provides a complete list of all variables in the weather dataset.

4.1.3 Weather data sampling

The robustness of the findings in this research relies on the authenticity of the weather data employed in the analysis. The data must be sourced from times and positions where vessels are realistically present. Moreover, it is crucial to use data spanning a sufficiently long timeframe and inclusive of all seasons. This is because weather patterns exhibit significant seasonal variation across different regions.

The criterion of timeframe and seasonality is satisfactorily met, as the data is procured from all of Western Bulk's commercially controlled fleet over a substantial duration, spanning nearly five years, from 1 January 2019 until 19 October 2023.

The criterion of positions is also met, as the data represents the entire ocean, accounting for variations in weather conditions across different geographical regions and seasons. Figure 4.1 visually represents all vessel positions of recorded weather data. Every point on the map below represents the last recorded position from each weather day of all individual voyages.

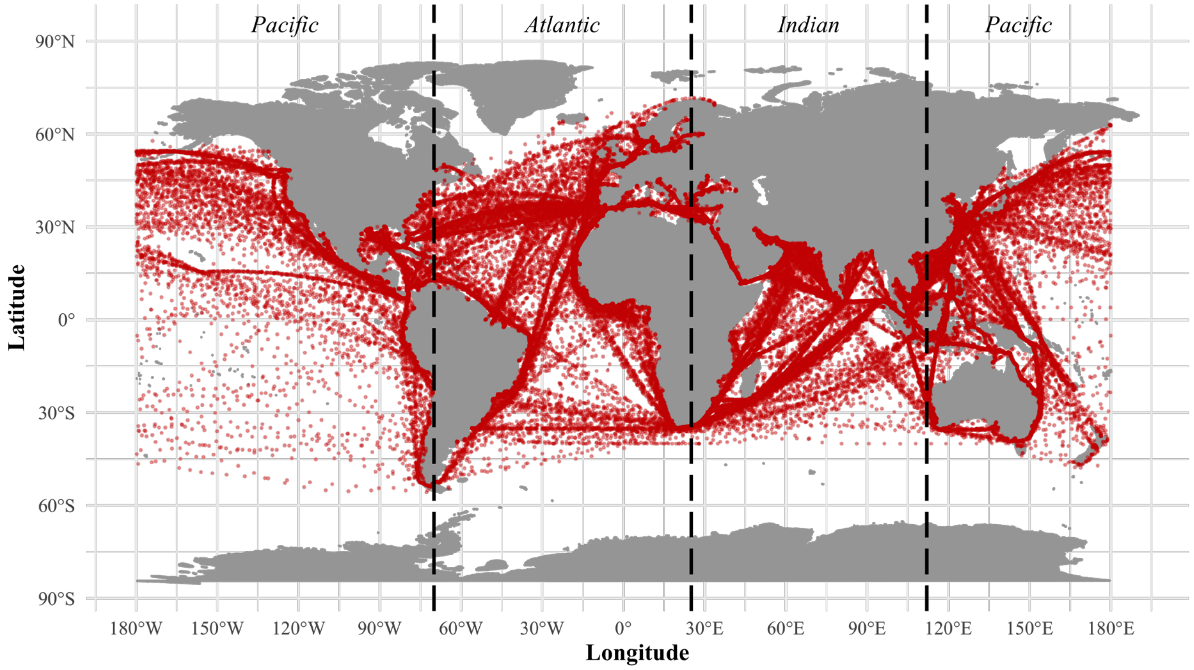


Figure 4.1: Vessel positions in weather data

In the figure, the ocean is divided into three distinct geographical regions. This is done to examine differences between regions. Although the division represents a simplification in the region splitting, the positions are divided into a Pacific, Atlantic, and Indian Region.

4.2 Data processing

As shown in Appendix A.1, the raw weather dataset contains the following columns of interest: *VoyageID, Date, Position, Wind Speed, Sea Height, Swell Height* and *Current Factor*. From this, three additional columns of interest have been created:

Weather Day was created by assigning all weather observations from the same voyage and the same date to a specific weather day. This means a weather day is recognised as a 24-hour interval from midnight to midnight. This makes it possible to assess if an individual weather day is a good one or not, based on the definition of 'Good weather conditions'.

Beaufort Wind Force was created by categorising the *Wind Speed* in compliance with Table 3.1.

Combined Sea and Swell and *Significant Wave Height* were created from *Sea Height* and *Swell Height* in accordance with, respectively, Equations 3.1 and 3.2.

4.3 Descriptive statistics

Table 4.1 summarises the main characteristics regarding how the key details of wordings in the charterparty data have evolved.

Table 4.1: Descriptive analysis of changes in key wordings in charterparties

	2021 - 2023 CP's		**2012 - 2020 CP's**		
	Frequency	%	Frequency	%	Δ%
Beaufort limit 3	2	9%	0	0%	9%
Beaufort limit 4	21	91%	25	100%	-9%
Specific wave heights / complex definitions of DSS 3	20	87%	10	40%	47%
No further definition than DSS 3	3	13%	15	60%	-47%
Explicitly stating 'No adverse currents'	21	91%	13	52%	39%
No remarks regarding currents	2	9%	12	48%	-39%
Explicitly stating '100% GW'	8	35%	1	4%	31%
No remarks regarding GW amount	15	65%	24	96%	-31%
Explicitly stating 'No extrapolation'	12	52%	1	4%	48%
No remarks regarding extrapolation	11	48%	24	96%	-48%

Analysing the 48 charterparties from 2012 to 2023 reveals a trend towards the increasing complexity and strictness in the definition of 'Good weather conditions' in performance clauses over time. Table 4.1 suggest an increase in the use of more complex definitions on Douglas sea state 3 (that is, quoting specific wave heights that are used as a limit), an increase in the use of a condition for not allowing adverse current periods, an increase in the use of a condition of '100% GW' in the definition of a 'Good weather day', as well as an increase in the disallowance for extrapolation of performance. The only element that has not changed substantially is the Beaufort limit 4. This limitation stands as a traditional limit that has not been subject to much negotiation. In general, the overall trend suggests that shipowners have become more aware of how these contractual terms have financial impacts, thereby including stricter terms.

Table 4.2 summarises the main characteristics of parameters concerning marine weather measurements in the weather data, accessed from StormGeo. In Appendix B.1, complete distribution plots of these parameters can be found.

Table 4.2: Descriptive statistics of weather data ($N = 477,144$)

	Mean	**St.d.**	**Min**	**Q1**	**Median**	**Q3**	**Max**
Beaufort Wind Force	4.04	1.23	0.00	3.00	4.00	5.00	11.00
Sea Height (m)	0.96	0.72	0.00	0.46	0.81	1.30	8.80
Swell Height (m)	1.48	1.02	0.00	0.70	1.32	2.00	9.01
Combined Sea and Swell (m)	2.44	1.50	0.00	1.39	2.20	3.18	14.83
Significant Wave Height (m)	1.85	1.12	0.00	1.06	1.67	2.41	10.52
Current Factor (kn)	-0.01	0.64	-4.00	-0.32	-0.01	0.30	4.00

In Table 4.3, descriptive statistics from the different regions are provided. From the table, one can see that, in general, the weather seems to be better in the Indian region than in the Pacific and the Atlantic, but the differences are small.

Table 4.3: Descriptive statistics of weather data for each geographical region

	Pacific		Atlantic		Indian	
	Mean	**St.d.**	**Mean**	**St.d.**	**Mean**	**St.d.**
Beaufort Wind Force	4.09	1.28	4.16	1.20	3.88	1.20
Sea Height (m)	1.00	0.78	1.02	0.72	0.87	0.65
Swell Height (m)	1.51	1.04	1.59	1.01	1.34	0.99
Combined Sea and Swell (m)	2.51	1.56	2.61	1.45	2.21	1.43
Significant Wave Height (m)	1.90	1.16	1.98	1.09	1.68	1.07
Current Factor (kn)	0.00	0.64	0.02	0.57	-0.05	0.70
	$N = 165,128$		$N = 153,775$		$N = 158,244$	

Table 4.4 showcases correlations between all variables. An interesting observation is that the current factor (CF) show little to no correlation with all other parameters; this can be explained by the fact that the current factor is calculated by assessing the effect of ocean currents on the vessel's sailing direction. Thus, the random element of any vessel's sailing direction makes the current factor not correlate with any other weather measurements.

Table 4.4: Correlation matrix of weather data

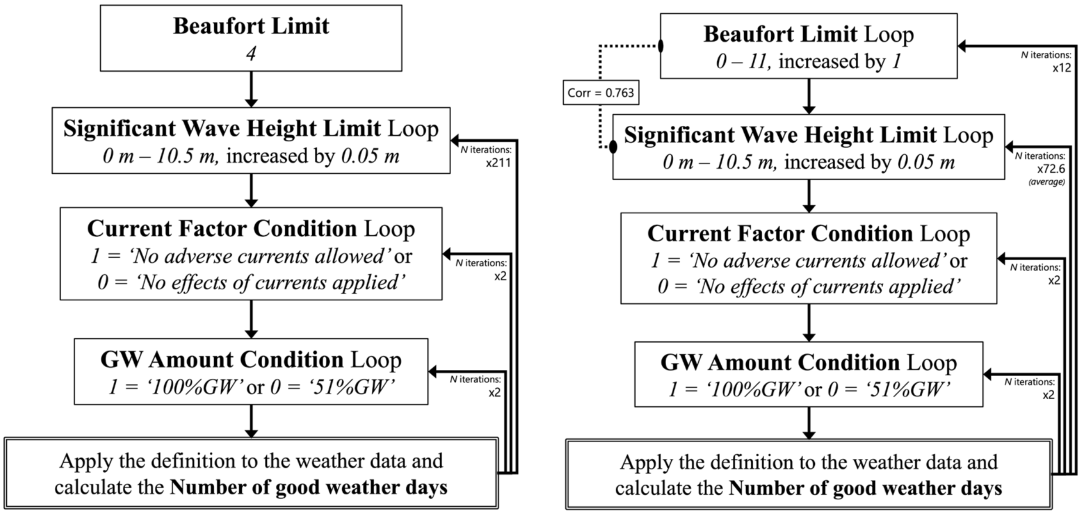
	BF	$\mathrm{H}_{\mathrm{Sea}}$	$\mathrm{H}_{\mathrm{Swell}}$	$\mathrm{H}_{\mathrm{Combined}}$	$\mathrm{H}_{\mathrm{Sig}}$	CF
BF	1.00					
$\mathrm{H}_{\mathrm{Sea}}$	0.87	1.00				
$\mathrm{H}_{\mathrm{Swell}}$	0.41	0.46	1.00			
$\mathrm{H}_{\mathrm{Combined}}$	0.70	0.80	0.90	1.00		
$\mathrm{H}_{\mathrm{Sig}}$	0.64	0.74	0.93	0.99	1.00	
CF	-0.01	-0.01	0.01	0.00	0.00	1.00

5 Methodology

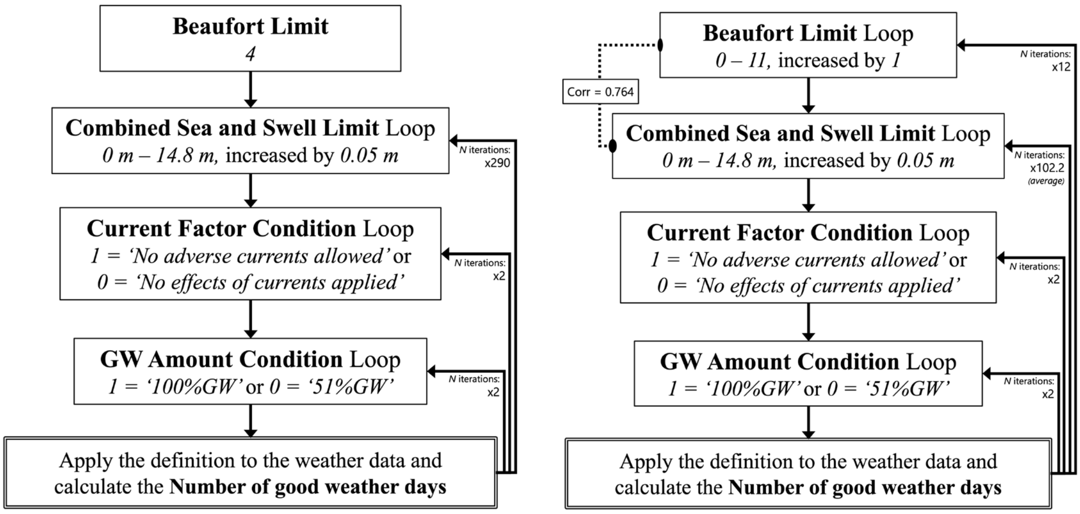
This chapter details the analytical techniques and methodology employed to analyse the importance of the elements that constitute the definition of a 'Good weather day'.

5.1 Simulation of good weather definitions

A comprehensive simulation was conducted to quantify the expected number of good weather days, given the definitions of it. The simulations are a precursor to a more in-depth analysis conducted using regression models. The simulations are implemented in R, leveraging its ability to handle large amounts of data.



(a) Simulation 1A **(b)** Simulation 1B



(c) Simulation 2A **(d)** Simulation 2B

Figure 5.1: Flowcharts of nested loops in performance clause simulations

The simulation outputs are data sets consisting of numerous combinations of the parameters defining a good weather day and how many weather days each combination yielded based on the underlying weather data.

As illustrated in Figure 5.1, four simulations were conducted, two including significant wave height as the parameter to define Douglas sea state 3 (Simulation 1), and two including combined sea and swell as the parameter to define Douglas sea state 3 (Simulation 2). For each of these two variations, Figures 5.1a and 5.1c show how simulations 1A and 2A were conducted for a Beaufort limit of 4 only. This is done because, as suggested from Table 4.1, the Beaufort limit 4 is an established industry norm that generally cannot be negotiated. Thus, simulations 1A and 2A represent the most realistic variations of good weather definitions. Figure 5.1b and 5.1d show how simulations 1B and 2B were conducted for all possible Beaufort wind forces in our weather data (0 to 11) with corresponding intervals of wave heights for each Beaufort limit. That is, the correlation between the Beaufort wind force limit and wave height limits is accounted for in these simulations. This splitting of different models is done in order to both conduct an analysis of realistic definitions of good weather and to analyse how different Beaufort limits will influence the expected number of good weather days. Hence, the two A models are more realistic, and the two B models include more data instances. Including both model types mitigates the potential tradeoff in interpretability.

In practice, nested loops are employed to iterate through all combinations of the parameters defining a ‘Good weather day’. The total number of good weather days is then calculated for each iteration. This number is based on the underlying weather dataset, consisting of 79,352 weather days to check on. The nested loops are illustrated in the flowcharts in Figure 5.1.

The results of each iteration, including the parameter values and the number of good weather days are then stored as *Beaufort Wind Force Limit*, *Significant Wave Height Limit*, *Combined Sea and Swell Limit*, *Current Factor Condition*, *GW Amount Condition*, *Number of Good Weather Days*, and *Probability of Good Weather Day.* In Tables 5.1 and 5.2, a complete list of variables and an explanation of them are presented for all simulation outputs.

Table 5.1: Simulation results dataset: Models 1A and 1B

Variable	**Unit**	**Range**	**Interpretation**
Beaufort Wind Force Limit	Scale (0-11)	0 to 11, increments of 1	Threshold for good weather conditions based on Beaufort wind force scale
Significant Wave Height Limit	Meters (m)	0 m to 10.5 m, increments of 0.05 m	Threshold for good weather conditions based on significant wave height
Current Factor Condition	Categorical (1, 0)	1 = (No adverse currents allowed); or 0 = (No effects of currents applied)	Condition for treatment of currents in the definition of good weather conditions
GW Amount Condition	Categorical (1, 0)	1 = (100%GW); or 0 = (51%GW)	Condition for the proportion of the day that must be good weather for a good weather day
Number of Good Weather Days	Days	0 days to 79,352 days	Number of good weather days resulting from definition of it, based on the underlying weather data
Probability of Good Weather Day	Per cent	0% to 100%	(Number of good weather days ÷ Total weather days): Interpreted as the probability for any given weather day to be a 'good' one

Note: For Simulation 1A, the Beaufort Wind Force Limit has the value 4 only. For Simulation 1B, Beaufort Wind Force Limit ranges from 0 to 11

Table 5.2: Simulation results dataset: Models 2A and 2B

Variable	**Unit**	**Range**	**Interpretation**
Beaufort Wind Force Limit	Scale (0-11)	0 to 11, increments of 1	Threshold for good weather conditions based on Beaufort wind force scale
Combined Sea & Swell Limit	Meters (m)	0 m to 14.8 m, increments of 0.05 m	Threshold for good weather conditions based on combined sea and swell height
Current Factor Condition	Categorical (1, 0)	1 = (No adverse currents allowed); or 0 = (No effects of currents applied)	Condition for treatment of currents in the definition of good weather conditions
GW Amount Condition	Categorical (1, 0)	1 = (100%GW); or 0 = (51%GW)	Condition for the proportion of the day that must be good weather for a good weather day
Number of Good Weather Days	Days	0 days to 79,352 days	Number of good weather days resulting from definition of it, based on the underlying weather data
Probability of Good Weather Day	Per cent	0% to 100%	(Number of good weather days ÷ Total weather days): Interpreted as the probability for any given weather day to be a 'good' one

Note: For Simulation 2A, the Beaufort Wind Force Limit has the value 4 only. For Simulation 2B, Beaufort Wind Force Limit ranges from 0 to 11

This simulation methodology provides a systematic and exhaustive approach to understanding the sensitivity and influence of different weather-related parameters on defining a ‘Good weather day’. The simulation lays a solid foundation for the subsequent regression analysis by testing a broad spectrum of parameter combinations.

5.2 Random forest regression methods

A random forest regression model is employed to analyse the importance and complexity of the elements defining ‘Good weather conditions’ in performance clauses. Random forest is a machine learning algorithm based on averaging across multiple decision trees for predicting outcomes (Molnar, 2020). Given its effectiveness on complex, nonlinear datasets, a random forest regression is the preferable methodology for this research. While a more traditional statistical analysis aims to infer relationships or test hypotheses, a random forest analysis is primarily used for making predictions or, as for this research, identifying patterns based on input data. Random forest is a non-parametric method that doesn’t make assumptions about the data distribution and therefore works well with complex datasets where relationships between variables might be non-linear.

Traditional statistical models often provide insights into the significance and impact of different variables. For this research, it is already known that the features in our simulation datasets will significantly influence the number of good weather days because they represent the limit that directly sets the threshold for defining them. However, what is interesting is the strength and nature of the relationship between the features (that is, the limits and conditions applied to the definition of a ‘Good weather day’) and the number of good weather days based on the actual weather data. Employing a random forest model will provide information about this relationship. The use of premature feature importance and partial dependence plots makes it possible to investigate this from the random forest models. These interpretations help clarify how variations in different features affect the outcome variable, which is crucial for insightful understanding and making well-informed decisions in practical applications.

All random forest analyses are implemented with the randomForest R-package (Liaw & Wiener, 2002). In total, four models are estimated, one model for each simulation. *Number of Good Weather Days* is the predicted outcome variable. The complete list of explanatory variables used in the random forest model is presented in Table 5.3.

Table 5.3: Overview of random forest models

	Model 1A	**Model 1B**	**Model 2A**	**Model 2B**
Dependant	Num.GWD	Num.GWD	Num.GWD	Num.GWD
Explanatory	–	$\mathrm{BF}_{\mathrm{Limit}}$	–	$\mathrm{BF}_{\mathrm{Limit}}$
	$\mathrm{H}_{\mathrm{Sig\ Limit}}$	$\mathrm{H}_{\mathrm{Sig\ Limit}}$	$\mathrm{H}_{\mathrm{Combined\ Limit}}$	$\mathrm{H}_{\mathrm{Combined\ Limit}}$
	$\mathrm{CF}_{\mathrm{Condition}}$	$\mathrm{CF}_{\mathrm{Condition}}$	$\mathrm{CF}_{\mathrm{Condition}}$	$\mathrm{CF}_{\mathrm{Condition}}$
	$\mathrm{GWA}_{\mathrm{Condition}}$	$\mathrm{GWA}_{\mathrm{Condition}}$	$\mathrm{GWA}_{\mathrm{Condition}}$	$\mathrm{GWA}_{\mathrm{Condition}}$

The random forests were run with forests of 1,000 trees, with two variables tried at each split in the individual decision trees. During the development of the model, we experimented with different tree depths, numbers of trees, and variables to try at each node. However, we found that combinations within reasonable bounds had minimal impact on the model's performance. Therefore, we decided to use default values for simplicity and reproducibility.

Permutation feature importance is used to determine what feature is most important for the value of the predicted outcome in a machine learning model. A feature's importance is determined by measuring the change in the model's prediction error after randomly changing the feature's values. A feature is important if changing its values increases the model error because, in that case, the model relied on the feature for the prediction (Molnar, 2020). If changing a feature's value did not change the model's prediction error much, this suggests that the feature is not as important in estimating the relationship between the feature and the target variable.

Partial dependence plots (PDP) provide a global perspective on the marginal influence of features on a machine-learning model prediction (Boehmke & Greenwell, 2019). These plots demonstrate how predictions vary with changes in feature values, factoring in the average effects of all other features. This plot helps visualise the relationship strength and nature between a feature and the prediction outcome, indicating whether the association is linear or more complex.

PDPs work for both numerical and categorical features. For a numerical feature X_i, the PDP suggests the average marginal effect on the prediction for all given values i that X_i can take. In our simulation data, for example, this can represent all possible wave height limits. In detail, it works by artificially replacing all data instances to the value i for the feature X_i and then averaging the predictions for all data instances and storing the values to build a plot.

For a categorical feature, computing partial dependence is also straightforward. For example, in a PDP for the categorical feature D_i, there are two possible values for i, 0 or 1. In our simulation data, for example, this represents one value for each condition, for the two categorical features. To compute the average output value for each value that D_i can take, the PDP artificially replace the value of all data instances with both possible values of D_i and averages the prediction outcomes.

It is crucial to mention that PDPs shall be interpreted with caution. They operate under the assumption that the features in the random forest model are uncorrelated. If this premise isn't met, the PDP estimation might generate an unlikely combination of data instances. This assumption is not entirely satisfied in the simulation data since the Beaufort limit correlates with the wave heights; for instance, if the Beaufort limit is 4, one would expect the significant wave height limit to be in the same range in describing the state of the sea. However, the 'Current factor condition' and the 'GW amount condition' apply to all the other values and do not correlate with the other features; for instance, one would not expect the choice of significant wave height limit to correlate with what current factor condition is used in the same good weather definition. Hence, this assumption holds to a certain extent in the dataset.

The types of problems that occur in PDPs, with data instances having unlikely or impossible combinations of feature values, can be avoided using accumulated local effects (ALE). Like the PDP, ALE shows how one or two features influence the predictions of a machine-learning model (Molnar, 2020). However, instead of taking the average prediction for all values of the relevant feature, ALE measures how smaller variations in the feature value affect predictions.

A variety of these plots were tested during the model development, but the differences had minimal impact on the interpretation of results. Therefore, PDPs are used to visualise the nature of the relationships.

6 Results and Analysis

6.1 Sensitivity analysis on the probability of a 'Good weather day'

In this section, a sensitivity analysis is presented to show the sensitivity of good weather definitions on the probability of a good weather day (that is, the probability of a random weather day in a voyage being a good one). In the analysis, various Beaufort limit values, significant wave height limits, as well as combined sea and swell limits are tested for all the possible conditions that can be applied to a clause. The different combinations of good weather definitions are applied to the weather data, and the proportion of weather days classified as good, under each definition, is calculated. The analyses suggest large differences in the number of good weather days based on the different definitions.

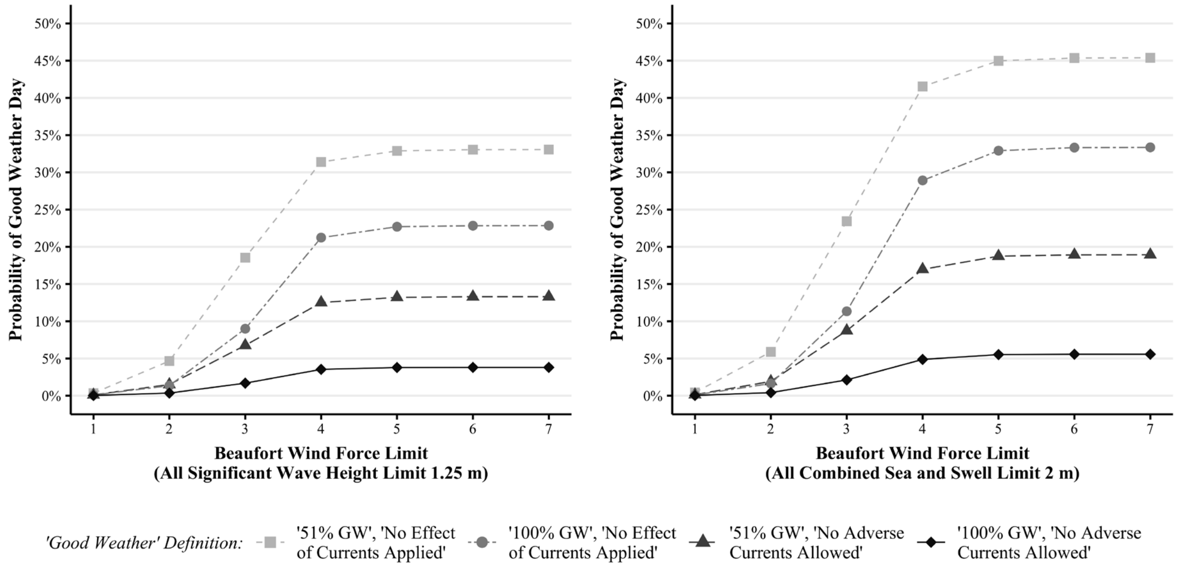


Figure 6.1: Sensitivities of Beaufort limits in variations of a 'Good weather day'–definition, on the probability of a good weather day

The two plots in Figure 6.1 show the sensitivity of changing the Beaufort limit while holding the wave height limits constant, respectively at a 1.25 m significant wave height limit and a 2 m combined sea and swell limit, as these are typical wordings in present clauses. Figure 6.1 suggests a negligible increase in the number of good weather days from raising the Beaufort limit above 4. It also shows that, in the definition of good weather, the selection of conditions has a large effect on the probability of a day being a good weather day. The plot shows that there is a more significant difference between the two ‘Current factor conditions’ than between the two ‘GW amount conditions’.

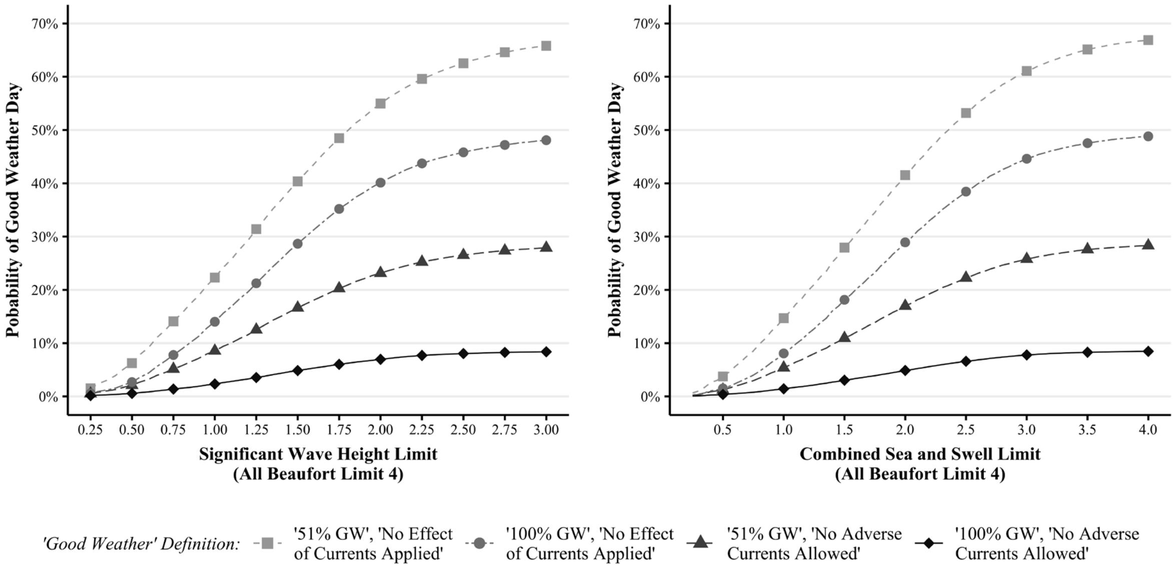


Figure 6.2: Sensitivities of wave height limits in variations of a ‘Good weather day’–definition, on the probability of a good weather day

The two plots in Figure 6.2 show the sensitivity of changing the wave height limits while holding the Beaufort limit constant at 4. This analysis is more interesting, as it more closely represents reality in contractual situations where the Beaufort limit stands as an element that is less subject to negotiation. The plots show the same tendency as the analysis for the Beaufort limits in Figure 6.1, suggesting a more significant difference between the two ‘Current factor conditions’ than between the two ‘GW amount conditions’. From this, we suspect that currents greatly affect the expected number of good weather days in a voyage.

It’s also observed that when performance clauses incorporate higher wave height limits, the two conditions - how current factors are treated and the required proportion of the day must be of ‘Good weather conditions’ - become more critical in determining the probability of a day being classified as a ‘Good weather day’. This is indicated by the difference between the lines being greater, for higher wave height limits.

6.2 Random forest regression results

Four random forest models were estimated to examine the complexity and nature of the relationship between the number of good weather days and our explanatory variables. The R-squared of the models are as follows:

Table 6.1: R-squared for all random forest regression models

	Model 1A	**Model 1B**	**Model 2A**	**Model 2B**
R^2	0.893	0.915	0.897	0.912

First, feature importance is derived from the random forest models to investigate which variables are more important when determining good weather conditions, related to to the expected amount of good weather days from a voyage.

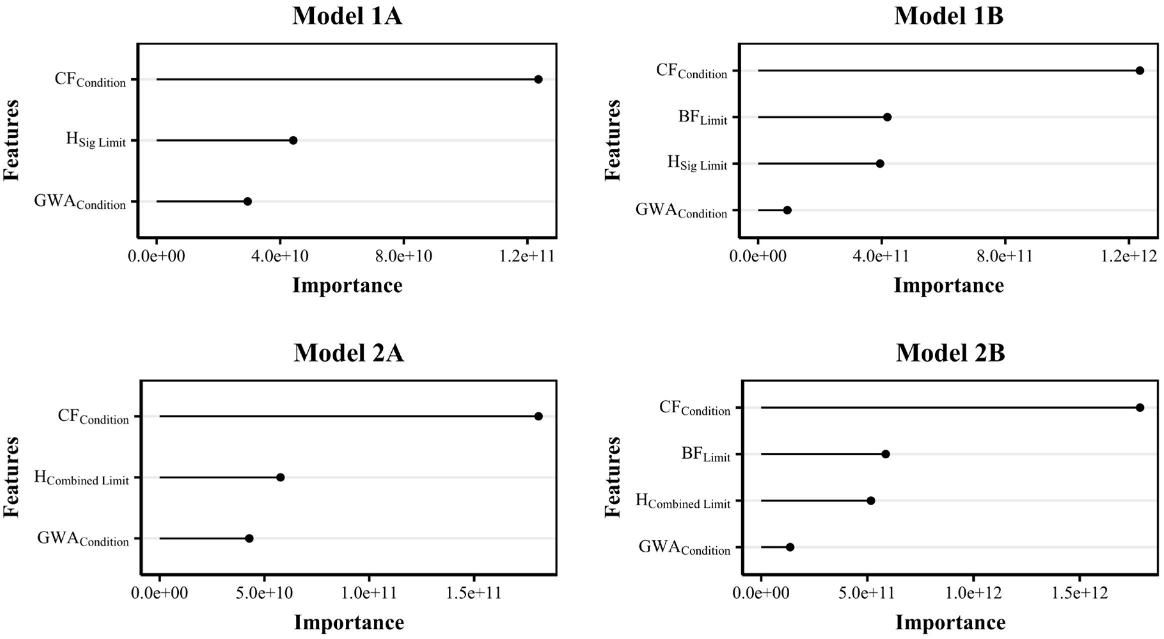


Figure 6.3: Feature importance for all features related to the expected amount of good weather days

From Figure 6.3, all models suggest that the current factor condition is the most important feature. This aligns with the findings in the sensitivity analysis in Figures 6.1 and 6.2, which suggested that the current factor condition was more important than the GWA condition. The GWA condition comes out as the least important feature in all models.

Additionally, results suggest that the current factor condition is more important than the wave heights and the Beaufort limit. The rationale behind this is logic, as it is reasonable to expect a prominent effect from allowing for all periods of adverse currents. According to the quantiles in the descriptive statistics in Table 4.2 as well as the distribution in Appendix B.1, the current factors are normally distributed around 0. This indicates that adverse current periods (that is, a negative current factor) account for roughly half of the weather observations. From this, it is reasonable to expect that the effect of allowing for all these extra adverse current periods is more pronounced than, for instance, allowing for one meter higher significant wave heights.

Models 1B and 2B, which include variations of the Beaufort wind force limit, show that, when assessed, the Beaufort wind force limit is the second-most important feature, although it is close to the same importance as the wave heights. This is natural, as is it reasonable to expect these limits (Beaufort and wave heights) to follow each other in the definition of good weather. It is also notable that there are little to no differences in using significant wave heights compared to combined sea and swell regarding how the variables behave in terms of importance.

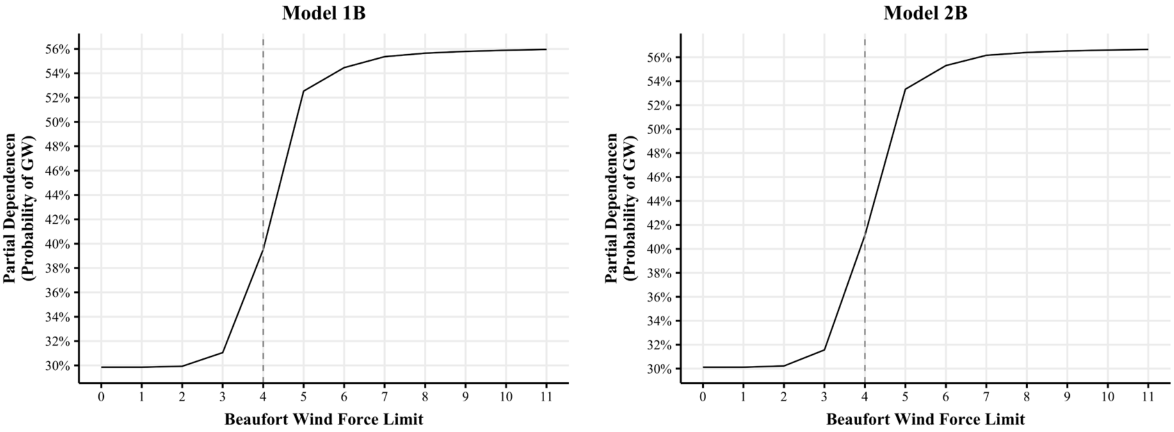


Figure 6.4: Sample partial dependence plots showing the marginal effects of Beaufort limits on the expected amount of good weather days for all models, averaging over all other features

Figure 6.4 show that when included in the model, an increase in the Beaufort wind force limit will result in a higher expected number of good weather days up until approximately Beaufort 5; from here, the weather does not seem to get so bad that an increase in the limit will have any substantial impact. It is essential to keep the correlation between the Beaufort limit and the wave height limits in mind, knowing that an increase in one limitation is expected to also increase the other limitation. However, since Beaufort 4 stands as a long-considered limit for weather conditions that are too heavy for warranted performance to be expected, we will not delve too much into the potential increase in this parameter. Nonetheless, it is noteworthy that increasing the Beaufort limit to more than 5 only results in a marginal increase in the expected number of good weather days.

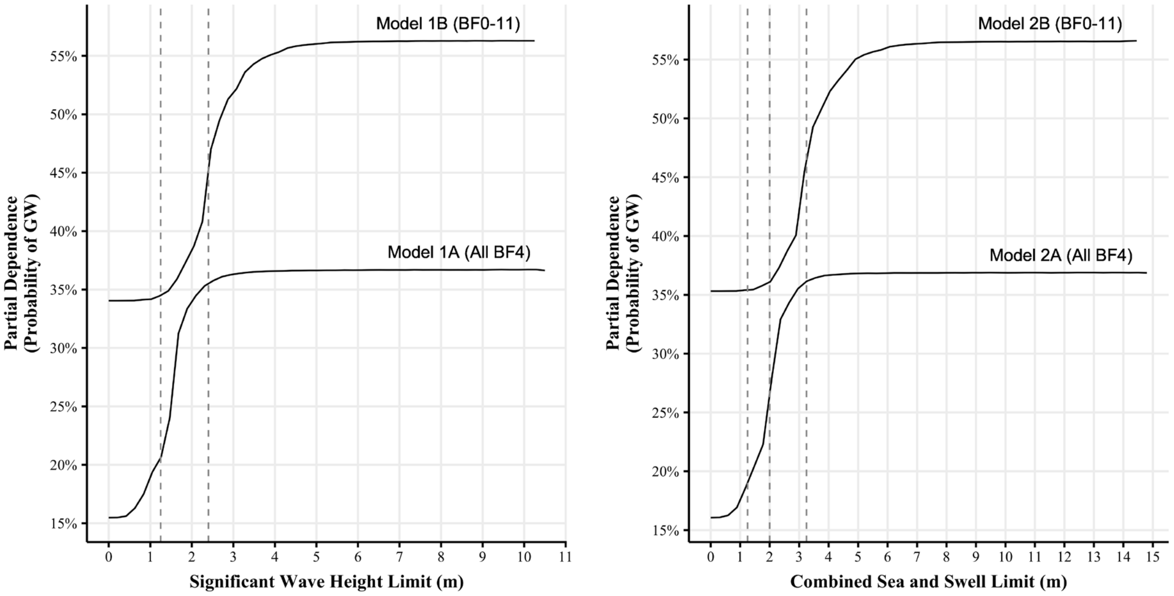


Figure 6.5: Sample partial dependence plots showing the marginal effects of wave heights on the expected amount of good weather days for all models, averaging over all other features

Figure 6.5 shows the interesting and complex relationship between wave height limits and the expected number of good weather days. Although the wave height limits are not the features that have the most impact in general, as implicated from the feature importance plots, Figure 6.5 suggests that it has a large influence over a short range of values. From Model 1A, which only considers Beaufort limit 4, one can observe that by increasing the limit for significant wave height from 1.25 m to 2.4 m, we can capture nearly all the change in the expected number of good weather days. For Model 2A, when the combined sea and swell reaches 3.25 m, the same captured increase in value occurs. This is interesting as it shows how the significant wave height wording translates to the combined sea and swell wording regarding the expected number of good weather days. From this, 6.5 suggests that a significant wave height limit of 2.4 m is equal to a combined sea and swell limit of 3.25 m, as they both yield a ceteris paribus effect of around $36 - 37\%$ expected number of good weather days, suggested from models 1A and 2A. Charterers should be aware of this when negotiating contracts as both types of wording appear in different charterparties.

Further, Figure 6.5 also implies that a 1.25 m combined sea and swell limit, which is a common phrasing in present performance clauses, is as unfavourable as a 1.25 m significant wave height limit, which also occurs in several clauses. Models 1A and 2A suggest that these limits describe significantly worse weather conditions than the underlying Beaufort 4 limit.

The rationale behind this is that the wave height limit is expected to equal the Beaufort limit at the point where the steepness of the partial dependence line flattens. An increase in the wave height limit beyond this point does not increase the expected number of good weather days. This is because the limitations then hinge on the Beaufort 4 limit. Based on this, Figure 6.5 suggests that a limit of 2.4 m significant wave height and 3.25 m combined sea and swell are the points where the partial dependence curve begins to flatten. Therefore, these wave height limits are equivalent to the Beaufort 4 limit in terms of describing the same weather conditions.

In Figure 6.5, Models 1B and 2B should be interpreted with caution since the partial dependence line averages over all variations of Beaufort limits. By this, the average Beaufort limit for the two B-models in Figure 6.5 would be 5.5 as this is the mean of all possible values of the Beaufort limit in the B-models, ranging from 0 and 11. Since a Beaufort of 5.5 is impossible, and since no other limit than Beaufort 4 is reasonable to expect in practice, the partial dependence of the wave heights cannot be interpreted directly in the B-models.

While the B-models represent an average Beaufort limit of 5.5, the A-models will represent an average Beaufort limit of 4, as this is the only value included in these models. Since both models average over the two categorical features, the B-lines will always remain above the A-lines. This is because the B-lines represent a less strict definition of good weather as compared to the A-lines.

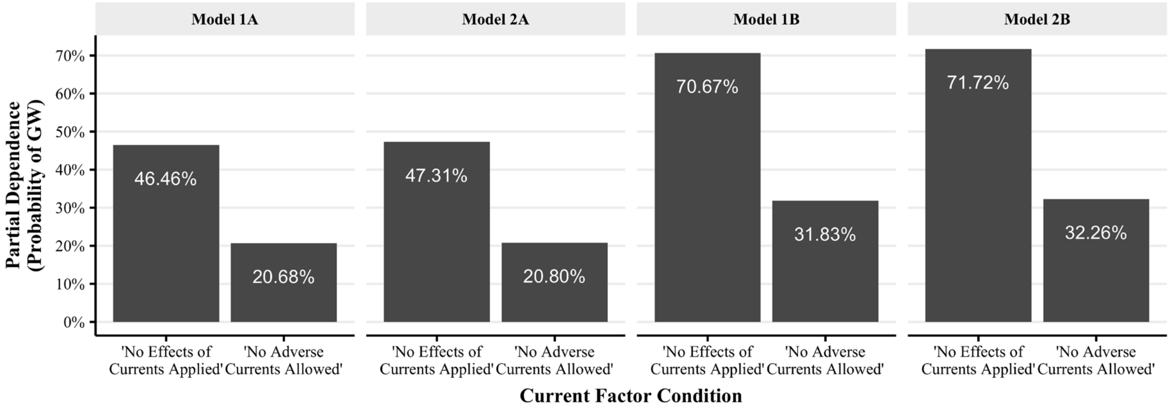


Figure 6.6: Sample partial dependence plots showing the marginal effect of the chosen 'Current factor condition' on the expected amount of good weather days for all models, averaging over all other features

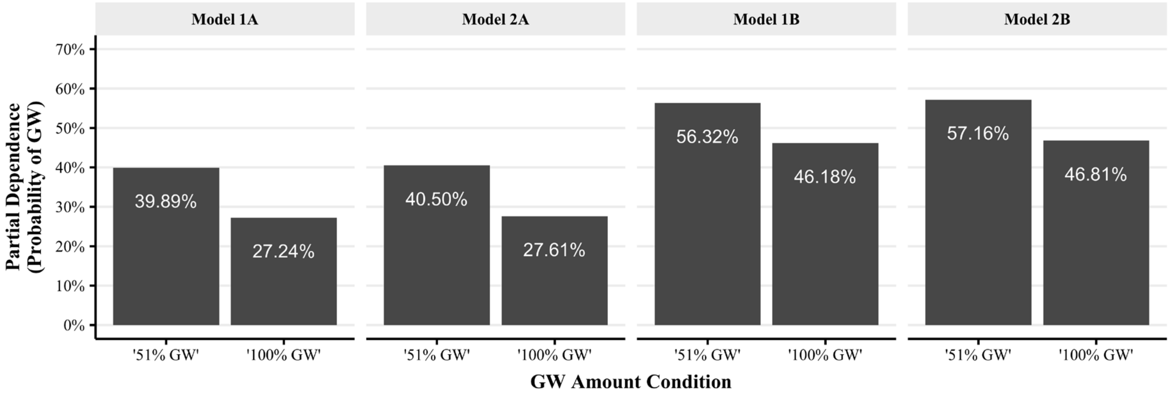


Figure 6.7: Sample partial dependence plots showing the marginal effects of the chosen 'GW amount condition' on the expected amount of good weather days for all models, averaging over all other features

Figures 6.6 and 6.7 show the relationship between the two possible categorical features and the expected number of good weather days. These plots show the effects of shifting from one condition to the other, over an average of the other features. Like the wave height plots, the B-models cannot be interpreted directly, as these represent an average Beaufort limit of 5.5, which is not possible. However, they still indicate a large effect from changing the wording in defining good weather from one condition to the other. In the A-models, the plots represent a more realistic approach as they only include clauses with Beaufort limit 4, resulting in an average Beaufort limit of 4 as well. Even though the wave heights are averaged in these plots, this represents a more realistic clause scenario than the B-models.

In line with the conclusion from the sensitivity analysis and the feature importance, the plots show that the difference in the expected number of good weather days is more significant when changing the ‘Current factor condition’ than it is when changing the ‘GW amount condition’, indicating that it is a more important feature in the determination of a ‘Good weather day’. This can be seen through the change in the expected number of good weather days when shifting from one condition to the other in the two figures. The PDPs highlight the significant impact of the ‘Current factor condition’ on the expected number of good weather days. The transition from ‘No adverse currents allowed’ to ‘No effects of currents applied’ is associated with a substantial increase in the expected number of good weather days, ranging between 35 and 45 percentage points. On the other hand, the transition from ‘100% GW’ to ‘51% GW’ is only associated with an increase of around 10 to 13 percentage points.

The rationale behind this is logic, as it is reasonable to expect that if the majority of a day is good weather, the entire day will likely maintain similar conditions. Conversely, is reasonable to expect a prominent effect from allowing for all periods of adverse currents, as detailed earlier in this chapter. Therefore, the ‘GW amount of day’ conditions should not be heavily prioritised by charterers during contract negotiations.

The above results answer our first research question, underscoring the importance of prioritising negotiations around the current factor condition. Additionally, when Beaufort limit 4 is non-negotiable, the results point to the importance of negotiating the significant wave height limit up to, but not exceeding 2.4 m or the combined sea and swell limit up to, but not exceeding 3.25 m, as any limit above these values yields no increase in the expected number of good weather days.

Further, the results suggest that the 2.4 m significant wave height limit and 3.25 m combined sea and swell limit are equal in describing weather conditions. The analysis also shows that these two wave height limits are equivalent to the Beaufort 4 limit in describing weather conditions.

7 Case Study on Claim Potential

In order to apply our results to real-life examples, a case study is conducted. In this study, we aim to quantify the potential claims associated with the various definitions of a ‘Good weather day’. This helps in understanding how the different definitions translate to the financial value of a claim, offering a more nuanced understanding of their impact on claim dynamics. The case study is simplified by focusing solely on claims arising from time loss. This also leads to easier interpretation of results, as the nature of claims for fuel overconsumption can be complex.

For the case study, we apply both the most favourable and the least favourable clauses, from a charterer’s perspective, on a representative voyage. This approach highlights the difference in claim potential from the outermost point of ‘Good weather day’–definitions. However, we emphasise the importance of a realistic approach.

Consequently, we selected the most favourable definition as the fairest definition of good weather, based on our analysis in Chapter 6. This definition sets a significant wave height limit of 2.4 meters or a combined sea and swell limit of 3.25 meters. Conversely, the least favourable definition selected includes a significant wave height and a combined sea and swell limit of 1.25 meters. Although the latter definition is commonly found in present performance clauses, our analysis reveals that these wave height limits actually reflect sea conditions more adverse than the Douglas sea state 3, in conjunction with Beaufort scale 4, are intended to characterise.

Results from Chapter 6 underscore the current factor condition as the most important element related to the expected number of good weather days from a voyage. To be able to study the effect of this condition, we calculate all claims under both distinct conditions: one with ‘No adverse currents allowed’ and the other with ‘No effects of currents applied’. Additionally, we incorporated the ‘100% GW’ condition in the least favourable clauses and the ‘51% GW’ condition in the most favourable clauses.

The selection of case is a 36-day Kamsarmax voyage crossing the Indian Ocean from South Africa to North China in July 2023. This voyage is applied in the case study as it represents a typical voyage with some open sea sailing, as well as some sailing in more protected seas. Figure 7.1 shows the voyage on which the case study is conducted. Each point on the map represents the last reported position from each day. Thus, each point also represents a weather day that can be classified as either a good or heavy weather day, depending on its definition.

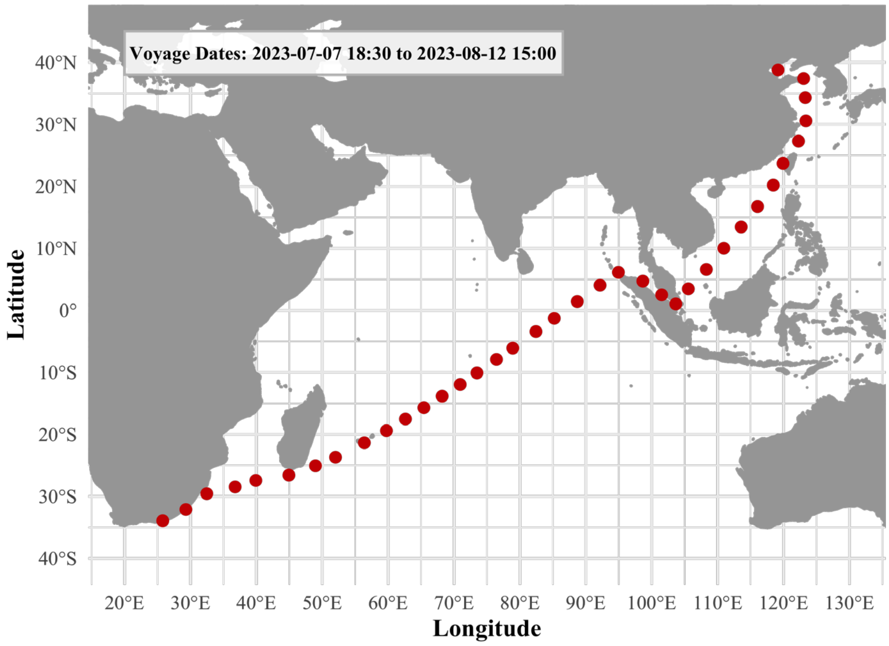


Figure 7.1: Case study: Daily positions from Kamsarmax voyage across the Indian Ocean

7.1 Claim calculation

In the below equations, the methodology for calculating a speed claim in the case study is presented. This methodology is detailed by Birketts LLP (2020, 13:55). The first step in calculating a speed claim is to establish a time loss. The time loss is established based on what periods of the voyage were of good weather conditions, and what periods were outside this definition. In the case study, this is done based on the different clause definitions.

From this, the total distance sailed in good weather periods is divided by the total time spent in good weather periods to obtain the average good weather performance speed (GW performance speed), as in Equation 7.1.

$$GW\ performance\ speed\ (kn) = \frac{Total\ GW\ distance\ (NM)}{Total\ GW\ time\ (hrs)} \tag{7.1}$$

If the clause states that extrapolation of performance is allowed, the extrapolated total voyage time (that is, the total time of the voyage if the vessel were to sail at the same speed as the average good weather speed, for the entire voyage), as in Equation 7.2.

$$Total\ extrapolated\ time\ (hrs) = \frac{Total\ voyage\ distance\ (NM)}{GW\ performance\ speed\ (kn)} \tag{7.2}$$

As long as extrapolation is allowed, the total allowed time of the voyage is calculated by dividing the total distance sailed on the warranted speed from the performance clause. However, 0.5 kn is subtracted from the warranted speed to account for the ‘about’ term in the clauses. As derived in Equation 7.3, this returns the total time the vessel is allowed to use if it were to sail in accordance with the warranted CP speed, minus a leeway of 0.5 kn.

$$Total\ allowed\ time\ (hrs) = \frac{Total\ voyage\ distance\ (NM)}{Warranted\ CP\ speed\ (kn) - 0.5\ kn} \tag{7.3}$$

When the clause states that extrapolation of performance is prohibited, a claim can only be raised for underperformance in periods of good weather conditions. Then, the good weather allowed time is calculated directly by dividing the total good weather distance on the warranted speed from the performance clause minus a leeway of 0.5 kn. This returns the total time the vessel is allowed to use in the good weather parts of the voyage if it were to sail in accordance with the warranted CP speed, as derived in Equation 7.4

$$GW\ allowed\ time\ (hrs) = \frac{Total\ GW\ distance\ (NM)}{Warranted\ CP\ speed\ (kn) - 0.5\ kn} \tag{7.4}$$

It is important to emphasize the difference in a potential claim dependent on whether the clause opens for extrapolation of performance to the entire voyage or if it only allows a claim for underperformance from periods of good weather. If the latter is the case, one extra ‘Good weather day’ will result in one extra claimable day, given that underperformance is established. For the first approach, one day with good weather is enough to extrapolate that performance to the entire voyage in order to calculate a claim.

When extrapolation is allowed, time loss is calculated as in Equation 7.5.

$$Time\ loss\ (hrs) = Total\ extrapolated\ time\ (hrs) - Total\ allowed\ time\ (hrs) \tag{7.5}$$

If the clause states that no extrapolation of the performance can be made, time loss is calculated as in Equation 7.6.

$$Time\ loss\ (hrs) = Total\ GW\ time\ (hrs) - GW\ allowed\ time\ (hrs) \tag{7.6}$$

To accurately determine the economic value, in terms of a claim for underperformance, the time loss in hours is divided by 24 to obtain time loss in days. To calculate a claim, this is multiplied by the daily fixed hire from the CP as in Equation 7.7.

$$Speed\ claim\ (\$) = \frac{Time\ loss\ (hrs)}{24\ hrs} \times CP\ rate\ (\$/day) \tag{7.7}$$

The above calculations indicate that if the average good weather performance speed is lower than the warranted CP speed, a claim for underperformance can be made. The extent of the claim increases with the magnitude of the actual performance speed shortfall vis-á-vis the warranted CP speed.

7.2 Case study results

The total voyage distance was 8,012.8 NM and the total voyage time was 845.5 hrs; this results in an average performance speed of 9.48 kn. For this particular voyage, the warranted CP speed was 12.5 kn. The large difference between the warranted CP speed and the total average performance speed sets the ground for potential underperformance.

However, to be able to establish such an underperformance and claim a deduction in hire, one must calculate the average performance speed in periods of good weather. To do this, the methodology and formulas described in Chapter 7.1 are employed. It is only if the average good weather performance speed is lower than the warranted CP speed of 12.5 kn, minus a leeway of 0.5 kn, that a claim can effectuated.

In particular, performance data from the voyage is applied to the formulas under the chosen definitions of a 'Good weather day'. From this, the total good weather distance and the average good weather performance speeds are calculated, cumulating into an estimated time loss with and without extrapolation of performance.

Since the hire for a specific voyage is undisclosed, we have used an estimate for the given route in the given time period. By utilising weekly average rates from Clarksons Research Shipping Intelligence Network, such an estimate of what was achieved by the vessel is employed in the case study.

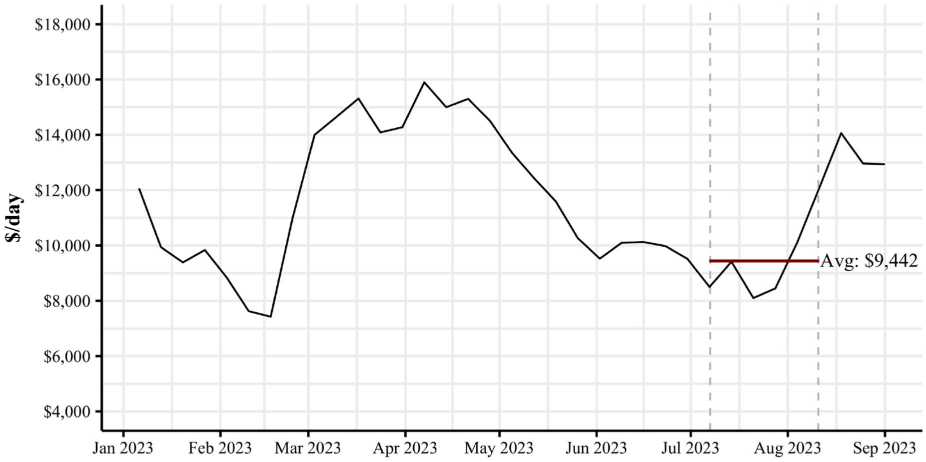


Figure 7.2: Kamsarmax 82,000 Dwt, Weekly average trip rates $/day. Retrieved from Clarksons Research.

As seen from Figure 7.2, the average trip rate for the period of the charter was $ 9,441. Due to the uncertainty of rates, the time loss in the case study is multiplied with an average rate of $ 9,500 per day, as this represents an estimation of rates earned by similar-sized vessels in the same time period as the voyage.

Table 7.1: Case study: Potential claims from various definitions of a ‘Good weather day’

The table shows, from a charterer’s standpoint, the most favourable and the least favourable clauses that are reasonable to expect in a negotiation. Based on the specific 36-day Kamsarmax voyage, potential claims for time loss are calculated from the ‘Good weather distance’ (GW distance) and the ‘Good weather performance speed’ (GW speed). These two numbers are estimated from the definition of a ‘Good weather day’ in the different clauses. Each row represents a clause with the various definitions of good weather, the corresponding good weather distance and speed, as well as potential claims with and without extrapolation. This table only includes claims for time loss; additional claims for fuel overconsumption may apply.

Clause definition of a ‘Good weather day’					GW Performance		Speed claim	
Beaufort limit	**Significant wave height limit**	**Combined sea and swell limit**	**Current factor condition**	**GW amount condition**	**GW distance**	**GW speed**	**Extrapolation allowed**	**No extrapolation allowed**
4	1.25 m	–	’No adverse currents allowed’	‘100% GW’	–	–	$ 0	$ 0
4	1.25 m	–	’No effects of currents applied’	‘51% GW’	652 NM	10 kn	$ 52,950	$ 4,311
4	2.4 m	–	’No adverse currents allowed’	‘100% GW’	–	–	$ 0	$ 0
4	2.4 m	–	’No effects of currents applied’	‘51% GW’	1,770 NM	9.86 kn	$ 57,282	$ 12,651
4	–	1.25 m	’No adverse currents allowed’	‘100% GW’	–	–	$ 0	$ 0
4	–	1.25 m	’No effects of currents applied’	‘51% GW’	194 NM	10 kn	$ 52,595	$ 1,272
4	–	3.25 m	’No adverse currents allowed’	‘100% GW’	–	–	$ 0	$ 0
4	–	3.25 m	’No effects of currents applied’	‘51% GW’	2,211 NM	9.85 kn	$ 57,852	$ 15,964

Note: Warranted CP speed: 12.5 kn

Table 7.1 displays the potential claims with and without extrapolation for the chosen clauses, that are on opposite ends of the scale in terms of how many good weather days they are expected to yield. Notably, wordings that include ‘No adverse currents allowed’, result in no good weather days and no possibility to claim for underperformance. This builds upon the analysis in Chapter 6, suggesting that the selection of the current factor condition is an important element in charterparty negotiation. The results also suggest that when extrapolation is allowed, an increase in the number of good weather days, with the associated increase in good weather distance sailed, does not necessarily increase claims. This is because, with extrapolation allowed, it is sufficient with one day of good weather to establish underperformance and claim for the entire voyage. However, when there are more days to calculate performance, the possibility for a fair performance evaluation is higher.

For the specific 36-day voyage, with an average rate of 9,500 $/day the total hire cost is estimated to be around $ 342,000. Thus, with extrapolation allowed, the potential claim is around 16% of the total hire cost. For a charterer with numerous voyages a year, this can add up to substantial amounts.

Table 7.1 also displays the potential claims without extrapolation. Now, a claim can only be made for underperformance in periods of good weather. Therefore, adding more good weather days will potentially have a larger impact on the potential claims than when extrapolation is allowed. The case study shows that from the 36-day voyage from Port Elizabeth, South Africa to Tianjin, China with a Kamsarmax in July 2023, the average difference in potential claims from allowing for extrapolation vis-á-vis from prohibiting it, is $ 46,620.

In general, the results from the case study are aligned with the results from the analysis in Chapter 6, suggesting that more favourable definitions of weather conditions result in a larger claim. Nevertheless, the difference in claim potential is substantially more significant when clauses include wordings for no extrapolation compared to those that allow for it.

The above study answers our second research question, underscoring that there can be substantial effects from negotiating more favourable definitions of good weather conditions, from a charterer’s perspective. However, the study suggests that the most important is to establish at least one good weather day and that a combination of wordings that corresponds to ‘1.25 m wave height limits’, ‘100% GW’ and ‘No adverse currents allowed’ can make it very difficult to establish any periods of good weather, as well as to effectuate a claim.

Following the analysis in Chapter 6, the case study suggests that a charterer will benefit from more favourable definitions of good weather conditions, as this not only leads to a higher claim potential but also facilitates a more fair assessment of the vessel’s performance. More favourable definitions of good weather will also make it easier to establish underperformance and effectuate a successful claim in cases of underperformance.

8 Discussion

8.1 Performance clause development

From interviewing chartering experts from Western Bulk and analysing the 48 performance clauses in the charterparty data, spanning from 2012 to 2023 and categorising them into two periods, older (2012 – 2020) and present (2021 – 2023), a noticeable trend from older to present performance clauses emerges. As shown in Table 4.1, the trend is visible for all key elements in the performance clause except the Beaufort limit. Four components experienced a noticeable change:

i. Present performance clauses have more complex definitions of Douglas sea state 3.

ii. Present performance clauses are more reluctant to allow for adverse currents.

iii. Present performance clauses are more consistent in requiring ‘100% GW’.

iv. Present performance clauses are more reluctant for extrapolation.

The present performance clauses differ in their approach of defining the Douglas sea state 3. For clauses with a detailed explanation, these definitions are not uniform across the performance clauses; they vary between significant wave height, combined sea and swell, or a combination of these. Furthermore, the thresholds for these wave heights differ, with limits like 1.2 meters, 1.25 meters, and 3 meters applied in various ways.

Results from the analysis in Chapter 6 suggest that the most significant part of the expected number of good weather days is whether or not to allow for an adverse current factor. Generally, the trend in present performance clauses is an increasing tendency not to allow for such adverse currents.

The trend also shows that present performance clauses tend to more consistently require the entirety of the day ('100% GW') to be good weather, in order to classify the day as a 'Good weather day'. As highlighted by table 4.1, there was an almost ninefold increase of this requirement in present performance clauses.

Extrapolation enables the possibility of underperformance claims even during heavy weather periods. Similar to the previously mentioned aspects, there is a noticeable contrast between present and older performance clauses regarding the inclusion of extrapolation.

Interestingly, the development of the different elements within the performance clauses all converge in the same direction. More complex definitions of Douglas sea state 3 imply that the definition is more rigorous and sets a higher threshold for what can be considered ‘Good weather conditions’. The same can be said about the observations regarding the disallowance of periods with adverse currents. When such periods are regarded as heavy weather, more specific conditions must be met for the overall weather to be considered as ‘Good weather conditions’. Naturally, the ‘100% GW’ criteria follow this trend, ultimately limiting the possibility of achieving overall ‘good weather’. Since good weather is required to establish an underperformance and, thereby, a performance claim, this development will, in principle, make it more difficult to press such claims.

Despite this development, approval for extrapolation could serve as a counterbalance to these heightened requirements. As concluded in ‘The Gas Enterprise’ verdict, unless explicitly ruled out by the performance clause, the primary approach is to base claim calculation on extrapolation. This benefits the charterers, as it allows for more claimable days. It could also be argued that this approach is objectively fairer since an established underperformance in good weather periods also leads to high chances for the vessel to underperform in heavy weather periods. However, the problem for the charterers occurs as the present performance clauses more often prohibit extrapolation. When this is the case, instead of being a counterbalance, the development of less extrapolation functions as a strengthening force for less possibility of claimable days.

When combining these four observations and setting an overall stricter threshold for a ‘Good weather day’, it becomes apparent that this favours the shipowners, often at the expense of the charterers.

A relevant question is what factors contribute to this development in the performance clauses, favouring the shipowners at the cost of charterers. Market dynamics leading to an uneven power balance for either of the parties should be considered a clear indication of possible bargaining power in negotiations of these clauses. Fleet development and vessel speed are examples of some of the decisive market dynamics in the shipping industry.

Available tonnage directly affects the supply side of shipping. If the fleet development (that is, a combination of newbuildings and removals) is low, this indicates a stronger freight market relative to periods with higher fleet growth. Utilising Clarksons' Shipping Intelligence Network, the percentage of year-on-year fleet development is lower in the present period than in the older. From 2012 to 2020, the average year-on-year fleet growth was 4.3 per cent, while for the present period, 2021 to 2023, the growth corresponded to 3.1 per cent.

Vessel speed is another influential aspect of the supply side of shipping markets, as slow steaming requires more vessels to cover the demand. Naturally, slower speed will, therefore, relatively speaking and, similarly to fleet growth, indicate a stronger freight market. According to Clarksons Research, in the 2012 to 2020 period, the average sailing speed for bulk carriers was 11.45 kn, while in the 2021 to 2023 period, the average was 11.19 kn.

An indication of shipowners having increased bargaining power over charters in performance clause negotiations is increased freight rates. By using Clarksons Research to analyse the Baltic Exchange Dry Index's average points over the last ten years a noteworthy trend is revealed. From 2012 to 2020, the average stood at 1,059.6 points; from 2021 to 2023, it increased to an average of 2,049.03 points.

Despite considerable volatility, these levels indicate, on average, higher freight rates in the same period as the observed change in performance clauses that favour shipowners to a greater extent. The higher freight rates will shift the market bargaining power towards shipowners relative to charterers. With this enhanced market leverage, it's natural to infer that shipowners have capitalised on the opportunity to negotiate performance clauses more favourable to their interests. This aligns with the research of Veenstra and van Dalen (2011), as they suggest that market variables can lead to shipowners behaving more speculative in negotiations.

Another aspect of the observed performance clause development could relate to the increased focus on climate neutrality and the green transition in shipping. This focus has grown in and around the same periods we can observe a rise in the Baltic Dry Index, with the IMO 2020 sulphur cap, Energy Efficiency Existing Ship Index (EEXI) and the Carbon Intensity Indicator (CII) being the most apparent (International Maritime Organization, 2019). Despite these abatement tools being designed to lower the industry's total environmental footprint, they are formed in a way that affects the vessels directly – meaning that the shipowners are punished relatively harder for pollution than the other market participants who are equally dependent on the shipowner's vessel. This reality underscores the unique aspect of the principal-agent problem, where the principal (charterer) is less motivated than the agent (shipowner) to invest in energy efficiency measurements.

The uneven distribution of the consequences stemming from regulatory measures among market participants logically leads to those with greater market influence exerting their power to minimise the impact of these regulations on their operations. Shipowners, who may perceive themselves as disproportionately impacted by energy efficiency regulations, are incentivised to leverage their position to negotiate performance clauses that mitigate this imbalance. The analysis of performance clause development suggests this is occurring, as the benchmarks for identifying underperformance have risen in present performance clauses. Consequently, the repercussions stemming from the present clauses are lessened, allowing shipowners to better align regulatory compliance with their profit-maximisation goals.

Shipowners may leverage their current market power to negotiate favourable performance clauses for themselves, but the overarching commitment to environmental stewardship is likely here to stay. The increased focus on sustainability in the maritime industry, coupled with more strict IMO regulations, suggests that the focus on achieving climate neutrality is a permanent shift within the maritime industry, as well as the global economy.

This leads to an essential consideration: if the expenses associated with emissions become sufficiently high, could the reduction of emissions transition from a matter of regulatory adherence to a profit-maximising opportunity? In such a scenario, cutting emissions would align with environmental mandates and serve as a strategic approach to enhance profitability. Thus, for shipowners, where profit maximisation is crucial, the shipping industry may very well be a perfect market to implement abatement tools targeting the industry's profitability.

If shipowners leverage their position to sidestep the immediate impacts of stringent performance clauses, it might create an impression that environmental initiatives are adverse to business interests. Yet, a strategy aimed at maximising profits does not inherently conflict with a commitment to sustainability. As this industry evolves, the prevailing view supported by this thesis is that profitability and environmental sustainability can and should be mutually reinforcing goals.

8.2 Good weather definitions

The many variations in defining 'Good weather conditions' in performance clauses make a more complex environment for negotiations. Additionally, this enhances the principal-agent problem in the contractual situation due to asymmetric information.

Unclear clauses are subject to discrepancies when a charterer claims a deduction in hire due to poor performance, and can lead to substantial legal expenses. Although some clauses go a long way in detailing specific wave heights and conditions, the results from Chapter 6 also show that some of these detailed definitions can be argued to be unfair in describing weather conditions. In light of our analysis, the following sections discuss some main differences around the standard parameters defining good weather conditions in performance clauses.

8.2.1 Beaufort wind force 4

This condition is the easiest to define in advance and to measure post-voyage. Weather-routing companies have no problem proving whether Beaufort limit 4 has been exceeded, as it is derived directly from the wind speed. Table 3.1 shows that a limit of Beaufort limit 4 clearly states that winds cannot exceed 16 knots.

The Beaufort limit 4 also stands as an established industry norm that generally cannot be negotiated. This is supported by a descriptive analysis from Table 4.1 which shows that clauses typically adhere to this limit. Because of this, there are fewer disputes around this element.

8.2.2 Douglas sea state 3

As mentioned in Chapter 3.2.6, the Douglas Sea Scale is divided into two components: wind waves and swell. Ideally, one should provide information on both. However, in many instances, the swell aspect is omitted. This omission poses significant challenges for charters when claiming deductions in hire from bad performance in good weather conditions.

When referring to ‘Good weather conditions’, this typically implies a maximum Douglas sea state of 3. However, the problem is whether that consideration adequately accounts for swell. Sigafoose (2017) argues that when a Douglas sea state of 3 is cited in isolation without mentioning swell, there is evidence from an arbitration award from London for consensus that a 2 m swell height and a 1.25 m wind-wave (sea) height is indeed the preferable understanding for Douglas sea state 3. This equals a combined sea and swell limit of 3.25 m. Nevertheless, it can be argued that it is more precise to specify the sea and swell conditions separately.

According to Mazarakis (2019), an even more precise and straightforward approach for data-driven analyses of sea conditions is to measure significant wave height and define ‘Good weather conditions’ as a maximum significant wave height, dropping the Douglas Sea Scale altogether. From his standpoint, if the term Douglas sea state 3 comes up in a charter party without any reference to the significant or combined wave height, the significant wave height limit is 2.4 m.

These two definitions correspond by applying Equation 3.2 on the individual sea and swell limits mentioned above. A limit of 1.25 m sea height and 2 m swell height corresponds to a significant wave height of 2.4 m. The results from Chapter 6 build upon this observation because the two limits both yield the same ceteris paribus amount of expected good weather days. Hence, they both quote the same sea conditions.

However, it is essential to emphasise that even though 1.25 m sea height and 2 m swell height equals a significant wave height of 2.4 m, as well as a combined sea and swell height of 3.25 m. A combined sea and swell of 3.25 m does not necessarily equal a 2.4 m significant wave height. The term 3.25 m combined sea and swell can also equal a higher significant wave height than 2.4 m.

Table 8.1: Combined sea and swell vs Significant wave heights

Sea height	Swell height	Combined sea and swell	Significant wave height
0.00	3.25	3.25	3.25
0.25	3.00	3.25	3.01
0.50	2.75	3.25	2.80
0.75	2.50	3.25	2.61
1.00	2.25	3.25	2.46
1.25	2.00	3.25	2.36
1.50	1.75	3.25	2.30
1.75	1.50	3.25	2.30
2.00	1.25	3.25	2.36
2.25	1.00	3.25	2.46
2.50	0.75	3.25	2.61
2.75	0.50	3.25	2.80
3.00	0.25	3.25	3.01
3.25	0.00	3.25	3.25

Table 8.1 demonstrates the relationship between the significant wave height and the combined sea and swell. It shows that, for instance, if the sea state is 3 m sea height and 0.25 m swell height, there is still a 3.25 m combined sea and swell, but now the significant wave height is 3.01 m. According to Mazarakis (2019), this exceeds DSS3. From the table, it is evident that only a tiny portion of the combinations of sea and swell that result in 3.25 m also equals a significant wave height greater than or equal to 2.4 m. This supports the statement that significant wave height is a more precise way to describe and measure the exact sea state that a vessel would experience.

As mentioned, the direct interpretation of Douglas sea state 3 is to treat sea and swell separately and, according to Sigafoose (2017), this means a includes of 2 m swell height. Although this is not stated explicitly in the clause, some weather routing companies tend to adhere to this limit when estimating good weather days, in addition to the other elements. The use of a significant wave height limit of 2.4 m also accounts for this swell part, ensuring that periods of adverse influence of swell (that is, a swell height above 2 m) are not included in the definition of good weather. As detailed in Table 8.1, the significant wave height limit of 2.4 m incorporates the limit for a swell height of 2 m. This strengthens the argument that it is more precise to quote the two heights with a single significant wave height instead of using the combined sea and swell.

The analysis of present performance clauses suggests that several CPs now specify a maximum significant wave height, aligning with the above conclusion. However, there's a substantial inconsistency in how common performance clauses use the Douglas Sea Scale in conjunction with quotations on wave heights. For instance, clauses that mention "Douglas sea state 3, and a significant wave height of maximum 1.25 meters" only capture part of the Douglas Sea Scale, overlooking the swell wave part.

This conflation of terms can lead to uncertainty and inefficiency, and when applied, the clause will refer to a Douglas sea state much lower than 3. This makes the performance clause unreasonable for charterers and less effective in adequately punishing underperformance, which is their intended use.

8.2.3 Current factor condition

As covered, currents can be both adverse or favourable for a vessel's performance. A common approach in present performance clauses is to explicitly treat periods where the vessel's speed is affected by adverse currents as heavy weather periods, leaving them out of the performance evaluation. The alternative approach would be not to consider the effect of currents when defining good weather conditions but rather to credit the adverse current to the vessel's speed when calculating performance in good weather periods. If so, the question that arises is whether favourable currents shall be debited from the vessel's speed when calculating performance in periods of favourable currents. As shown from our analysis, whether to leave periods out of performance evaluation or not is the most important element related to the expected number of good weather days.

The two approaches of treating currents leave room for different incentives for the master operating a vessel. Watson Farley & Williams (2020) argues, "Given environmental concerns, it might be imprudent for a tribunal to penalise shipowner for taking advantage of positive current to reduce RPM and bunker consumption." In a 2012 London arbitration, the tribunal dismissed the primary approach of classifying a period of adverse current as heavy weather, favouring the alternative method described above (Watson Farley & Williams, 2020). However, as presented in Chapter 2.5.3, 'The Divinegate' ruling from 2022 acknowledged that favourable currents could be significant for the vessel's performance but that they generally should be excluded from performance evaluation, reverting to the primary approach. The arbitrator explicitly stated that this is because a master should not be punished for finding a favourable current since this is in everyone's interest. After all, the vessel will sail faster and consume less fuel.

One effective solution to this dispute is to exclude currents when defining good weather, aligning with the alternative approach. Adverse currents would be credited to the vessel's average speed, while favourable currents would not be debited from it. This approach would still incentivise the master to find favourable currents. As presented in Chapter 2.4, studies have shown that wave and wind conditions significantly influence ships (Carlton, 2018), while current and swell conditions have less influence (Abebe et al., 2020). This aligns with the latter solution, supporting the idea that periods of adverse currents should not be left out of performance evaluation. For example, if the average current factor for a given weather day is -0.1 knots, leaving this period out of the evaluation can be argued to be unfair, as it is expected to have a negligible influence on performance.

We argue that the better solution is to include these periods in the performance calculation and credit the negative current factor to the vessel's average speed. With this, one would ensure more transparency in performance by preventing vessels from hiding poor performance behind what was earlier defined as heavy weather, but also incentivise the master to find favourable currents, aligning with environmental concerns.

8.2.4 Good weather amount condition

Until now, the limits of weather measurements in defining weather conditions have been discussed. However, in the definition of a 'Good weather day' in performance clauses, it is also essential to consider how long of a continuous period the weather has to be good for it to be considered a good weather day. The 'good weather amount condition' comes into play as different clauses open for different interpretations.

One of the experts from the weather routing company StormGeo stated in an interview that the primary approach for weather routing companies when calculating the performance of vessels is to explicitly treat periods of 24 hours of consecutive good weather conditions ('100% GW') as a 'Good weather day' (B. A. Townson, personal communication, 5 September 2023). The alternative approach is to treat days where the majority of the 24 hours is good weather ('51% GW') as a good weather day. Some clauses also explicitly state that this 24-hour period has to be recorded from noon to noon.

The different approaches are subject to discrepancies and are often decided in courts. As outlined in the literature review, in a 2015 London arbitration, the arbitral tribunal ruled that to qualify as an admissible period of good weather, such a period must consist of 24 consecutive hours, from noon to noon, in line with the primary approach (Polaris Shipping Co Ltd v Sinoriches Enterprises Co Ltd, 2015). This determination was founded on the maritime tradition that noon to noon traditionally is considered a ship's day.

However, after the charterer appealed to the High Court in London, the judge ruled that the arbitral tribunal had made a legal mistake. The high court held that the term 'Good weather' in the charterparty did not necessarily imply a continuous 24-hour period from noon to noon. Furthermore, the judge noted that the charterparty contained no wording supporting the interpretation of good weather as a full 24-hour day, beginning at noon (North P&I Club, 2016).

Seen in the light of the ruling, it's essential that the wording in the charterparty explicitly defines what constitutes a 'Good weather day' to avoid legal disputes post voyage. Should the intent be to exclude periods of good weather less than 24 consecutive hours, this should be clearly articulated in the performance clause.

Our analysis showed that the 'Good weather amount condition' was the least important element in the definition of a 'Good weather day'. The logic behind this is that if 51% of a day has good weather, the rest of that day is likely to have good weather as well because weather tends to change gradually over time. For charterers, this means that negotiating the other elements in the definition of good weather will provide more value.

8.3 Environmental impact

As covered in Chapter 2.2, the industry's environmental footprint is among the most significant challenges that shipowners, charterers, and other market participants face today. The industry consensus combines several aspects to reach carbon neutrality, including regulatory pressure, financial incentives, and end-user expectations (DNV, n.d.).

Performance clauses could be one of the many drivers contributing to a more environmentally friendly industry, mainly by incentivising the use of fuel-efficient vessels.

All else equal, a charterer who pays for bunkers will always prefer efficient vessels over higher fuel-consuming alternatives. With performance clauses being the only clause in the charterparties concerning fuel efficiency directly, these clauses could, on many occasions, be a vital part of the charterers' decision when selecting a vessel. Naturally, this preference would accumulate in the most fuel-efficient vessels to be chosen every time, incentivising shipowners to run fuel-efficient vessels.

However, this argumentation rests on the assumption that the performance clauses are effective in punishing underperformance and that the warranted performance of the vessel can be trusted. With quotations on 'Good weather conditions' that are too strict for what is the intended limit of heavy weather, the performance clause becomes dysfunctional. As long as the performance clauses do not adequately punish underperformance, and the freight income from winning contracts is higher than a potential underperformance claim, shipowners will be incentivised to oversell their vessels in order to obtain higher rates, with a low risk of consequences for doing so. The results from our analysis show that wave height limits below a significant wave height of 2.4 m or a combined sea and swell below 3.25 m result in a larger principal-agent problem, where both parties are incentivised to behave more speculative. A clearer formulation of the performance clauses will mitigate the risk of shipowners overselling their vessels and contribute to the intended purpose of performance clauses. Pertaining to that, the positive environmental effect caused by fuel-efficient vessels will happen as a consequence of improved performance clauses but nevertheless be a welcomed side effect for the industry. However, for performance clauses to actually change, charterers must be aware of what elements they should negotiate in the contracts and understand the economic value of different wordings.

Although fuel-efficient vessels are more environmentally friendly than higher-consuming alternatives, central to this discussion is whether the methods used to meet the preference for modern tonnage are overall beneficial for the environment.

To meet this preference, should the shipowners scrap older but still usable vessels and build new ones? This is undoubtedly costly for the owners but could also be very damaging from an environmental point of view. Although the majority of a vessel's total environmental footprint originates from its operations, a significant amount stems from the shipbuilding - and dismantling process. Built to last for 25 – 30 years, scrapping a vessel prior to this age to meet environmental expectations seems contradictory. According to Clarksons Research, in 2022 and 2023, the average demolition age for bulk carriers was 27 years, which must be considered an acceptable retirement age from an environmental perspective. However, the increased focus on sustainability in the industry implies that modern vessels will be increasingly preferred. The same applies to the stricter emission regulations enforced by the IMO. Many shipowners will find the cost of upgrading to meet the required CII ratings too high, resulting in a rise in demolitions and a decrease in the average scrap age (Rasmussen, 2023).

A middle ground in promoting fuel-efficient vessels and premature demolition is through energy-saving retrofitting. This process can involve installing modern technologies, upgrading engines, fitting solar or wind harnessing devices, and other enhancements. According to Bureau Veritas Bureau Veritas (n.d.), retrofitting could not only extend the expected lifespan of a vessel but also enhance its environmental performance. However, retrofitting presents financial challenges for shipowners. These costs stem from various sources, including the acquisition of equipment, yard expenses, and the potential loss of operational income while the vessel is out of service. Furthermore, the precise impact of retrofitting on performance and efficiency can be hard to predict, introducing a degree of business risk for the owner.

8.4 Economic benefits

Our research has shown how distinct wordings in performance clauses can cause substantial financial value for charterers. However, a relevant question is whether such financial adjustments should be categorised as cost savings or merely as deductions for expenses that the charterers were not rightfully obligated to bear in the first place.

Suppose the premise is that performance clauses are meant to provide a fair warranty of fuel consumption. In that case, one can argue that more balanced performance clauses don't necessarily create savings for either party but instead level the playing field regarding financial power. However, the economic impact for charterers will manifest as a tangible expense reduction regardless of the technical classification. This is reflected in dollars deducted from hire, compared to a scenario with no deductions. In practical terms, such a reduction is likely to be perceived as a cost-saving by the charterers, even if it may not be technically defined as such.

Although this thesis proposes modifying variables to facilitate smoother handling of performance claims, which in turn can reduce the likelihood of litigations, it recognises disputes are, to some extent, inevitable. This research aims not to eliminate all types of conflicts but to suggest a formulation of the clauses that can make such disputes more efficient and straightforward.

Legal proceedings can be expensive, removing a big part of a potential claim, a fact highlighted in the Eastern Pacific Chartering Inc v Pola Maritime Ltd (2022) dispute. Expensive legal proceedings also question which party possesses the greater financial resources to dedicate to these processes. By improving the clarity and concreteness of performance clauses, clearer expectations for both parties can be established. This approach can make any disputes that arise more manageable and less costly for all parties, fostering a more equitable and transparent conflict resolution procedure.

As previously highlighted, enhancing performance clauses can encourage the adoption of more fuel-efficient vessels and make the warranted speed- and consumption more reliable. This will not only be advantageous for the environment but could also offer economic gains for the charterers because the vessels they choose are the most fuel-efficient alternative, thereby the most cost-effective option.

The economic advantages identified in this thesis are readily apparent for charterers. However, defining the impact for shipowners may present a more significant challenge. Nonetheless, it is crucial to emphasise that this thesis should not be interpreted as economically detrimental for shipowners. On the contrary, while the benefits might be less direct or immediate, there are still notable positive implications for shipowners in the long term, stemming from the adoption of more efficient and transparent performance clauses.

As covered by Adland et al. (2017), shipowners should expect that more fuel-efficient vessels achieve higher rates than their less efficient counterparts. This is also the case, but not to the extent of what you can expect, as the researchers showed that shipowners typically recoup only about one-fifth of the realised fuel savings.

Improved fuel efficiency, however, inherently reduces operational costs, enhancing overall vessel profitability, even if the charter rates do not fully compensate for the increased efficiency. Additionally, in a regulatory environment increasingly focused on emissions cuts and bunker expenditure, fuel-efficient ships reduce compliance costs and maintain higher resale values. Finally, more efficient operations mitigate risk associated with fuel price volatility, contributing to more robust financial planning and risk management. This is relevant, as most vessels also operate in charterparties where the owners must cover the bunkers themselves. Overall, these factors offer economic benefits beyond direct fuel cost saving.

Will better performance clauses be beneficial for all shipowners, though? This thesis suggests that better performance clauses will incentivise efficiency, as overselling the vessels will be more effectively penalised through performance claims than it currently is.

Implementing better performance clauses and emphasising efficiency naturally favours ships already excelling in this area, while less efficient vessels may find themselves at a disadvantage. This trend is substantiated by charterer's and cargo owners' preference for modern tonnage, which is intrinsically linked to fuel efficiency. Modern vessels offer economic fuel consumption, enhanced predictability, a stronger market reputation, and greater cargo capacity – and efficiency. Consequently, shipowners with fuel-efficient fleets will likely be more appealing to these charterers and cargo owners, potentially attracting more business. This means better performance clauses predominantly benefit those with newer, efficient fleets at the cost of those with ageing, more fuel-intensive vessels.

8.5 Increased transparency

Due to their inherently technical nature and the wide variety they encompass, performance clauses can be challenging to comprehend, even for the parties directly involved. A better understanding and possible quantification of the different elements in the performance clauses will show the actual effect of such clauses and make potential disputes less severe. Increased transparency will benefit all the parties affected by the performance clauses.

For shipowners, two perks from increased transparency stand out as prominent: market reputation (attractiveness to charterers and customers) and trust. High transparency enhances a shipowner's trust and market reputation, appealing to potential charterers and end-users of the transported cargo. As explained by Bateman and Bonanni (2019), the entire customer base, encompassing governments, businesses, and private households, is progressively valuing attributes such as precise and predictable performance clauses. These stakeholders are showing a growing interest in the transparency of their entire value chain, which also includes the transportation phase. Performance clauses play a crucial role in this, as they directly impact the perceived reliability and accountability of the transport segment of the value chain.

Trust and transparency are closely connected with the workplace environment and business performance (Lakhdar & Lindblad, 2022). These attributes enhance organisational efficiency and boost economic performance, underscoring their importance as critical objectives for all shipowners.

For charterers, the array of potential benefits of increased transparency in performance clauses is diverse but substantial. Among these, the aspect of predictability emerges as particularly prominent. With predictability, charterers can more precisely estimate the economic effects of heavy weather. Despite better performance clauses and higher transparency, it does not change the actual weather conditions in the areas where the vessel operates. With better performance clauses and increased predictability, heavy weather's economic risk will be lowered, as the performance claims are less exposed to coincidences and based more on facts. Improved predictability and more reliable performance clauses will enhance charterers' decision-making; if they can trust the performance clauses and relate to a somewhat standardised performance claim process, they can make more informed decisions when selecting vessels.

8.6 Time charter industry-standards

As a final remark for the discussion on the quotations of 'Good weather conditions' in performance clauses in the dry bulk segment, a comparison of such clauses in the tanker segment's equivalent is an interesting approach. The broad standardisation of time charter contracts within the different shipping segments makes it interesting to look for more efficient practices.

The New York Produce Exchange form (NYPE) is the most frequent time charter contract used in dry bulk shipping (BIMCO, n.d.). Subsequently, as time charter contracts are the most common of the different charterparties, the NYPE is therefore the most used contract in dry bulk shipping. Revised and updated several times since its origin in 1946, the NYPE 2015 is currently the latest version of the standard contract. Of the 57 clauses in NYPE 2015, clauses eight and nine deal directly with the vessel's performance and fuel consumption (BIMCO, n.d.). Although the NYPE 2015 sets the foundational criteria for identifying underperformance, it does not prescribe a specific methodology for its calculation.

Like the NYPE 2015 in the dry bulk market, the Shelltime 4 forms the standard charterparty contract for the tanker market. Created by Shell International Trading and Shipping Company in 1984, the revised version from 2003 is still the most popular for tanker time charters (Kasi, 2021).

Generally, tanker time charter contracts tend to go further in defining how deductions for underperformance are to be applied and how potential underperformance claims are to be calculated. In contrast, dry bulk time charter agreements, typically based on the NYPE format, offer less clarity on this matter (Watson Farley & Williams, 2020). When an underperformance under the NYPE 2015 contract is established, the parties must decide how the underperformance should be calculated. An underperformance will, therefore, not guarantee a successful speed and consumption claim in the event of underperformance. Consequently, identifying underperformance is less influential for charterparties on the NYPE 2015 form than for Shelltime 4.

9 Conclusion

This thesis has investigated the practice of understating weather limitations for performance evaluation in dry bulk shipping time charter contracts. With the angle of a principal-agent problem, we have examined the misalignment of incentives between shipowners and charterers in a contractual situation. Earlier research has established that such a misalignment is present.

To mitigate this misalignment and to make performance clauses more transparent in their enforcement, charterers must understand what elements to negotiate and the economic value of different wordings. This will contribute to levelling the bargaining power in contractual situations. Our discussion also implies that this can have a positive environmental effect, indicating that more transparent and functional performance clauses will lead to an increased demand for fuel-efficient tonnage. The fact that performance clauses directly state warranted quotations on a vessel's efficiency makes the need for charterers to leverage this knowledge in negotiations even more relevant.

Through different random forest models, where the expected number of good weather days is related to the definition of a 'Good weather day', we have established that charterers should focus on negotiating the current factor condition to increase the expected number of good weather days. Additionally, earlier research suggests that currents, compared to wind and waves, have the most negligible effect on vessel performance. Therefore, we argue for the solution of allowing for all currents when calculating a vessel's performance, with any adverse currents being credited to the vessel's average speed. However, we also argue that favourable currents should benefit the vessel as it would be undesirable to punish a master for finding favourable currents and saving fuel, both economically and environmentally.

Further, through analysis, we have established that when the Beaufort limit is non-negotiable, charterers should negotiate significant wave height up to but not exceeding 2.4 m or combined sea and swell up to but not exceeding 3.25 m. A limit above this would not only make a negligible difference in the expected number of good weather days in conjunction with Beaufort 4, but it would also quote wave heights that are worse than the Beaufort limit refers to. Additionally, we shed light on the fact that common performance clauses today quote wave heights that refer to a Douglas sea state much lower than 3, benefiting the shipowner at the expense of the charterer. The results from Chapter 6 suggest that the 'GW amount condition' is the least essential element in defining a 'Good weather day' in relation to the expected number of good weather days.

The case study reveals that the growingly common wording regarding extrapolation of performance in present clauses significantly influences the potential claim in dollars. From a 36-day Kamsarmax voyage from South Africa to North China the average difference in potential claims from allowing for extrapolation vis-á-vis not doing so is $ 46,620 when comparing clauses that are on opposite ends of the scale in terms of how many good weather days they are expected to yield. The case study also suggests that when a clause states no extrapolation, it is even more important to negotiate weather conditions limits in line with the conclusion above, as this gives more days to claim deductions in hire form.

Ultimately, this thesis proposes a path towards more transparent and efficient contractual arrangements in the time charter segment of dry bulk shipping. The industry can move towards more equitable and less speculative practices by addressing the principal-agent problematics and mitigating them by providing knowledge on the influence of the different elements going into negotiations.

9.1 Limitations

This thesis has partially pointed to a shift in the wording used in performance clauses in dry bulk time charter contracts. Nevertheless, a more extensive analysis encompassing a broader range of charterparty data is required to generalise these results and establish a significant change.

Regarding weather data, the dataset includes multiple observations for each day. These observations have been categorised by date, deviating from the conventional practice of defining weather days as 24-hour periods from noon to noon. Due to the varying number and timing of daily observations, the most feasible method was to consider a weather day as 24 hours from midnight to midnight. Although this method differs from traditional interpretations of performance clauses, it does not statistically affect the results. A weather day is still 24 hours, and each weather observation is assigned to its respective weather day.

Due to the lack of charterparty data, only a case study was conducted for the financial implications of claims related to the wording of ‘Good weather conditions’. However, a more comprehensive analysis is required to generalise the results.

9.2 Further research

There is some scope for further research on the topic of good weather quotations in performance clauses. First, our analysis has been based on weather data, particularly examining the nature of the relationship between the parameters used to define good weather and the expected number of good weather days. Further research could shed more light on the exact formulation of a principal-agent type time charter contracting model regarding the selection of good weather definitions. In such a model, the agent’s utility would have to be made dependent on market (that is, freight rates) variables.

Further research could also look into the shipowner or charterers’ contractual behaviour related to the exact relationship between good weather definition and the leverage variations in time charter contracting. How has the wording in clauses changed over time? Utilising tabular data with comprehensive information on charterparties or conducting textual analyses on time charter contracts to analyse these changes could be relevant to understanding how shipowners have changed their priorities over time.

Employing charterparty data, including information on warranted vessel speeds and fuel consumption in conjunction with performance data and weather data, could also provide ground for further research. This data could be utilised to develop a more extensive model that relates the size of a potential underperformance claim to various explanatory variables, like contractual wordings, similar to this study, but also market variables and vessel attributes.

Nevertheless, our discussion highlighted that researching performance clauses, which outline a vessel’s efficiency in time charter contracts, is an increasingly interesting field in light of growing environmental concerns.

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Appendices

A List of Variables in Weather Data

Table A.1: Explanation of variables (Weather Data)

Variable	**Unit**	**Range**	**Interpretation**
VoyageID	–	Unique for each voyage	A unique code for each of the 5,038 voyages in the dataset
Date	Date and Time	1 Jan 2019 00:00 to 19 Oct 2023 23:53	The exact date and time of the weather observation, with 79,352 unique weather days
Weather Day	Integer (Days)	1 to 79,352	Grouping of rows that together represent a weather day (that is, a 24-hour period)
Position	Degrees (Lat, Lon)	(63, 180) to (-55.9, -180)	Latitude and longitude of the vessel at the time of weather observation
Wind Speed	Knots (kts)	0 kts to 56.6 kts	Speed of the wind at the time of the weather observation, measured in knots
Swell Height	Meters (m)	0 m to 9 m	Approximate average height of the top one-third of the sea swell
Sea Height	Meters (m)	0 m to 8.8 m	Approximate average height of the top one-third of the wind waves
Current Factor	Knots (kts)	−4 kts to 4 kts	Ocean current speed experienced by the vessel in relation to its intended path, measured in knots
Beaufort Wind Force	Scale	0 to 11	Category of wind speed, derived from Beaufort scale
Combined Sea & Swell	Meters (m)	0 m to 14.8 m	Sum of sea height and swell height at the time of the weather observation
Significant Wave Height	Meters (m)	0 m to 10.5 m	Approximate average height of the top one-third of the total waves (sea or swell)

B Distribution Plots of Variables in Weather Data

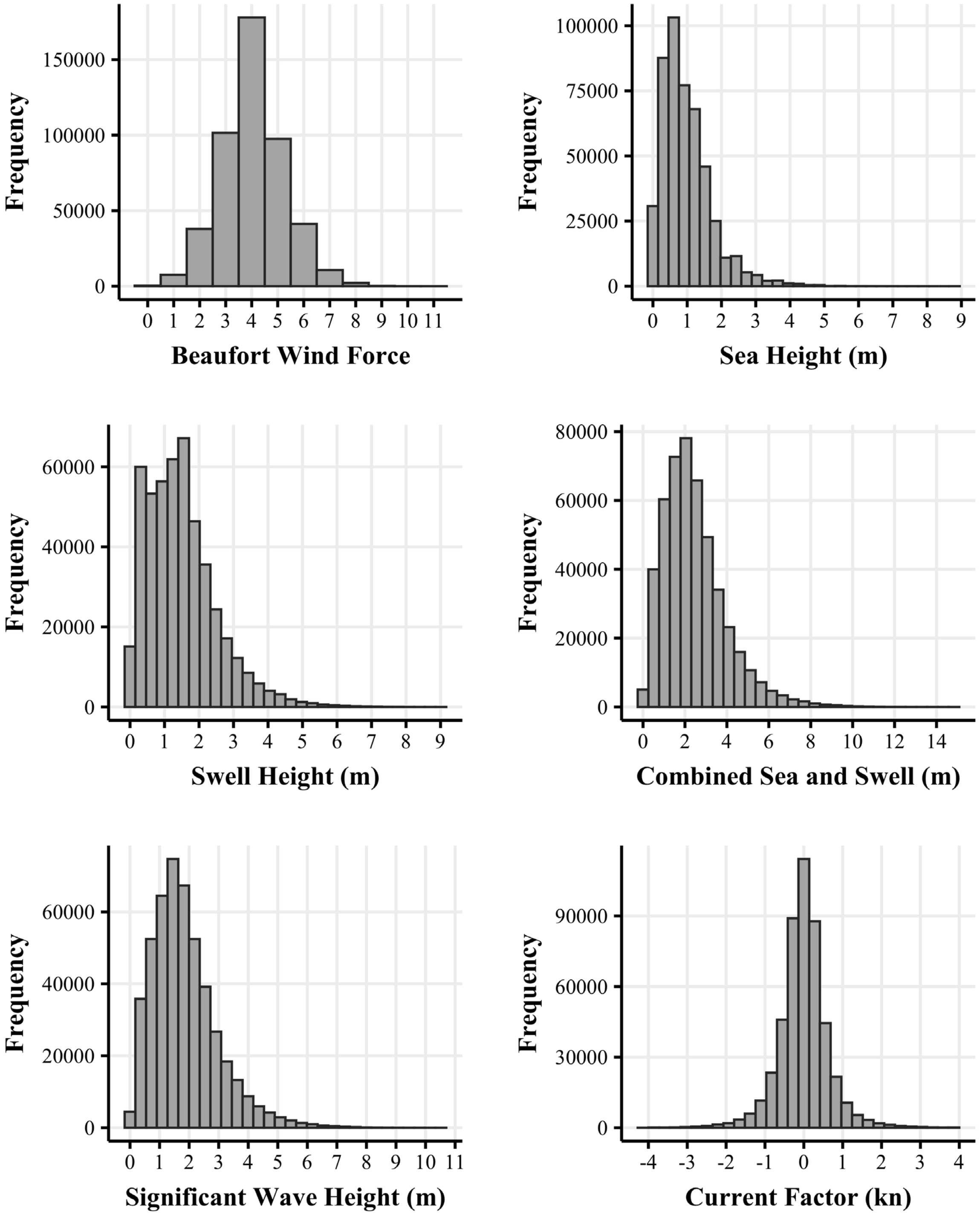

Figure B.1: Distribution plots of variables in weather data