Norwegian School of Economics

Bergen, Spring 2022

The Contractual Pillar of Maritime Decarbonisation

A study on the challenges and potential of improving energy efficiency in shipping through contractual means

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Master thesis, MSc in Economics and Business Administration,

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Abstract

Climate change has grown into an increasingly important concern for the shipping industry, but the contractual infrastructure of bulk shipping has not fully evolved to reflect this. As a result, this thesis examines the challenges and potential of improving energy efficiency in shipping through contractual means. In particular, we focus on how charterparties could be adapted to both encourage and enable more efficient ship operations, while also recognising that stakeholders such as shipowners, charterers and cargo owners often have conflicting interests. Furthermore, we also examine the key challenges in revising chartering contracts both generally and specific to different efficiency-oriented contractual solutions. Properly aligning charterparties and all stakeholders' interests with operational efficiency is important since chartering contracts serve as the underlying framework of international shipping.

We combine a literature-based analysis with interviews of key stakeholders in the shipping value chain to not only synthesise previous research results, but also explore how industry experts currently perceive the promise and limits of efficiency-oriented contractual changes. Firstly, we expand the literature by examining the common barriers to revising chartering contracts. Secondly, we review the current status of just-in-time arrivals, particularly when requiring contractual changes, and analyse how policy interventions such as carbon pricing and the upcoming CII regime could also contribute to tackling operational inefficiencies through contractual means. Finally, we evaluate more recent efficiency-linked contractual innovations and assess the challenges they are facing or might face in the future.

Our findings suggest that policy interventions are necessary to incentivise more efficient ship operations, but their effectiveness depends heavily on stakeholders' willingness to adapt contractual structures and fixture behaviour accordingly. As the status quo is maintained by stakeholders' vested interests, external stimuli are generally required to motivate widespread contractual changes. Furthermore, although charterers and cargo owners play a crucial role for revising charterparties, they have varying responsiveness to price signals and interest in proactively reducing their shipping emissions, which creates some difficulties for improving energy efficiency through contractual means.

Keywords: charterparties, operational efficiency, sustainable shipping, just-in-time arrival, carbon pricing, CII, contractual innovation

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1. Introduction

Shipping is often identified as the most energy efficient and cost-effective mode of transport, but the International Maritime Organization's (IMO) Fourth Greenhouse Gas (GHG) Study nevertheless estimated that shipping alone contributed almost 3% to global GHG emissions in 2018 (IMO, 2021a). While the energy efficiency of the global fleet has steadily improved throughout recent decades, total shipping emissions have still increased on the back of growth in world seaborne trade (Bouman et al., 2017). Given the nature of the shipping as a 'hard-to-abate' sector, its share in global emissions is expected to continue growing as international trade expands and other industries decarbonise faster (Chen et al., 2019). At the same time, the IMO has established its 2050 targets of reducing international shipping's total annual GHG emissions by 50% and CO_2 emissions per transport work by 70% compared to 2008 levels (IMO, 2018). For such ambitious targets to be successfully met, decarbonisation must become an integral part of the industry's operational logic, despite the IMO suffering from institutional erosion and remaining divided on policy measures that could further incentivise market-driven emission reductions at the global level (Monios & Ng, 2021).

Upcoming IMO regulations, including the Carbon Intensity Indicator (CII) and the Energy Efficiency Existing Ship Index (EEXI), as well as the expansion of the European Union Emissions Trading System (EU ETS) into maritime transport are being implemented from early 2023 onwards (European Commission, 2021; IMO, 2021b). Although these policy measures will certainly contribute towards maritime decarbonisation, the most important keys to emission reductions arguably lie in the collective hands of shipowners, charterers and cargo owners. The widespread implementation of emission reduction measures has thus far been hindered by various energy efficiency barriers, and significant inefficiencies remain in both ship operations and the charter market (Rehmatulla & Smith, 2015a). The contractual framework of bulk shipping, structured through bilateral contracts known as charterparties, also has a substantial role in maintaining existing inefficiencies and does not often actively reward energy efficiency (Plomaritou & Papadopoulos, 2017; Psarros, 2017). This lack of efficiency-oriented contracting can be explained by the vested interests of stakeholders in the status quo and the conservatism of market actors given how highly commercial and legal certainty are valued (Davies, 2020; Rehmatulla & Smith, 2015a). Indeed, by allowing the contracting parties to agree freely on contractual arrangements, the freedom of contract can both discourage and enable the adoption of more efficiency-oriented chartering contracts.

As the interests of all stakeholders (namely shipowners, charterers and cargo owners) in the shipping value chain should be aligned to effectively facilitate maritime decarbonisation, both academics and industry experts have increasingly underlined the need for revising contractual frameworks and finding new contractual solutions that enable as well as motivate more efficient ship operations (Dirzka & Acciaro, 2021; Jafarzadeh & Utne, 2014; Kylstad, 2022; Zografakis, 2021). Whereas previous research has extensively studied the energy efficiency barriers in shipping and their underlying causes (Jafarzadeh & Utne, 2014; Johnson & Andersson, 2016; Rehmatulla, 2014; Rehmatulla & Smith, 2015a), this thesis examines how charterparty revisions and new contractual innovations could both encourage and enable more efficient ship operations, while also accounting for stakeholders' differing interests. Additionally, we analyse the challenges of revising chartering contracts both at a general level and specific to different contractual solutions. We focus on how emission reductions can be achieved through improved operational efficiency, but discussion on how contractual changes could increase the uptake of technical measures is also included where appropriate. The research questions of this thesis can therefore be stated as follows:

- How can charterparties be adapted to enable and encourage all stakeholders towards more efficient ship operations with regards to emissions?
- What are the key challenges and prerequisites for facilitating widespread adoption of contractual solutions that could improve operational efficiency?

The main objectives of this thesis are three-fold: (i) analyse the common barriers to revising charterparties; (ii) overview the current status of efficiency-oriented contractual solutions and assess the potential of policy interventions to incentivise operational efficiency through contractual means; and (iii) evaluate the potential and challenges associated with more recent contractual innovations that are being currently developed or have been proposed by industry experts. Therefore, this thesis contributes to the academic literature by not only reviewing well-established contractual solutions (e.g. just-in-time arrivals), but also by analysing the feasibility of newer contractual innovations that have yet to be evaluated by earlier research. Similarly, we examine whether higher energy efficiency can be facilitated by incorporating CII-related provisions into charterparties since this has not yet been examined by literature. When examining the ways in which policy interventions can intertwine with contractual revisions, we concentrate on the CII regime and carbon pricing since these are upcoming regulatory measures that could have a tangible influence on vessels' operational efficiency.

This study focuses on bulk shipping, also known as tramp shipping, which is characterised by irregular trading patterns and a fragmented market structure (Stopford, 2008). The thesis adopts a qualitative methodology since the issues under examination have yet to be widely implemented in the market, and a heavily quantitative approach is thus not appropriate. We combine a literature-based analysis with semi-structured expert interviews to both (i) provide an overview of previous literature that addresses our research questions and (ii) draw new insights from interview data about the feasibility of efficiency-oriented contractual revisions and the challenges for their implementation.

The remainder of this study will be structured as follows. Section 2 outlines the methodology of the thesis. Section 3 first provides a brief background on key concepts for the thesis and thereafter presents a literature-based overview of inefficiencies in ship operations and their underlying causes. Section 4 examines common barriers to updating chartering contracts, including wider adoption of efficiency-improving contractual changes. Section 5 examines just-in-time arrivals and the facilitative role that certain policy interventions (i.e. the CII regime and carbon pricing) could have in motivating higher operational efficiency through being incorporated into charterparties. Thereafter, Section 6 evaluates newer contractual innovations in light of related literature and expert interviews. Section 7 discusses our main findings and contributions to the current body of literature. Finally, Section 8 presents conclusions, the limitations of the study and possible avenues for future research.

2. Methodology

This section outlines and justifies the methodological choices made in this thesis. We apply a qualitative research design, which combines a targeted literature review with semi-structured expert interviews of relevant stakeholders in the maritime value chain.

Targeted literature review

A literature review collects and synthesizes existing literature related to the research questions (Snyder, 2019), thereby providing a solid foundation for future empirical work and theory development. The literature review component of this study is mainly relevant for Sections 3–5 where the discussed topics have, to varying extents, already been discussed in previous research. A systematic literature review has not been conducted since our purpose is not to comprehensively review all topic-related literature, but instead to leverage literature selectively to inform our answers to the posed research questions. Moreover, by contrast to traditional literature reviews, expert interviews are incorporated alongside previous research as a primary data source that provides contemporary industry insights. The balance between earlier literature and interview data varies throughout the sections due to existing gaps in both data sources. Section 6 focuses on newer contractual innovations and leverages the interview insights and related literature to critically evaluate their potential and practical challenges. Indeed, directly topical research does not exist yet for the discussion in Section 6 due to the recentness of the examined initiatives and industry proposals.

With regards to Sections 3–5 of the thesis, the literature collection strategy was initiated by a broad database search followed by reverse snowballing, meaning that citations from relevant research were used to identify additional relevant literature (Webster & Watson, 2002; Wee & Banister, 2016). The initial search stage utilised search terms such as 'energy efficiency AND charterparties', 'carbon pricing AND maritime,' 'virtual arrival', 'just-in-time arrival' and 'CII AND shipping'. Although most of the identified literature consists of journal articles and academic books, some grey literature and industry commentaries have also been included, particularly in relation to more recent policy developments (e.g. the CII) that have yet to be extensively examined in academic research. To restrict the scope of our research, the literature pool was finally filtered based on (i) relevance to the research questions, (ii) recentness of the publication as well as (iii) credibility of the author(s) and possible publisher. When analysing how policy facilitation intertwines with contractual changes in

Section 5, the included literature only includes research that has direct relevance to the contractual element of these policy interventions.

Semi-structured interviews

Twelve expert interviews were conducted during spring 2022 to collect primary data on industry thinking regarding the potential and challenges of efficiency-oriented contractual solutions. To ensure the anonymity of interviewees, all participants are identified in this thesis only by their generalized professional role and industry viewpoint. All of the interview sessions took between 45 and 90 minutes. Written notes were made based on the interviews and processed using qualitative content analysis methods (Mayring, 2004). The sessions can be characterised as 'expert interviews' since the interviewees are considered 'experts' in their respective fields based on their profession and domain-specific knowledge (Meuser & Nagel, 2009). Expert interviews are focused on collecting specialist knowledge relating to the topic of study from the interviewees (Flick, 2009). Given that the interviewees are either shipping professionals or have a close affiliation with the industry, they may also possess practical insider knowledge that is only accessible through one-on-one conversations (Bogner et al., 2018). Because this thesis seeks to capture current industry thinking on potential contractual revisions, expert interviews are the most suitable complement to a literature-based analysis given that previous academic research alone cannot encapsulate the most recent industry developments at the practical level (Gillham, 2005).

Table 1 provides an overview of the expert interviewees. Relevant stakeholders range from shipowners and ship operators to charterers and industry associations as well as maritime technology providers and maritime lawyers. The experts' insights are used as references (referred to as *Int. X* or *Interviewee X*) across Sections 4–6, which represent the main findings of this thesis. Purposive sampling was used to gather relevant experts as the interviewees were selected based on their expected ability to provide the most valuable information for answering our research questions (Schreier, 2018). This sampling method allowed us to encompass a diverse range of stakeholder perspectives relating to the research topic, but purposive samples cannot be interpreted as representative of a broader target population (Saunders et al., 2009). Furthermore, we must acknowledge that some of our interviewees from the private sector may represent companies that have been more proactive in terms of their energy efficiency and decarbonisation efforts than the average stakeholder in the shipping industry (e.g. shipowner or charterer), so this must also be recognized when reflecting the findings of the study against a broader market landscape.

Table 1: Overview of expert interviewees

Interviewee number	Generalized professional role	Industry viewpoint
1	Charterparty specialist	Shipping industry association
2	Operations manager	Dry bulk ship operator
3	Chartering manager	Dry bulk ship operator
4	Legal counsel	Dry bulk ship operator
5	Fleet performance manager	Liquid bulk industrial charterer
6	Maritime lawyer	Commercial law firm
7	Maritime lawyer	Academia
8	Senior executive	Maritime software provider
9	Business development manager	Maritime software provider
10	Data science manager	Liquid bulk shipowner
11	Sustainability manager	Multi-segment shipowner
12	Senior executive	Multi-segment shipowner

A semi-structured interview structure was used to (i) guide the discussions towards specific topics that each interviewee had specialist knowledge on and (ii) maximize the collection of relevant primary data within a time-limited session as many experts have busy schedules and interviews must be conducted under time pressure (Harvey, 2011). The semi-structured nature means that the interviews were guided by a number of general themes around which key questions were prepared (Saunders et al., 2009). Semi-structured interviews provided enough flexibility for experts to share their insights freely, while also limiting the discussion to issues relevant to the research topic (Gillham, 2005). Since the stakeholders differed in their expertise, some themes and key questions were also adjusted or omitted to best match specific interviewees' expected knowledge and the direction of the interview conversations. Indeed, not all interview themes and questions were relevant for interviewees that did not represent charterers, shipowners or ship operators. While adjusting themes and questions for specific interviewees limits the generalizability of findings, this allowed us to best capture the current state of industry thinking from a limited interviewee pool. The generic interview guide, adjusted for specific interviews as necessary, is provided in Appendix 1.

3. Literature review

This section first provides a brief summary of common charterparty types, categories of emission reduction measures and principal-agent problems created by chartering contracts. Thereafter, we present an overview of common inefficiencies in ship operations and their root causes as identified by previous research. We do not seek to cover all operational inefficiencies, but rather focus on ones that are most relevant to our analysis in later sections.

3.1 Conceptual background

Different charterparty types

A charterparty is a bilateral contract between a shipowner and charterer for the employment of a ship for the purposes of transporting cargo by sea (Plomaritou & Papadopoulos, 2017). The negotiations between shipowners and charterers are governed only by the freedom of contract, so they can, in theory, agree to any contractual terms both parties find satisfactory (Wilson, 2008). Charterparties are agreed (i.e. 'fixed') in the 'charter market' between shipowners and charterers (Plomaritou & Papadopoulos, 2017). For simplicity, this thesis often uses the term 'shipowner' to also refer to a disponent owner unless it is necessary to distinguish a vessel's legal owner from e.g. an asset-light ship operator. Most chartering contracts are based on standard charterparty forms drafted by industry associations such as the Baltic and International Maritime Council (BIMCO) (Psarros, 2017). BIMCO has a particularly important role as the leading industry association that develops standard charterparty forms and rider clauses to facilitate commercial activity in shipping (Plomaritou & Papadopoulos, 2017). Rider clauses are further contract clauses that are commonly added to standard charterparty forms at the contracting parties' discretion (Psarros, 2017).

The two most common contract types are voyage and time charterparties, which differ substantially in their allocation of risks and responsibilities between the shipowner and the charterer (Plomaritou, 2014). On a voyage charter, the shipowner bears all the costs (capital expenses, operating expenses and voyage costs) and bears the risk for delays at sea, while the charterer pays a fixed freight rate and carries the risk for port delays (Wilson, 2008). The shipowner must meet his contractual obligations, but remains in operational control of the vessel. By contrast, a time charterparty transfers operational control to the time charterer who can flexibly give voyage orders to the vessel's master, but must bear the voyage costs involved, mainly bunker and port costs (Wilson, 2008). The shipowner is compensated with a daily hire throughout the contract regardless of how the vessel is operated (Wilson, 2008).

Besides these two basic charterparty types, hybrid chartering contracts also exist, namely contracts of affreightment (CoAs), trip charters and consecutive voyage charters (Plomaritou & Papadopoulos, 2017). However, most of these hybrid contracts can be classified as either voyage or time charters based on their cost allocation principles (Rehmatulla & Smith, 2015a). CoAs are also known as quantity or volume contracts as they bind the shipowner to providing a certain amount of transport capacity to the charterer over a specific time period, but are not associated with a named vessel (Plomaritou & Papadopoulos, 2017). Bareboat charters, whereby the vessel is leased to the charterer for long-term use, are not examined here (Plomaritou & Papadopoulos, 2017). CoAs will be discussed more in Section 6.1 due to often requiring substantial shipowner–charterer collaboration throughout the contract period.

Categorisation of emission reduction measures

Previous research has divided available emission reduction measures into technical and operational measures (Xing et al., 2020). Technical measures refer to emission-reducing technological or vessel design solutions, which can be applicable to only newbuilds or also installable as retrofits onto older vessel (Xing et al., 2020). While often promising significant emission reductions, many technical measures involve high investment costs and some can only be implemented at vessel design (Eide et al., 2011). By contrast, operational measures are less capital-intensive and reduce emissions by optimising ship operations at the level of individual vessels or fleets (Bouman et al., 2017). Operational measures do not involve major retrofits and can be undertaken regardless of ships' technical specifications (Bouman et al., 2017). Examples of much-discussed operational measures include general speed reductions, weather routing, optimisation of ballast legs, just-in-time (JIT) arrivals, hull and propeller maintenance as well as trim/draft optimisation (IMO, 2009; Rehmatulla, 2014; Xing et al., 2020). While some operational measures such as trim/draft optimisation and weather routing can also involve some additional costs, these are lower than for technical measures (Rehmatulla, 2014). Since our main focus is on operational inefficiencies, higher implementation of relevant operational measures is of primary interest to this thesis.

Principal-agent problems in charterparties

Misaligned incentives and information asymmetries between shipowners and charterers, identified as market failures in existing literature (Rehmatulla & Smith, 2015a), sit alongside a broad range of energy efficiency barriers to energy efficiency in shipping (Rehmatulla & Smith, 2015b), but are most central to our research themes due to being closely associated with the prevalent contractual infrastructure. The extent of different stakeholders' incentives to optimise and improve energy efficiency, through either operational or technical measures, depends heavily on their responsibilities under a chartering contract. Previous literature frames the chartering process as an agency relationship in which the charterer (i.e. principal) engages the shipowner (i.e. agent) to provide transportation services (Veenstra & Van Dalen, 2011). This arrangement lends itself to principal-agent problems, principally in the form of misaligned incentives and informational problems (Rehmatulla & Smith, 2015a).

Under voyage charters, there exists a 'usage' problem as the charterer generally pays a fixed freight rate to the shipowner and thus has limited financial incentives to optimise operational efficiency (Rehmatulla & Smith, 2015a), despite also holding some influence over certain commercial decisions such as port and speed choice (Poulsen et al., 2022). The freight paid is determined independently from the voyage's operational efficiency, so particularly uptake of operational measures that require the charterer's cooperation (e.g. JIT arrivals and speed reductions) is hindered (Rehmatulla & Smith, 2015a). At the same time, the shipowner's abilities to optimise ship operations are also constrained by contractual obligations as will be demonstrated later. Of course, the shipowner is still able to capture the possible economic benefits of any technical measures that might have enabled a lower fuel consumption.

In the time charter context, an 'efficiency' problem exists instead as the shipowner is mainly responsible for determining a vessel's technical efficiency, but the charterer is the one that benefits from higher efficiency through lower bunker costs (Rehmatulla & Smith, 2020). If a shipowner expects to operate a ship on time charters for much of its lifespan, there are weak incentives to invest into technical measures unless these capital outlays can be recouped in the market (Rehmatulla & Smith, 2015a). However, research has found more fuel-efficient vessels being rewarded with only limited premiums on time charter rates, likely due to information asymmetries and bargaining power differences between market actors (Adland et al., 2017; Agnolucci et al., 2014). Of course, such a market failure discourages technical upgrading of the global fleet. In theory, the 'usage' problem is not highly relevant for time charters as the charterer pays the bunker costs and should thus be incentivised to optimise ship operations as well. However, market circumstances such as low bunker prices can also reduce a time charterer's interest in minimising fuel consumption by optimising operational efficiency as lower fuel costs reduce the relative cost of inefficiency (Poulsen et al., 2022).

3.2 Inefficiencies in ship operations

This section presents an overview of common inefficiencies in ship operations and their underlying causes as identified by previous literature. These operational inefficiencies are overviewed here since later sections will analyse how contractual changes, alongside with appropriate policy facilitation, might help reduce them. We do not cover all operational inefficiencies, but instead focus on ones that are most relevant to our subsequent discussion.

Rush-to-wait behaviour

Firstly, vessels engage in so-called 'rush-to-wait behaviour' when they sail to their loading or discharge port at unnecessarily high speeds, only to wait at anchorage or elsewhere at port without being able to start cargo operations (Lindholm, 2014). This inefficient behaviour is often pursued even when congestion at the next port is known in advance and it translates into excess fuel consumption and emissions, which could be avoided if the speed of vessels was, for example, adjusted according to a pre-specified arrival time (Adland & Jia, 2019; Jia et al., 2017). Moreover, curtailing rush-to-wait behaviour would also tackle local air pollution and improve navigational safety at busy ports (GloMEEP, 2020). As will be demonstrated, rushing to wait as an operational inefficiency should be most prevalent under voyage charter due to the more pronounced misalignment of incentives between relevant stakeholders. The underlying reasons for rush-to-wait behaviour can be broadly divided into three primary categories, which will be examined in turn: (i) charterparty obligations; (ii) prevalent queuing policies at ports; and (iii) conflicting demurrage-related interests.

Charterparty obligations

The literature on the speed choice of vessels highlights the impact of contractual obligations on supporting rush-to-wait behaviour and preventing speed adjustments. Without external constraints, a profit-maximizing shipowner would prefer to sail at an optimal speed that equates the marginal fuel savings from speed reduction to the lost marginal revenues from completing fewer voyages over a given time period (Ronen, 1982). This suggests that freight rates and bunker prices are crucial for determining the theoretical 'optimal speed' that would maximize a shipowner's income given the nonlinear nature of the speed–fuel consumption relationship (Adland et al., 2020). However, several empirical studies (Adland & Jia, 2016, 2018; Aßmann et al., 2015; Prochazka & Adland, 2021) have shown that vessels' speed choice, across both the dry bulk and tanker segments, does not align robustly with maritime economic theory and observed ship speeds do not respond to market conditions as expected.

According to Adland and Jia (2018), part of this inflexibility in vessels' speed choice can be attributed to charterparty obligations, particularly under voyage charters. Indeed, Rehmatulla and Smith (2015a) find that nearly 60% of surveyed shipowners perceived contractual obligations as a significant barrier to speed reductions and thus flexible speed choice. Under a voyage charter, a vessel is often obliged to 'proceed at utmost despatch' (or another similar phrase) on at least its laden leg (Rehmatulla & Smith, 2015a). In principle, this means that the vessel should sail as swiftly as possible to its next port and without unreasonable deviation, while of course accounting for safety and weather (Baatz, 2014; Wilson, 2008).

While the ambiguity of 'utmost dispatch' might enable a degree of voyage optimization by shipowners, it does not allow for significant speed adjustments. As a result, according to Rehmatulla (2014), there are rarely explicit pre-fixture negotiations between shipowners and charterers on the relationship between speed choice and the freight rate. Under many tanker voyage charterparties, the general 'utmost despatch' obligation can also be complemented by a stated charterparty speed (hereafter 'C/P speed'), which the vessel must pursue on its laden leg unless otherwise requested by the charterer (Rehmatulla, 2014). Devanney (2011) notes how these C/P speeds are dictated by charterers and adjust slowly to dynamic market circumstances, which further contributes to the mismatch between the economically optimal and observed sailing speed of vessels. Naturally, if a vessel is employed on a time charter, the speed choice can be more flexible depending on the charterer's voyage orders. This is supported by the fact that Rehmatulla and Smith (2015a) find speed reduction measures to be implemented more frequently under time charters than voyage charters.

Moreover, while ballast legs may, in principle, provide more flexibility to the ship's master regarding speed choice, ballast vessels are often also be under a contractual obligation to meet a certain laycan window for their next cargo (Jia et al., 2017). The laycan window is a range of dates inside which a vessel must present itself at the first loading port (Wilson, 2008). If a vessel is far away from the loading port and the laycan window is only given at short notice, the ship's master is indirectly forced to sail at high speeds to avoid contract cancellation. Particularly during weak and declining freight markets, many shipowners will also prefer to leave some buffer to the final cancellation date to ensure their fixture cannot be cancelled by the charterer, because this would lead to wasted bunker costs and replacement fixtures with similar income potential might be difficult to secure (Adland & Jia, 2019).

Prevalent queuing policies at ports

The continued prevalence of ports' first-come-first-served (FCFS) queuing systems also perpetuates rush-to-wait behaviour (Rosaeg, 2010). While queuing systems have developed further in the liner trade, most terminals in bulk shipping continue to allocate berthing slots based on when vessels physically arrive to the port, although this may also be modulated by terminals' commercial priorities (Alamoush et al., 2020; GloMEEP, 2020). Under the FCFS principle, vessels are incentivised to steam to port at high speeds just to 'get in line' as their queue position is determined based on when they arrive to the port (Rosaeg, 2010). In the absence of explicit ship–port coordination, each ship's speed choice also affects the relative position of other similar vessels in the queue, thereby even encouraging a race to the port between competing ships (Merkel et al., 2022), which is far from operationally efficient.

Rosaeg (2010) believes that the FCFS principle has remained popular due to its (i) low degree of implementation complexity and (ii) relatively high transparency and fairness as perceived by market actors. Alternative queing policies include, for example, the Vessel Arrival System (VAS) used at the Port of Newcastle (Heaver, 2021), but similar procedures have not been widely adopted by major ports elsewhere. Cargo owners also prefer to have their cargoes transported as speedily as possible, largely due to in-transit inventory costs (Psaraftis & Kontovas, 2013), and they do not pay the fuel expenses for voyage charters, so securing a better position in an FCFS queue by rushing to port is often also their preference (Poulsen & Sampson, 2019; Rosaeg, 2010). Given how strongly FCFS policies incentivise rushing to 'get in line', it is clear that ports' queuing policies must be updated for this element of operational inefficiency to be tackled comprehensively (Schwartz et al., 2020).

Conflicting demurrage-related interests

Voyage charters also encourage rush-to-wait behaviour by rewarding shipowners for rushing to port through the long-standing concepts of demurrage and laytime (Adland & Jia, 2019; Rosaeg, 2010). Laytime, also referred to as lay days, is the voyage time allocated for the charterer's cargo operations at the loading and discharge ports (Wilson, 2008). The laytime is included in the freight rate, and it begins counting once the vessel's master tenders a successful Notice of Readiness (NOR) (Schofield, 2021). If the laytime is exceeded, the charterer must compensate the shipowner for the additional port time as this leads to a longer voyage duration than factored into the freight rate (Plomaritou & Papadopoulos, 2017). This compensation takes the form of demurrage, which has been defined as liquidated damages for the charterer's breach of contract due to exceeding the allowed laytime (Schofield, 2021).

The daily demurrage rate is negotiated between the contracting parties, but should more or less reflect the expected freight market conditions (Plomaritou & Papadopoulos, 2017).

NOR can generally be tendered upon arrival to port even if a berth is unavailable so that port delays, excluding laytime exemptions, are borne by the charterer (Wilson, 2008). Hence, shipowners may want to start the laytime clock as early as possible since this increases their chances of getting 'on demurrage' if there is known congestion (Poulsen & Sampson, 2019). This demurrage-related incentive for rushing to wait is strongest during weak freight markets and low bunker prices (Adland & Jia, 2019). Using fixture data on Aframax tankers, Adland and Jia (2019) show that, in a depressed market, demurrage rates can be higher than time charter equivalent earnings, so spending time on demurrage with minimal fuel consumption is more profitable for the shipowner than sailing. Bunker prices influence this trade-off since they determine the bunker costs incurred for sailing at a higher speed (Rosaeg, 2010). If the expected bunker costs from rushing to port are lower than the expected demurrage income, this behavior is rational for the shipowner, while higher bunker prices render the fuel savings of not rushing more attractive (Rosaeg, 2010). As a result, even with speed-related flexibility on ballast legs, shipowners may have financial incentives to reach a port as early as possible.

Finally, many voyage charters are fixed as a result of underlying sale contracts. For bulk commodity transactions, these contracts are often agreed on either 'Free On Board' (FOB) or 'Cost, Insurance and Freight' (CIF) terms (Bridge, 2013). The FOB buyer or the CIF seller serves as the charterer under a charterparty, but has only partial control over delays related to cargo operations due to the seller being involved in the loading, while the buyer arranges the unloading (Baughen, 2016). However, the charterer bears all demurrage liability under the charterparty regardless of whose actions lead to laytime being exceeded. Many sale contracts thus include demurrage clauses that allocate liability for demurrage between the seller and buyer depending on which port call(s) lead to demurrage (Baughen, 2016). As sale contracts are often agreed before charterparties, it is not uncommon for sale contracts to establish demurrage terms that are independent from the charterparty (Bridge, 2013). However, this can lead to traders (sellers or buyers) also treating demurrage as a profit centre by making money on the margin between the demurrage paid to the shipowner and the demurrage received from their counterparty under a sale contract (Baughen, 2016). Traders may also be able to claim demurrage from terminals if they are attributed as responsible for delayed cargo operations (GloMEEP, 2020). This explains why also charterers may lack incentives to minimize demurrage across all port calls and revise contractual structures accordingly.

Unproductive ballasting and capacity utilization

Vessels undertake ballast voyages when sailing empty to reposition themselves from their last discharge port to either (i) their next loading port or (ii) closer to lucrative loading areas if their next fixture remains undetermined. Ballast legs can therefore result from either a contractual obligation to load the next cargo or from shipowners speculatively repositioning their vessels towards major loading areas where charterers are more likely to fix them, even at short notice to the laycan window (Alizadeh & Talley, 2011a, 2011b). While ballasting itself involves lower bunker consumption than sailing laden, ballast legs fulfil no productive transport work and can be considered an operational inefficiency if not properly optimised.

As explained by Poulsen et al. (2022), chartering managers on the shipowner side seek to maximize vessel utilization in most instances, but still prefer longer ballast legs over shorter ones if there is more money to be made. Despite higher bunker expenses, repositioning a vessel with a longer ballast leg can provide better profits due to strong front- and backhaul patterns across many dry bulk and tanker trades (Poulsen et al., 2022), particularly in the case of larger vessels that are more restricted in the ports they can call. Perhaps the clearest example is the case of crude oil markets where trade flows are highly binary and suitable backhaul cargoes are hard to find (Lindstad et al., 2012). Indeed, Polakis et al. (2019) argue that many ballast legs are out of shipowners' control due to these structural reasons. In trades where ballast distances cannot be substantially reduced, the emission externality of ballast legs can nevertheless be reduced with slower ballast speeds (Rehmatulla, 2014). However, as highlighted earlier, vessels' ballast speeds often depend significantly on charterers' timing of fixtures and their transport demands relative to vessels' current geographical positioning.

Vessel utilization can be improved by completing several consecutive laden voyages with nearby discharge and loading ports, but effective triangulation is most feasible for smaller vessels that have more diverse trading patterns (Poulsen et al., 2022). With enough visibility on future fixtures, large and medium-sized bulk carriers may also be able to divert on their ballast legs to carry backhaul cargo (at a lower freight rate) instead of ballasting directly to a major exporting region. Although diverting to carry backhaul cargo increases ship-specific emissions, this improves vessels' laden-ballast ratios and could lower shipping emissions at the fleetwide level (Bouman et al., 2017; Schwartz et al., 2020). However, if a ship already has its next fronthaul cargo fixed, taking a backhaul cargo that brings the vessel closer to its subsequent loading port increases the shipowner's risk of missing the laycan window of the fronthaul fixture if unexpected delays occur during the backhaul. More generally, without explicit carbon pricing, the negative consequences of suboptimal ballasting are only reflected through higher bunker costs, but nobody is directly liable for the emission externality.

It is also challenging for shipowners to minimize ballasting due to the strategic timing of market players with regards to entering the charter market, which depends on freight market conditions and actors' risk preferences (Prochazka et al., 2019). Previous research supports the hypothesis that strong freight markets, which imply a larger risk of charterers being unable to secure acceptable tonnage that can meet their desired laycan window, motivate earlier fixtures than weak markets when tonnage may be oversupplied (Prochazka et al., 2019). Moreover, more risk-loving shipowners or charterers may prefer to opportunistically establish fixtures at shorter notice to the laycan window if they expect freight rates to move in their favour (Zannetos, 1966). This further complicates the extent to which a shipowner can minimize ballasting without sacrificing profitability as speculative ballasting impedes productive transport work, but provides flexibility for timing fixtures to maximize profits.

Finally, laden vessels' partial capacity utilization also represents an operational inefficiency. Schwartz et al. (2020) argue that bilateral contracting hinders transparency on matching of cargoes and vessels with suitable carrying capacity. This leads to ships sailing partly loaded as charterers fix excessively large vessels and cannot combine cargoes with market actors due to the absence of multilateral coordination. While higher capacity utilization increases voyage-specific emissions, it reduces the total number of voyages required for the same transport supply. Adland et al. (2018b) also note how charterparty type affects charterers' incentives to maximize capacity utilization. In the context of voyage charters, the charterer pays a fixed $/tonne regardless of capacity utilization, whereas daily hire is fixed for time charters so the charterer achieves the lowest unit transport cost by maximizing cargo intake.

Weather routing and speed-related inflexibility

Another source of ship-level operational inefficiency can be limited usage of weather routing as a decision-support tool for minimising bunker consumption based on weather forecasts for the planned voyage. Weather routing can improve operational efficiency as the direct route between two ports is not always the most energy-efficient option due to dynamic weather and sea conditions (Zis et al., 2020). Previous research has examined whether charterparty types affect the adoption of weather routing, but there does not appear to be a significant influence due to the operational nature of this measure so we will not elaborate on this here

(Rehmatulla, 2014; Rehmatulla & Smith, 2015a). However, strict speed-related contractual obligations under voyage charters can nevertheless be seen as limiting the extent to which shipowners can extract fuel savings from more sophisticated weather routing. This element of operational inefficiency is mainly relevant for our subsequent discussion in Section 6.3.

In principle, a constant speed throughout a laden leg is the most cost-effective option under static weather and sea conditions since costly speed increases are thereby avoided during voyage execution (Zis et al., 2020). However, real-world operational conditions are far from static so the most economic outcome could instead be achieved by adjusting speed more dynamically, while also selecting the optimal routing according to forecasted weather (Li et al., 2018; Tzortzis & Sakalis, 2021). As a result, if a tanker voyage charterparty requires a C/P speed of 12.5 knots for the laden leg, the shipowner has a limited flexibility in adjusting vessel speed based on current and future weather and sea conditions, even if a non-constant speed choice could reduce total bunker consumption and enable the ship to arrive at the next port as quickly as would be expected with a static C/P speed of 12.5 knots. Vessel speeds will naturally be affected by weather and can be adjusted for safety (Zis et al., 2020), but the margin inside which daily speeds can fluctuate is still determined by the C/P speed. In this regard, the absence of explicit C/P speeds in other voyage charters (e.g. within dry bulk) may perhaps provide slightly more speed-related flexibility for purposes of voyage optimization.

This speed-related inflexibility derives indirectly from the fact that voyage charters do not often bind shipowners to meeting specific estimated times of arrival (ETAs) at subsequent discharge ports after meeting the laycan window at the first loading port (Plomaritou & Papadopoulos, 2017). While the master is required to supply the charterer with ETA notices as the vessel approaches its next port, these notifications are mainly provided for informative purposes so that cargo operations can be better planned (Plomaritou & Papadopoulos, 2017). It is rational that most shipowners have not agreed to contractually binding arrival windows for other ports than the first loading port (i.e. laycan window) due to risks associated with e.g. weather disruptions and unexpected port delays. Consequently, a constant C/P speed or the more ambiguous ‘utmost despatch’ obligation have provided an implied ETA window to charterers and cargo owners. As a result, strict speed-related obligations serve as indirect assurances on the timely delivery of cargo, but also reduce the vessel’s operational flexibility and restrict the extent to which speed choice can be used as a lever of weather-dependent voyage optimization. Under time charters, larger speed adjustments are possible, so the full potential of weather routing can be unlocked if this reduces the expected fuel consumption.

4. Barriers to revising chartering contracts

Before analysing the potential and challenges of different efficiency-oriented contractual amendments, this section examines common barriers to substantial revisions of chartering contracts. In the terminology of Brown (2001), these can be labelled as non-market failures (or market barriers) since they slow down the diffusion of efficiency-improving contractual changes. These barriers are mainly relevant for contractual changes that are not necessitated by policy interventions, which will be discussed further in Section 5.1 and Section 6.

Conservatism of market actors

As noted by Rehmatulla and Smith (2015b), one of the barriers to energy efficiency in shipping is inertia, which is also integral to market actors' unwillingness to revise their contractual arrangements. Inertia means that individuals as well as organisations are often prone to following their existing habits and routines, which can be challenging to change (Thollander et al., 2010). Indeed, Davies (2020) notes that many concepts and contractual structures of maritime law have fallen behind the realities of modern commercial practice as shipowners and charterers continue to use old charterparties they are most familiar with. A concrete example of this is the persistence of older standard charterparty forms, including the 1946 version of the New York Produce Exchange (NYPE) time charter form, as a common basis for modern-day chartering contracts despite new charterparty forms being drafted by industry organizations constantly (Davies, 2020). The NYPE standard form has been revised already three times since 1946, but the 1946 version still remains widely used as contracting parties leverage their freedom of contract and prefer the legal certainty facilitated by their existing routines and the extensive case law based on previous disputes (Davies, 2020).

Ironically, using older standard forms, which must nevertheless be adjusted for modern-day commercial requirements, often results in quite complicated chartering contracts with a large amount of rider clauses (Int. 1). The extensive incorporation of rider clauses into older charterparty forms, instead of transitioning to newer standard forms, demonstrates how the freedom of contract, combined with market actors' conservatism, can render it challenging for efficiency-oriented contractual revisions to become mainstream across bulk shipping, at least without further incentives being created by policy interventions as emphasized by multiple interviewees (Int. 5, Int. 10). This means that, if revising contractual structures involves additional negotiation costs (e.g. increased time spent on agreeing to a fixture) or carries a possible risk of negative financial consequences, it is logical for many shipowners and charterers to prefer the status quo and refrain from changing contractual arrangements.

Practical setting of pre-fixture negotiations

The practical setting of pre-fixture negotiations also fosters contractual inertia. A dry bulk chartering employee explained that, when a shipowner and a charterer have had no previous transactions, it is not uncommon for a charterer to propose that the new contract should be based on a previously executed charterparty between the charterer and another shipowner, with smaller adjustments being made in back-and-fourth negotiations (Int. 3). However, if an earlier charterparty exists between these two parties, the default option is to continue using the same template for future fixtures given the nature of the trades allows this (Int. 3). From a chartering manager's viewpoint, it might be commercially beneficial to propose small changes to an existing template in repeat transactions to gradually render the charterparty more favourable to themselves, but this also opens the door to the counterparty's proposals for contractual changes in their favour (Int. 3). In general, we can see that this does not create a conducive environment for making large changes to existing bilateral templates.

This conservative tendency is exacerbated by the fact that especially spot fixtures are often negotiated under time pressure, so well-established charterparty forms are easiest to agree on and more sophisticated contractual changes (e.g. JIT arrival clauses) might be sacrificed to save valuable time, particularly in one-time transactions (Psarros, 2017). Indeed, no standard charterparty forms currently include JIT-related clauses (GloMEEP, 2020), which means they need to be negotiated bilaterally as additional rider clauses at the time of fixture. When discussing the challenges of including JIT arrival clauses into voyage charters, an industrial charterer also emphasized the extensive negotiation costs that would be required for making any meaningful impact on their spot fixture portfolio (Int. 5). The company deals with over a hundred counterparties annually, so negotiating a JIT arrival clause with each separately was seen as unappealing and impractical, particularly due to many shipowners' hesitancy towards JIT arrival clauses (Int. 5). Circumventing this problem through a higher usage of time charters that are more conducive to adapting JIT arrivals was instead preferred (Int. 5).

The hesitancy to adopt efficiency-oriented contractual changes for short-term charters is strongest when the contracting parties do not have a pre-existing relationship and a lack of trust exists, especially under one-time transactions (Int. 4). Indeed, Poulsen et al. (2016) highlight that, at least within the dry bulk segment, most shipowners and charterers only meet once through single spot fixtures. From a historical viewpoint, bulk shipping markets have developed over the decades towards an increasingly spot-driven market structure where short-term contracts and one-time transactions dominate the marketplace across many trades (Miller, 2019). This contrasts with the pre-1970s market structure, particularly in the tanker segment, where oil majors still signed long-term time charters or even owned vessels that fulfilled most of their transportation needs (Glen & Martin, 2010; Lyridis & Zacharioudakis, 2012). Although a spot-driven market structure is economically efficient due to the high level of competition it enables, one can argue that short-term contracts are suboptimal for facilitating shipowner–charterer collaboration to effectively pursue maritime decarbonisation (Schwartz et al., 2020). As a practical example, a dry bulk ship operator also explained how buying more expensive carbon offset bio-blend bunkers to reduce voyage-specific emissions is currently only feasible in close collaboration with proactive charterers who are willing to pay premium on the freight rate to minimize their carbon footprint (Int. 4).

Human element in pre-fixture negotiations

Contractual inertia is also maintained by the people who establish fixtures. A maritime lawyer noted that chartering managers are generally not legal professionals (Int. 7), thereby suggesting that they alone are unlikely to drive large changes to contracts and are hesitant to accept unfamiliar clauses proposed by their counterparties. As a result, 'business as usual' is often the safest option for chartering employees as well (Int. 7). Moreover, when chartering professionals themselves are measured mainly based on minimizing freight costs and not on the carbon footprint of their fixtures, they have very limited incentives to care about the emissions created by the voyages they fix (Int. 4, Int. 10, Int. 11). At least one larger tanker charterer is starting to include emission-related performance metrics into the bonus schemes of their chartering and trading employees (Int. 8, Int. 9), but similar mechanisms should become more widespread to have a meaningful impact. Indeed, Interviewee 10 emphasized how charterers' strategic concerns about reducing their shipping emissions (if these exist) must also trickle down to the people who charter vessels and trade cargoes on a daily basis.

Finally, given the highly competitive nature of bulk shipping markets, Interviewee 5 noted that mutual distrust regarding charterparty changes can exist even between shipowners and charterers that are familiar from previous interactions. Deep-rooted skepticism about the true intensions of counterparties can therefore hinder the chances of success when, for example, proposing the incorporation of a JIT arrival clause into an existing charterparty template. For example, Interviewee 5 explained that, in their previous efforts to discuss JIT arrival clauses for voyage charters, a common reaction from shipowners has been that the charterer must be trying to unfavourably alter the charterparty and the discussions have ended very quickly.

Lack of external pressure to revise contracts

Particularly for short-term charters, it is typically upon the charterer to propose the basis of a charterparty and take the lead on substantial contractual changes, including e.g. JIT arrival clauses (Int. 3). However, although maritime decarbonisation has become a larger priority, Poulsen et al. (2016) finds that most market actors in bulk shipping are still not under much external pressure from e.g. cargo owners to improve energy efficiency through contractual means or otherwise. The transport activities of the tanker and dry bulk segments also remain quite detached from the pressures of end consumers due to the business-to-business nature of these transactions (Poulsen et al., 2016). After all, most bulk cargoes are either (i) further processed before delivery to final customers, (ii) used as industrial feedstock or (iii) sold forward to another business. Bulk cargoes also include many carbon-intensive products such as crude oil and coal that are anyways environmentally harmful, which may also lower cargo owners' concerns for reducing emissions from their transportation (Poulsen et al., 2021).

As a result, while charterers should have a key role in pushing emission-reducing revisions into charterparties, many of these market actors are not being heavily pressured to reduce the carbon footprint of their shipping activities. Interviewees noted that, while more proactive charterers have established chartering policies to also reduce their shipping emissions as part of a broader sustainability strategy, these practices remain in the minority given charterers' traditional focus on minimizing transport costs (Int. 4, Int. 8). Moreover, Poulsen et al. (2021) note how regulatory efforts at improving transparency on shipping emissions, namely the EU Monitoring, Reporting and Verification System (EU MRV) and the IMO Data Collection System (IMO DCS), are exclusively focused on the reporting responsibilities of shipowners and ship operators instead of cargo owners. Similarly, national regulatory efforts such as the United States' GHG Reporting Program, which requires emission accounting in the oil and gas sector, include upstream and downstream emissions, but exclude emissions from maritime transportation (Jia, 2018). Consequently, unless a cargo owner has voluntarily committed to collecting and disclosing emissions from their chartering activities through, for example, the Sea Cargo Charter, visibility on their shipping emissions remains limited and fails to provoke external pressure to revise contracts (Sea Cargo Charter, 2022). Higher transparency on cargo owners' shipping emissions should increase public pressure and also encourage more contractual collaboration between stakeholders (Jia, 2018; Poulsen et al., 2021). Interviewee 5 argued that, at least within certain bulk trades, the continued increase in the granularity of final products' carbon disclosure might serve to increase charterers' reputational costs related to operational inefficiencies in their shipping activities.

Furthermore, several interviewees noted how even larger charterers and cargo owners that have ambitious decarbonisation targets are still primarily focused on improving emission reporting and developing a more comprehensive understanding of the emission profile of their shipping operations (Int. 10, Int. 11). While mapping current shipping emissions is a prerequisite for benchmarking future emission reductions as noted by Interviewee 10, this provides a reality check on how much is still left to do for many charterers and cargo owners until getting to practical measures to reduce their emissions. Moreover, in cases where corporate sustainability efforts motivate charterers to also reduce their shipping emissions, the easiest first steps may involve chartering more fuel-efficient vessels wherever possible or altering their chartering strategy rather than pursuing time-consuming contractual revisions that probably involve additional negotiation costs (Int. 5, Int. 8).

Finally, Poulsen et al. (2016) remind that charterers in the tanker segment, including large oil majors and commodity trading houses, are generally more concentrated than in the dry bulk segment where the charterer base is more fragmented. While bulk shipping markets are sometimes described as almost perfectly competitive, certain market players do possess more market power than others (Adland et al., 2016). In the tanker segment, it is the oil majors and large commodity traders that have the market power to force fleetwide behavioural changes (Cariou et al., 2021). For example, oil majors have shown their market power by imposing strict vetting procedures on tankers and drafting their own standard charterparties that are brought to pre-fixture negotiations on a 'take-it-or-leave-it' basis that does not leave much flexibility for shipowners to negotiate (Plomaritou & Papadopoulos, 2017; Poulsen et al., 2016). Indeed, environmental safety became a concern for tanker shipping due to external pressure resulting from high-publicity oil spills and large charterers had the market power to revise industry practices (Poulsen et al., 2016). However, shipping emissions have yet to reach this stage and drive contractual changes (Poulsen et al., 2021). In general, interviewees emphasized the importance of larger charterers using their market power to transform new contractual solutions into 'industry standard' so that smaller charterers could follow in their wake to also revise their own charterparties with less shipowner resistance (Int. 3, Int 8).

5. Contractual revisions and policy facilitation

This section first discusses the current status of JIT arrivals, alternative benefit-sharing mechanisms and the key challenges hindering widespread implementation, including the contractual modifications required for voyage charters. Thereafter, we examine the potential and challenges of policy interventions, namely the upcoming CII regime and carbon pricing, in indirectly encouraging more efficient ship operations through contractual means.

5.1 Just-in-time arrivals

JIT arrivals were first discussed in bulk shipping during the early 2010s when they were proposed in the tanker segment, primarily to reduce fuel consumption in response to high bunker prices (Poulsen & Sampson, 2019). JIT arrivals tackle rush-to-wait behaviour by having ships adjust their speed based on actual berth or cargo availability at port instead of continuing to sail at the same speed regardless of port circumstances (Jia et al., 2017). This speed adjustment can occur either during the approach voyage or when the vessel sails towards any of its subsequent port calls (BIMCO, 2021). Ideally, a vessel's arrival to port would be perfectly matched with the necessary terminal facilities and port services becoming available (GloMEEP, 2020). JIT arrival has also been previously referred to as virtual arrival, which can be seen as one element of the broader JIT arrival procedure that typically requires more than only bilateral collaboration between the shipowner and charterer.

In contrast to general slow steaming, JIT arrivals have, in principle, the advantage of not increasing the total voyage duration as adjusting speed based on berth availability keeps the overall transport supply unchanged by converting expected port waiting time into additional sailing time (Poulsen & Sampson, 2019). Of course, one can also imagine that a port-wide JIT arrival system could lead to certain vessels being requested to sail faster, if technically possible, to meet a specified arrival time before a congestion materialises (GloMEEP, 2020). Although this improves the overall efficiency of port operations and reduces the total voyage duration, upwards speed adjustments also cause higher bunker consumption for the involved vessels (Rosaeg, 2019). Most JIT arrival proposals ignore this further layer of complexity, so only speed reductions can be requested. Assuming that JIT arrivals only involve speed reductions, estimates of the potential fuel savings have ranged as high as 20% (Gibbs et al., 2014; Jia et al., 2017), but this depends heavily on the vessel segment, the nature of the voyages involved and prevailing market circumstances (Johnson & Styhre, 2015; Merkel et al., 2022). Naturally, the efficiency gains from a JIT arrival can be more significant if a new arrival time is given to the ship's master as early as possible, because this allows for speed adjustment over a longer sailing distance (Andersson & Ivehammar, 2017). Additionally, if a requested arrival time is given too late, a vessel cannot necessarily slow down enough to avoid waiting at port given the minimum speed that vessels must maintain due to safety and engine considerations (Merkel et al., 2022). To achieve meaningful fuel savings, requesting a delayed arrival time early is most important during weak freight markets and high bunker prices when vessels are already slow steaming, so the fuel savings from further speed reductions are smaller due to the nonlinear speed–consumption curve (Merkel et al., 2022).

As time charterers can flexibly instruct a vessel's master on speed choice and pay the bunker costs, there are no charterparty-related constraints to JIT arrivals on time charters, although non-contractual challenges remain. An additional rider clause is, however, required to enable JIT arrivals under voyage charters where the misaligned incentives between the shipowner and charterer must be solved by sharing the benefits of speed adjustment (GloMEEP, 2020). BIMCO's Virtual Arrival Clause for Voyage Charter Parties 2013 and the Just In Time Arrival Clause for Voyage Charter Parties 2021 are the most well-known standardized rider clauses for enabling JIT arrivals (BIMCO, 2013, 2021). Table 2 outlines their main features.

Table 2: Main elements of BIMCO's Virtual Arrival and Just in Time Arrival Clauses

	Definition
Extra time at spent sea	– Difference between the vessel's initial ETA (if speed was not adjusted) and its actual arrival time, which should be close to the updated arrival time requested by the charterer – Exact extra time spent at sea should be agreed upon bilaterally or calculated by a third-party expert in case of disagreements
Benefit-sharing mechanism	– Fuel savings are 'kept' by the shipowner (difficult to quantify due to e.g. disagreements on benchmark fuel price), but the charterer is compensated by needing to pay only partial demurrage for the extra time spent at sea
Relationship to other contract clauses and third parties	– Vessel can adjust its speed in response to the requested time of arrival without violating any 'utmost despatch' obligations – Charterer agrees to indemnify the shipowner for third-party liabilities that might arise from third parties under e.g. bills of lading

Adapted from (BIMCO, 2013, 2021)

The overriding of the 'utmost despatch' obligation, upon the charterer requesting the ship to adjust speed and meet an updated arrival time, is probably the least contentious element of

JIT arrivals. Standard JIT arrival clauses agree that the extra time spent at sea, defined broadly as the difference between the vessel's original ETA and the actual time of arrival after speed adjustment, should fall onto the charterer's account (BIMCO, 2013, 2021) since otherwise the vessel would have reached the port earlier and started the counting of laytime. This implies that a win-win solution cannot be achieved without the charterer compensating, either indirectly or indirectly, the shipowner for the longer than expected voyage duration.

If the charterer is not made at least partially liable for the extra sailing time, the shipowner's demurrage-related incentives of not slowing down are often larger than only the fuel savings achievable from speed adjustment (Rosaeg, 2010). Additionally, the shipowner may benefit from waiting longer at anchorage by being able to complete maintenance, often only possible when a ship is stationary, on the charterer's account (Johnson & Styhre, 2015). On the other side, the charterer does not benefit from a JIT arrival if the extra time spent at sea is simply treated as normal laytime or demurrage since the freight rate remains fixed (Rosaeg, 2010). Indeed, without a benefit-sharing mechanism, adopting a JIT arrival (instead of having the vessel sail normally to a congested port) only increases the charterer's risk of paying more for the extra sailing time than might be incurred through normal demurrage at port.

Current status of JIT arrivals

Despite first gaining industry attention over a decade ago under the name of virtual arrival, interviewees explained that JIT arrivals are still uncommon in bulk shipping (Int. 1, Int. 5). Industry interest in using JIT arrivals as a cost-efficient operational measure, even under voyage charters, has nevertheless slowly renewed as also signalled by BIMCO's recent Just In Time Arrival Clause and increasing work on the port–ship interface (Int. 1). However, interviewees stated that JIT arrivals remain mostly limited to either (i) time charters where the charterer has significant control over the receiving terminal (e.g. ownership) or (ii) CoAs where negotiating a fair benefit-sharing mechanism is considered more worthwhile by the contracting parties and mutual trust can be developed due to the repeat nature of commercial interactions (Int. 5, Int. 10). Poulsen and Sampson (2020) also highlight terminal ownership as a determinant of port turnaround times due to enabling better ship–terminal coordination.

The tanker segment was still considered the most promising avenue within bulk shipping for broader adoption of JIT arrivals due to (i) its higher market sophistication (ii) the strong role of large oil majors and commodity traders as charterers that could drive contractual changes and (iii) the commercial relationships that these charterers may have with the terminals they often use (Int. 1). These criteria were also seen as partly fulfilled by major charterers in the dry bulk segment, at least when fixing large vessels on major trade routes (Int. 3). However, there existed more hesitation regarding the short-term viability of JIT arrivals for the broader dry bulk trade (Int. 3, Int. 4), particularly across smaller vessel sizes, due to the higher fragmentation of the market and the more undeveloped nature of many ports being called (Int. 1). In fact, chartering and operations employees from the dry bulk segment confirmed that JIT arrival rider clauses had never been included in their charterparties (Int. 2, Int. 3).

JIT arrivals also require substantial involvement from ports to ensure that the requested arrival times communicated to ships well-aligned with the expected availability of terminal facilities and necessary port services (GloMEEP, 2020). In practice, the receiving port must be willing to place a vessel in the queue based on its requested arrival time rather than only upon physical appearance (Merkel et al., 2022), but this contradicts with the prevalent FCFS principle (Int. 3). As mentioned earlier, a well-known example of a major port with a more advanced queuing system (VAS) is the world's largest coal port, the Port of Newcastle (Heaver, 2021). In short, the system monitors inbound coal vessel movements and places ships in the waiting queue several days ahead of their original ETA, so they can adjust their speeds accordingly and ships competing for the same berths are not encouraged to race to port (Port of Newcastle, 2019). However, Heaver (2021) argues that, compared to many other ports, the Port of Newcastle's facilitation of JIT arrivals has been made easier due to its relatively homogenous nature of port calls given the port's heavy focus on coal exports. Consequently, facilitating JIT arrivals at a port that serves a more diverse commodity mix and a broader range of vessel types could be significantly more challenging (Heaver, 2021).

Even major ports that are considered frontrunners in their environmental efforts have found the facilitation of JIT arrivals for bulk shipping challenging to implement or unworthy of the investment costs (Poulsen et al., 2018). Poulsen et al. (2018) argue that this is likely due to the high implementation complexity of JIT arrivals and the low visibility of the emission reductions to port stakeholders and city residents since the emission reductions are achieved at sea rather than in port. Hence, port authorities, who have significant influence over port actors through their landlord–regulator role in port communities, prefer to instead invest into green initiatives that demonstrate their environmental benefits locally (Poulsen et al., 2018). Moreover, Interviewee 5 argued that smaller, yet forward-looking ports are probably easiest for charterers to bilaterally negotiate JIT arrival procedures with (even without ownership ties), especially if the charterer has vessels visiting those ports on a regular basis.

Benefit-sharing mechanisms for JIT arrivals

Two main strands of benefit-sharing mechanisms under voyage charters can be identified. The charterer could either (i) directly receive a share of the theoretical fuel savings from speed reduction or (ii) be compensated indirectly through, for instance, paying only reduced demurrage for the extra time spent at sea rather than spent waiting at port (Ahokas, 2019).

The first option of directly sharing the theoretical fuel savings from slowing down requires a relatively technical assessment of the expected fuel consumption under the alternative reality that the vessel had not adjusted its sailing speed (INTERTANKO, 2011). Due to information asymmetries between shipowners and charterers regarding vessels' true fuel efficiency under varying operational conditions (Rehmatulla & Smith, 2015a), third-party modelling services are generally recommended to achieve a realistic estimation of the theoretical fuel savings that accounts for actual weather and sea conditions as well as the loading condition and technical specifications of the vessel (Ahokas, 2019). However, Interviewee 5 suggested that the abatement potential of JIT arrivals lies mainly in economies of scale given the moderate magnitude of fuel savings on most voyages, thus implying that overly complicated benefit sharing might not be warranted. By extension, the post-voyage workload of this option may be undesirable under spot fixtures since the mechanism should ideally allow for quick settlement, preferably against the demurrage liabilities incurred anyways by the charterer. On the other hand, it benefits from not involving much work if a JIT arrival is not initiated.

The BIMCO rider clauses instead adopt a non-prescriptive approach to benefit sharing, recommending this to be agreed on a case-by-case basis (BIMCO, 2013, 2021). To avoid the precise estimation of theoretical fuel savings, the second option is to require the charterer to pay a reduced demurrage rate for the extra sailing time, so it is also in his interest to have the ship spend more time at sea rather than at port (Ahokas, 2019). Hence, the shipowner 'keeps' all the fuel savings, but receives only partial demurrage as compensation for the additional sailing time. This benefit-sharing mechanism may lead to slightly less precise benefit sharing, but can avoid the usage of third-party experts. However, a static compensation for the extra time spent at sea (e.g. half demurrage rate) is often too simplistic for a shipowner given how much bunker prices affect the relative value of the expected fuel savings (Int. 5).

As highlighted earlier, a rational shipowner's decision on whether to accept a JIT arrival clause in his charterparty depends heavily on the relationship between the agreed demurrage rate and bunker prices since these market-based parameters influence the profitability of either (i) rushing to port to maximize expected demurrage payments or (ii) slowing down for a JIT arrival to reduce fuel expenses (Adland & Jia, 2019). As higher bunker prices increase the economic value of slowing down for a JIT arrival, the reduction in the demurrage rate for the extra time spent at sea can also be larger under higher bunker prices, while still keeping the arrangement economically attractive to both parties. Indeed, Interviewee 5 also argued that a JIT arrival clause that benefits the charterer by differentiating between the cost for extra sailing time and waiting time at port must account for bunker price variations.

A more refined approach with a range of possible bunker costs and the associated demurrage rate reductions, also proposed by BIMCO, could facilitate more balanced benefit sharing as exemplified by Table 3 (BIMCO, 2021). This addresses the fact that the contracting parties might be operating under significant uncertainty at the time of fixture regarding relevant bunker prices during voyage execution as voyage charters can be made with some lead time to the agreed laycan window. Given the differing speed–consumption curves of individual vessels, the exact relationship between different bunker price ranges and the associated reductions in the demurrage paid for the extra sailing time should be based on vessel-specific sample calculations that also account for the agreed demurrage rate (BIMCO, 2021).

Table 3: Example of a market-dependent benefit-sharing mechanism

Bunker price (USD per metric ton)	Reduction in demurrage paid for the extra time spent at sea (%)
200 – 400	20 %
400 – 600	40 %
+ 600	60 %

Adapted from BIMCO (2021)

Although completing such calculations for each charterparty separately can be burdensome at first, much of this process can be automated if this became common due to charterers' requests. Transparency regarding these sample calculations is, however, crucial for ensuring mutual acceptance due to existing information asymmetries on vessels' actual fuel efficiency (Rehmatulla & Smith, 2015a). As a downside, this mechanism requires these calculations to be completed regardless of whether a JIT arrival is ultimately initiated on the voyage or not.

Additionally, voyage charters can leave the nomination of a specific vessel to a later date after the fixture (Plomaritou & Papadopoulos, 2017). Thus, it is not uncommon for the final demurrage rate to also be left undecided, at least within the dry bulk segment, by capping the maximum demurrage rate, but stating it should "...always to be in line with the market at the time of nominating the performing vessel" (Int. 3). To ensure fair benefit sharing, the exact relationship between bunker price ranges and compensation for sailing time should therefore be finalized only after a performing vessel has been nominated and the final demurrage rate agreed. Otherwise, the contracting parties lack the relevant speed–consumption curve and final demurrage rate, which are fundamental to ensuring a balanced outcome in this case.

Finally, the contracting parties must agree on which bunker price to use for determining the appropriate bunker price range for settling the benefits of a JIT arrival. As bunker prices can vary a lot across bunkering hubs, the most likely options are probably (i) the price paid during the latest bunkering operation or (ii) the average market price upon discharging at the final port (BIMCO, 2021). There will always be a benchmark price that is favourable for different stakeholders in terms of determining the daily compensation paid by the charterer for the extra sailing time. If a charterer wants to ensure that a JIT arrival clause is accepted by the shipowner and is willing to sacrifice financial gains, he can agree to always apply the lowest benchmark bunker price since that is most beneficial to the shipowner. Of course, a more flexible approach to benefit sharing is only relevant for cargo owners who, besides the financial gains from JIT arrivals, seek to also reduce their Scope 3 emissions (Int. 5). In fact, Interviewee 5 noted that, from an emission-conscious charterer's viewpoint, the demurrage money has, in principle, been lost already if there is known port congestion at the next port, so there can be some flexibility on benefit sharing if this enables further emission reductions.

Challenges with JIT arrivals

The absence of widespread JIT arrival practices suggests that considerable challenges remain to be overcome. Firstly, lack of trust between key stakeholders serves as a practical barrier to JIT arrivals. Under voyage charters, the contracting parties have to agree on how to define the extra time spent at sea (BIMCO, 2021), which significantly influences the additional compensation payable by the charterer. While the end point is clearly the vessel's actual time of arrival to port, it is questionable whether the vessel's original ETA is a reliable starting point due to natural uncertainty in arrival estimates or even strategic motives to report overly optimistic ETAs that extend the theoretical extra time spent at sea. Indeed, a dry bulk operations manager noted how it could be difficult to assess the reliability of a master's ETA notifications (Int. 2). Especially if the charterer requests a new arrival time when the ship is still relatively far away from port, the vessel's original ETAs are likely to contain some uncertainty (Veenstra & Harmelink, 2021). Third-party services could of course be used to determine the theoretical extra sailing time (INTERTANKO, 2011), but this again involves additional verification costs. This problem of defining the extra time spent at sea persists regardless of the specific benefit-sharing mechanism used by the contracting parties.

The lack of trust is not limited to the shipowner–charterer nexus, but also relates to whether port services and terminals can be trusted to serve the vessel at its updated arrival time instead of still placing it to the back of the queue upon arrival (Poulsen & Sampson, 2019). Interviewee 2 also explained that terminals may have queuing policies that are affected by the terminal operator's own commercial interests to, for example, minimize demurrage paid to charterers. This lack of transparency can lead to charterers and shipowners doubting whether a JIT arrival actually ensures reduced waiting time if berthing priorities can change unexpectedly or the charterer's arrival time notice is ignored (Poulsen & Sampson, 2019). At less sophisticated ports, there is also the risk of corruption and facilitation payments altering the queuing order (Int. 4). More generally, widespread JIT arrivals would require extensive data exchange and transparency between all parties, particularly terminals and relevant port services that are needed for moving ships into and out of berth (GloMEEP, 2020). However, terminal operators are often unwilling to share scheduling and queuing data since this is considered commercially sensitive (GloMEEP, 2020). Furthermore, whereas shipowners and charterers could save money through JIT arrivals, the monetary benefits for ports and terminals are less direct and perhaps obtained only through higher competitiveness (Gibbs et al., 2014; GloMEEP, 2020), hence also reducing portside actors' interest in JIT arrivals.

Given the volatility of commodity markets, it is also common for onboard cargo to change owners several times during a voyage (Poulsen et al., 2022). Hence, the exact destination of a vessel may only be determined by the needs of the last buyer, which allows traders to maximize profits based on short-term price movements. While this flexibility enables vessels to be utilised as valuable tools of commodity trading, it complicates JIT arrivals since there is low visibility regarding the vessel's final destination and all stakeholders in the contractual chain may not be interested in a JIT arrival process (GloMEEP, 2020). Moreover, the value of the onboard cargo is often so high that, from a charterer's viewpoint, any financial savings from a JIT arrival are generally far outweighed by the value of flexibility that remaining uncommitted to a specific arrival time provides (Poulsen & Sampson, 2019). For instance, Poulsen and Sampson (2019) highlight how it may be entirely rational for an oil trader to have a laden vessel waiting at anchorage despite incurring demurrage costs if the oil market is in contango and delaying the selling of the cargo could improve profits from the trade. Indeed, Interviewee 10 noted that, when freight costs form only a fraction of the cargo value, it is particularly difficult to encourage JIT arrivals based on the financial benefits alone.

Moreover, most charterers are mainly concerned with ensuring that the cargo is delivered on time, likely due to either their own supply chain needs or delivery windows in sale contracts. Hence, risk-averse charterers may prefer to have ships rush to port despite congestion as this ensures the cargo is available for unloading as soon as possible (Poulsen & Sampson, 2019). For instance, an oil refinery might wish to have vessels carrying its crude oil feedstock arrive early and wait in queue outside the terminal instead of using JIT arrivals, which could lead to unexpected delays due to weather events or vessel malfunctions. Indeed, Interviewee 10 underlined how the cost of e.g. disrupted refinery operations from shipment delays are much higher than any financial gains from JIT arrivals. Of course, supply chain disruption risks can be reduced by leaving a reasonable buffer between a ship's requested arrival time and the latest time at which the cargo must arrive (Int. 5). Interviewee 5 noted how data-driven technological tools that leverage short-term weather forecasts can also be used by charterers to quantify and manage the risk of vessels not meeting their requested arrival time. However, using data-driven solutions to reduce the risk of supply chain disruptions from JIT arrivals is only realistic for charterers that possess the necessary technological capabilities (Int. 5).

Finally, Interviewee 6 argued that earlier efforts at JIT arrivals have been unsuccessful due to their bilateral nature between shipowners and charterers. After all, JIT arrival clauses are incorporated only into charterparties, but are absent from any sale contracts that might be involved – charterparties and sale contracts have no direct legal link with each other (Int. 6). Depending on the sale contract terms, only the buyer or seller is the charterer so these parties do not have fully aligned interests to reduce waiting time with JIT arrivals. As sale contracts are often made before fixtures, one practical option could be to specify that, if a charterparty allows for JIT arrivals, the demurrage recoverable by the charterer under the sale contract cannot exceed the demurrage claimed by the shipowner, including compensation for extra sailing time (Bridge, 2013). As a result, demurrage could no longer serve as an additional profit centre for traders and thereby disincentivise operational efficiency, but this would require financial concessions from market actors. Additionally, keeping the demurrage terms of sale contracts aligned with a chartering contract become harder when lengthy contractual chains form between consecutive buyers and sellers of a cargo due to trading (Bridge, 2013).

5.2 CII regime

Multiple interviewees argued that the financial and reputational costs of inefficiency must increase for operational inefficiencies to be significantly reduced and efficiency-improving contractual changes, including JIT arrival clauses, to become more popular (Int. 5, Int. 11). The IMO's upcoming CII regulations, which will come into force in January 2023, focus on the reputational element by categorising vessels based on their operational carbon intensity. All ships above 5000 GT will be ranked annually from A to E depending on their carbon intensity performance during the preceding calendar year (IMO, 2021b). Vessels have to achieve a minimum C rating each year to remain compliant, but the rating boundaries will become progressively stricter to motivate continuous reductions in fleetwide carbon intensity (IMO, 2021b). The shipowner must report what corrective actions will be undertaken in cases of repeated non-compliance (IMO, 2021b), but there are currently no regulatory sanctions for failing to comply even if a vessel's CII rating remains below C for several years (Psaraftis, 2021). Non-compliant vessels may still suffer from negative commercial repercussions as some charterers may establish chartering policies whereby they only charter in vessels with at least a C rating (Psaraftis, 2021; Standard Club, 2021). As a result, vessels with non-compliant CII ratings may face lower market demand and reduced income streams (Int. 1), at least during weaker freight markets when tonnage may be oversupplied.

While carbon intensity simply represents how much CO_2 is emitted per each unit of transport work, the IMO has long disagreed over how to define 'transport work' (IMO, 2021a). For regulatory purposes, the most common candidates for measuring carbon intensity have been the Annual Efficiency Ratio (AER) and the Energy Efficiency Operational Indicator (EEOI). The AER and EEOI, often calculated on an annual or otherwise aggregated basis, can be represented mathematically as follows (Wang et al., 2021a):

$$AER = \frac{CO_2 \text{ emissions of the vessel}}{\text{Deadweight tonnage of the vessel} \times \text{sailing distance}}$$

$$EEOI = \frac{CO_2 \text{ emissions of the vessel}}{\text{Cargo carried onboard} \times \text{sailing distance}}$$

The regional EU MRV requires the reporting of detailed cargo information that enables the calculation of EEOI values, whereas the global IMO DCS is more focused on maintaining confidentiality and omits such information (Deane et al., 2019). While the EEOI reflects a vessel's actual operational efficiency more accurately, the AER was ultimately selected as the underlying carbon intensity measure for the CII regime (DNV, 2021). This allows for the existing IMO DCS to be used as the basis for calculating annual CII ratings and has been seen as less controversial from the viewpoint of market actors (Panagakos et al., 2019).

Contractual element of the CII regime

If a vessel is mainly operated on voyage charters, the shipowner has significant influence over its CII rating since he maintains operational control and can select which voyages are completed by the vessel (Int. 5). He can undertake both technical and operational measures to improve the vessel's energy efficiency, while also avoiding fixtures that are expected to have an unfavourable AER impact. CII-related provisions do not have to be incorporated into voyage charters, but as suggested by Interviewee 5, shipowners might become more interested in e.g. using JIT arrival clauses as a cost-effective instrument for achieving CII compliance, especially if technical measures are not feasible. In a similar vein, for older and less fuel-efficient vessels, general slow steaming clauses may also be included into voyage charters to secure CII compliance (Standard Club, 2021). After all, a vessel's AER cannot be unilaterally improved by the shipowner through, for example, reducing speed, deviating from the most direct route or limiting cargo intake since this could result in a breach of contractual obligations on both time and voyage charters (Standard Club, 2021). However, since the CII regime focuses solely on shipowners, it does not directly create any further incentives for voyage charterers to agree to, for example, incorporating JIT arrival or slow steaming clauses into charterparties if they are otherwise hesitant to do so. In theory, some shipowners could make these rider clauses prerequisites for agreeing to fixtures, but this also narrows down prospective charterers to those that are willing to compromise on such issues.

By contrast, the CII regime necessitates a new level of shipowner–charterer collaboration under time charters since the charterer's operation of the vessel determines its CII rating, but the shipowner remains responsible for CII compliance (Int. 1). As argued by Poulsen et al. (2022), the CII regime continues the IMO's ship-oriented regulatory approach, which places regulatory responsibility on shipowners, but not other stakeholders. The time charterer has traditionally been allowed to freely operate the vessel within its trading limits, but this freedom may be contractually limited in the future by the shipowner demanding his vessel to be operated such that it achieves a certain CII rating or is redelivered within a certain AER window (Int. 1). Interviewee 1 identified this as a significant change since time charterers are not used to being restricted in their employment orders. While time charterers are already encouraged to optimise ship operations through bearing the fuel costs, additional CII-related obligations could thus further expand the appeal of emission-reducing operational measures.

While time charters continuing into 2023 are already being signed, interviewees from both the shipowner and charterer side of the business stated that CII-related provisions were not yet incorporated into their contracts (Int. 4, Int. 5), expecting that most market actors are still waiting to see how the broader market will react to the CII regime coming into force. To encourage collaboration between the contracting parties as a means of ensuring that a shipowner's desired CII rating can be achieved also under time charters, BIMCO is working on a CII Clause for Time Charterparties (BIMCO, 2022a). As the CII-related obligations are created by policy intervention, most of the barriers identified in Section 4 are also less relevant here. Table 4 summarises the main responsibilities of both contracting parties under BIMCO's draft CII Clause (i.e. might be subject to some changes before final publication).

Table 4: Main responsibilities of the contracting parties under BIMCO's CII Clause

Shipowner's rights and responsibilities	Charterer's rights and responsibilities
– Monitor the vessel's actual fuel consumption and provide the charterer with compliance-related data on a monthly or voyage-specific basis	– Operate the vessel such that CII compliance is achieved and the agreed CII is not exceeded during the contract period
– Request the charterer to provide a written plan of the vessel's future commercial operation if there is reasonable doubt about the agreed CII being met	– Provide the shipowner with a written plan for the vessel's commercial operation for at least the next voyage upon written request
– Entitled to not follow the charterer's written plan or adjusted written plan for vessel employment if these are unaligned with their commitment to not exceeding the agreed CII	– Liable to indemnify the shipowner for losses or damages caused by the charterer's breach of CII-related obligations, including any negative impact on the vessel's CII rating
Shared responsibilities of both contracting parties	
– Work together in good faith to devise an adjusted operational plan to meet the agreed CII if the shipowner deems the charterer's initial written plan to be inadequate for achieving CII compliance	

Simplified from BIMCO (2022a)

CII-related rider clauses do not directly unlock better energy efficiency similar to e.g. JIT arrival clauses, but rather seek to incentivise the contracting parties to achieve more efficient ship operations by any means available. In practice, such rider clauses bilaterally reallocate CII-related responsibilities between shipowners and time charterers to better reflect who has operational control over the vessel (Int. 1). It remains to be seen which time charters will include CII-related rider clauses as short-term time charters may be considered unworthy or too difficult for implementation, thereby forcing these shipowners to pursue CII compliance mainly through technical measures and more careful screening of prospective charterers. It also possible that, due to no sanctions existing for non-compliance, some shipowners might disregard the CII regime and seek to attract charterers by continuing to provide them with unrestricted operational flexibility (Int. 1). This shows how the CII regime will only affect energy efficiency if shipowners consider regulatory compliance relevant. Newer and more fuel-efficient vessels may also obtain their desired CII rating purely through higher technical efficiency, which reduces the CII's expected effect on tackling operational inefficiencies.

Challenges with the CII regime

Encouraging better energy efficiency through CII-related clauses also has its difficulties due to significant weaknesses in the CII regime and its underlying AER metric. Firstly, since the AER uses the vessel's deadweight tonnage in the denominator instead of cargo carried, the CII rating does not reflect vessels' actual capacity utilization or penalise lengthy ballast legs (Psaraftis, 2021). Indeed, Wang et al. (2021a) explains how charterers could be incentivised to deliberately sail vessels empty to achieve a lower annual AER given that ballasting involves lower fuel consumption than laden sailing. The AER-based CII regime can thus do the opposite of encouraging more voyage triangulation and less ballasting (Int. 8). For example, Interviewee 8 highlighted how the CII regime does not incentivise industrial time charterers to improve their time charter vessels' laden-ballast ratios by trading them out on e.g. complementary spot fixtures since this makes it more difficult to meet the CII ratings that might have been agreed with shipowners. In principle, shipowners could also explicitly limit cargo capacity at the pre-fixture stage to ensure that their vessel is not fully loaded by charterers and a lower annual AER can be achieved. However, this also runs contrary to efficient ship operations as it decreases the vessel's capacity utilization instead of increasing it as would be desired. Changing the CII's underlying metric to the EEOI would naturally resolve these issues by accounting for vessels' actual capacity utilization, but this has been controversial due to cargo carried being seen as commercially sensitive (Wang et al., 2021a).

Both the voyage-level AER and EEOI metrics also contain a lot of noise due to, for example, uncontrollable weather effects and port delays (Panagakos et al., 2019; Polakis et al., 2019). A given vessel's CII rating can thus vary significantly from one year to the next, depending on route choice and external noise (Psaraftis, 2021). As a result, if a time charterer trades the vessel on an irregular pattern, he needs good visibility on the expected CII impact of each voyage to ensure the CII rating agreed with the shipowner can be achieved (Int. 1). Many market segments also have seasonal patterns in freight rates, so ships' carbon intensity is unlikely to be equally distributed across a calendar year (Kavussanos & Alizadeh-M, 2001). Robustly managing a ship's long-term CII trajectory therefore requires significant planning and data analytics capabilities, which not all might time charterers possess or have the willingness to invest in (DNV, 2021). Thus, if a time charterer does not proactively plan his voyages to achieve the agreed CII rating and the shipowner has to intervene to request changes in how the vessel is operated, it is less likely that only emission-reducing measures are utilised to improve the AER since operational shortcuts such as longer ballast legs are also available to the charterer due to the CII's shortcomings. This implies that shipowners who want to ensure that CII-related rider clauses actually encourage higher operational efficiency must be more selective in whom they accept as charterers for their vessels (Int. 1).

The fact that failing to comply with the CII regime triggers no regulatory sanctions can also render it challenging for shipowners to, for instance, impose financial penalties on charterers if they fail to return the vessel with the agreed CII rating. After all, it can be difficult for a shipowner to prove the extent of commercial losses that they would incur from trading the vessel at a lower CII rating during the following year (Int. 1). BIMCO's draft CII Clause does make the charterer liable for damages and losses if the vessel's future employment is negatively affected by a lower CII rating (BIMCO, 2022a), but it remains unclear how this will be interpreted in practice. If shipowners cannot properly claim damages for charterers failing to meet the agreed CII rating, the efficacy of CII-related rider clauses in encouraging more efficient ship operations also suffers since charterers would only face reputational costs in the charter market for failing to fulfil their CII-related contractual obligations. Hence, there could also be a need for clearer 'blacklisting' of time charterers who disregard their contractual CII-related responsibilities and redeliver vessels below their agreed AER.

Although rider clauses such as BIMCO's CII Clause rely on tighter shipowner–charterer collaboration, the seasonality of carbon intensity can also render it difficult to determine when it is suitable for a shipowner to intervene and request the charterer to adapt vessel operations so that the contractually agreed CII rating can be met (Int. 1). It is challenging to establish a robust cause–effect relationship between a charterer's specific voyage orders and CII non-compliance, so shipowners cannot unilaterally reject voyage orders on this basis

(HFW, 2021). Moreover, open-ended contractual provisions on 'agreeing to agree' (i.e. cooperating in 'good faith'), also included in BIMCO's draft CII clause, do not prescribe many practical tools for shipowner–charterer collaboration at the time of contracting and are open to disputes if mutual agreement on the best path forward cannot be found (Int. 1).

As ships' CII ratings are defined based on all voyages within the preceding year, the duration of time charters will often not overlap perfectly with the CII monitoring period (Int. 1). This temporal mismatch also complicates the way in which shipowners and time charterers can ensure that a certain CII rating is achieved. Interviewee 1 explained that, if an initial time charter lasts only for the first half of a year, all subsequent time charterers need to know the vessel's previous CII trajectory to align their employment orders with the desired CII rating. However, it could be difficult for shipowners to decide on appropriate AER targets for time charters that end mid-year due to seasonality in ships' carbon intensity. The year-long lag between monitoring periods and CII ratings being published unfortunately also means that a vessel's latest rating does not necessarily reflect its current operational efficiency (Int. 1).

5.3 Carbon pricing

By compliment to the CII regime, carbon pricing, whether through an emissions trading system (ETS) or a bunker levy, increases the financial cost of inefficient ship operations by explicitly pricing the emission externality (Psaraftis et al., 2021). While these market-based measures have been discussed since at least the early 2010s (Psaraftis, 2021), this thesis does not examine the relative merits of an ETS versus a bunker levy, but instead evaluates how carbon pricing could encourage both more efficient ship operations and relevant contractual changes based on how carbon costs are contractually allocated. Although carbon pricing is often highlighted for its long-term effects on adoption of green technologies and low-carbon fuels (Metzger, 2022), we focus on its potential consequences for operational inefficiencies. Many studies have argued that a global bunker levy would be preferable (Lagouvardou et al., 2020; Psaraftis et al., 2021), but special reference is made here to the EU ETS expansion as it represents the first application of carbon costs to shipping (European Commission, 2021).

Contractual element of carbon pricing

For carbon pricing to effectively incentivise efficient ship operations, carbon costs should be borne by the party that has commercial control over the vessel (Psaraftis, 2012). In line with the ‘polluter pays’ principle, this places the carbon burden on shipowners and ship operators under voyage charters and on charterers under time charters. If shipowners are responsible for carbon costs also under time charters, this encourages shipowners to consider technical measures on their vessels to improve energy efficiency, but does not further incentivise time charterers to optimise ship operations despite having operational control (Psaraftis, 2012). Indeed, the first draft of the EU ETS expansion to shipping actually places the carbon costs onto the shipowner (or bareboat charterer) regardless of charterparty type, but a revised draft has been proposed to align with the ‘polluter pays’ principle (European Parliament, 2022). BIMCO’s recently published ETSA Clause for Time Charterparties, drafted in anticipation of the EU ETS expansion, also aligns with the ‘polluter pays’ principle (BIMCO, 2022b)

If the time charterer is made contractually liable for the carbon costs in addition to fuel costs, his financial incentives to tackle operational inefficiencies are clearly strengthened (Psaraftis et al., 2021). There are no large misaligned incentives with the shipowner on operational measures, so these become crucial short-term tools for time charterers in minimising their carbon costs as major technical retrofits (or alternative fuels) are often not feasible, at least in the short-run. However, shipowners that trade their vessels out on time charters still face the ‘efficiency problem’ unless the carbon price is high enough and transparency on vessels’ true fuel efficiency improves, so that more fuel-efficient ships get appropriately rewarded in the charter market through e.g. lower off-hire days and higher daily hires than their more inefficient peers (Adland et al., 2017; Agnolucci et al., 2014; Psaraftis et al., 2021).

Under voyage charters, contractual allocation of carbon costs has generally been considered unnecessary as the shipowner or ship operator controls the vessel and is expected to pay the emission bill. As a result, the shipowner is incentivised to use both operational and technical measures (feasibility of technical measures depends on vessel ownership) to minimise voyage costs (Psaraftis, 2012). However, this still leaves the ‘usage problem’ unsolved since the carbon costs are paid only indirectly by the charterer as part of the fixed freight rate, which does not reflect the actual voyage-specific emission footprint. Indeed, Rehmatulla (2011) notes how the voyage charterer would be best motivated to optimise charterparty structures if he was directly responsible for the carbon costs. This is simply, because the charterer’s decisions regarding, for example, JIT arrivals or the demanded C/P speed would be directly reflected in his emission bill. However, bilaterally allocating the carbon costs to voyage charterers is not feasible in practice since the shipowner still maintains operational control of the vessel and voyage charterers could no longer rely on a fixed freight cost.

With regard to the practical implications of carbon costs on ship operations, Jia et al. (2017) argue that carbon pricing could motivate the adoption of JIT arrivals since it increases the financial savings achievable from this measure. Carbon pricing also explicitly values the emission externality of unproductive ballasting so, depending on the carbon price level relative to freight rates (Gu et al., 2019), this could motivate further optimisation of ballast legs and higher voyage triangulation (Int. 8). Smaller shipowners may also find commercial pools even more appealing to increase their vessels' capacity utilization through leveraging economies of scale. Interviewee 8 also noted that carbon costs can lead to reorientation of vessels' trade patterns if underlying commodity flows enable this. As a result, cargoes would be redistributed between vessels to their most 'efficient' carriers (Wang et al., 2019). After all, with higher carbon costs, optimisation of ballast legs becomes increasingly important for vessels' price competitiveness in fixture negotiations as most charterers will typically select, with everything else equal, the vessel that can offer the lowest freight rate (Int. 8).

Indeed, charterers can reduce ballast emissions by either fixing vessels that are already closer to the loading port or making fixtures with a longer lead time so that laycan windows do not indirectly force vessels to sail at high ballast speeds simply to avoid contract cancellation (Prochazka et al., 2019). Naturally, this is more likely to occur if high carbon costs are properly passed onto voyage charterers and the price signal is large enough to influence charterers' decision-making, particularly in trades where the relative magnitude of freight costs to cargo value is higher than across much of the tanker segment. Moreover, carbon costs would also reduce the economic appeal of vessels opting for longer sea routes to avoid costly canal passages (e.g. Suez or Kiel Canal) even during lower bunker prices (Poulsen et al., 2022; Wang et al., 2021c). Of course, these canals must be able to handle higher traffic without suffering from huge congestions or certain ships may still choose longer sea routes.

Challenges with carbon pricing

With shipowners liable for carbon costs under voyage charters, Interviewee 10 noted that some charterers may still not receive a strong enough price signal through freight rates that encourages them to adapt efficiency-oriented contractual changes and/or change their fixture behaviour. For example, risk-averse charterers may still be unwilling to adopt JIT arrivals and risk unexpected cargo delays despite their increased economic benefits if freight costs continue to represent only a small fraction of cargo value (Poulsen & Sampson, 2019). Given the political disagreements seen at the IMO, it is also unclear whether a 'large enough' carbon price would be politically feasible, at least on a global scale (Psaraftis, 2019). More broadly, inflexible contractual structures such as strict speed-related obligations on voyage charters could prevent carbon pricing from having its intended effects on ships' operational behaviour (e.g. speed choice) if charterers do not adapt their contracts and fixture decisions accordingly (Adland & Jia, 2018; Prochazka et al., 2019). For instance, reducing vessel speeds optimally in response to carbon costs may be difficult under voyage charters unless charterers agree to include slow steaming clauses into charterparties (Int. 1). However, as noted by Lindholm (2014), slow steaming clauses are perhaps even harder for charterers to accept than JIT arrival clauses as general speed reductions also increase the total voyage duration. Similarly, charterers' laycan windows with short lead times relative to vessels' current geographical positioning will continue to drive high ballast speeds if charterers do not actively consider this in their fixture decisions and prefer to maintain strategic flexibility in fixture timing to capitalise on short-term freight rate fluctuations.

Moreover, the pass-through of carbon costs onto voyage charterers can depend heavily on freight market conditions and the underlying commodity trade (Chowdhury & Dinwoodie, 2011; Kosmas & Acciaro, 2017). Indeed, Kosmas and Acciaro (2017) show that shipowners are likely carry more of the carbon costs during weak freight markets, while they can pass a larger cost share onto charterers in stronger markets. As a result, voyage charterers' visibility of the true carbon costs remains limited, so it is unclear how significantly charterers would be motivated by carbon pricing alone to cooperate more on emission-reducing operational measures (e.g. JIT arrivals) to lower their freight costs, especially during weak markets when shipowners might carry a larger share of the carbon costs anyway. Under an ETS, the temporal mismatch between shipowners' purchasing of emission allowances and voyage execution also reduces charterers' visibility on the relationship between freight rates and voyage-specific carbon costs (Psaraftis, 2012). If voyage-specific carbon costs are hard to define due to variable carbon prices, this can also create further issues for benefit sharing under JIT arrival clauses since the theoretical carbon cost savings should also be shared.

Finally, regional carbon pricing, as manifested by the EU ETS, can also inadvertently encourage operational inefficiencies regardless of charterparty structures. Regional carbon pricing might, for example, motivate emission-increasing evasion strategies involving route diversions and additional port calls by vessels attempting to minimize their carbon costs (Psaraftis et al., 2021). While global carbon pricing would prevent evasion, a global scheme is unlikely to be achieved at least in the immediate future (Haites, 2009; Wu et al., 2022).

6. Recent contractual innovations

This section examines more innovative efficiency-focused contractual solutions, which are either being currently piloted or were proposed by industry experts during interviews. Our objective is to analyse the main elements of these more recent contractual solutions and evaluate the challenges ahead for their implementation. By contrast to contractual revisions discussed in Section 5, some of the contractual solutions examined here require charterers to be actively interested in reducing their shipping emissions rather than being solely motivated by the financial benefits of higher energy efficiency as could be the case on, for example, JIT arrivals. As a result, these innovative solutions still face the overarching problem of many bulk shipping cargo owners remaining largely unconcerned about their shipping emissions.

6.1 Efficiency-adjusted compensation

Some industry players have proposed incorporating bilateral incentive mechanisms within charterparties to reward lower carbon intensity and penalise higher carbon intensity, even without mandatory carbon pricing. In practice, this means creating a more direct relationship between the compensation of the shipowner or ship operator (a freight rate or daily hire) and the carbon intensity of the executed voyage(s) (Kylstad, 2022; Zografakis, 2021). We focus on efficiency-adjusted freight rates as interviewees also emphasised potential applications to long-term CoAs as well as voyage charters (Int. 8, Int. 11). By creating additional economic incentives for shipowners to optimise energy efficiency, efficiency-adjusted freight rates adopt a non-prescriptive approach to further encouraging efficient ship operations. Whether it is advanced weather routing, optimisation of ballast legs or optimised hull and propeller maintenance, all of these improve the vessel's emission performance and the shipowner is rewarded accordingly. As it requires charterers to be willing to pay a premium on the freight rate in return for lower carbon intensity, this contractual tool is only relevant for stakeholders that see themselves as industry frontrunners (Int. 11). The 'usage problem' is not addressed by this mechanism given that charterers voluntarily commit to pricing emissions bilaterally.

In practice, the freight paid is adjusted upwards or downwards based on whether an agreed carbon intensity benchmark was achieved on the executed voyage (Int. 8, Int. 12). Since the shipowner maintains operational control of the vessel under both CoAs and voyage charters, he is rewarded with a higher freight rate if the voyage's actual carbon intensity is below the benchmark, while he receives reduced freight income if the benchmark is exceeded. As the charterer pays reduced freight when the shipowner exceeds the benchmark, he can use the saved freight costs to, for example, offset these excess shipping emissions. A first example of a chartering contract incorporating efficiency-adjusted compensation is a six-year CoA that was signed between Klaveness Combination Carriers (KCC) and South32 in early 2022 (Klaveness Combination Carriers, 2022). Naturally, long-term CoAs provide the optimal environment for such a bespoke incentive mechanism since the additional negotiation costs can be considered more worthwhile (Int. 11). Efficiency-adjusted freight rates for voyage charters remain in conceptual development, but might be tested in the tanker segment by a few larger charterers during 2022, perhaps also with existing CoA partners (Int. 8).

Establishment of voyage-specific emission benchmarks

Firstly, the contracting parties must agree on a fair carbon intensity benchmark against which the actual voyage-specific carbon intensity can be evaluated (Int. 12). The first method for defining emission benchmarks, mainly relevant for long-term CoAs, is using the shipowner's historical voyage data (Int. 11). The contracting parties must trust each other on data sharing in this context since the benchmarks would be based solely on the shipowner's internal data. Strong mutual trust is often absent from spot fixtures (Int. 4), so using shipowners' historical data for benchmark establishment is less feasible under voyage charters. If historical voyage data exists for the expected CoA routes, route-specific emission benchmarks can be defined as, for instance, the average amount of CO_2 emitted per unit of cargo carried. However, this is only feasible if the CoA voyages are relatively standardized (e.g. due to the charterer's regular trading patterns) and route-specific historical data exists. Otherwise, a larger pool of the shipowner's historical voyages with similar ships would need to be used, so voyage-level carbon intensity is scaled by distance as done in the EEOI. Alternatively, as argued by Panagakos et al. (2019), one benchmark indicator alone might not be enough to properly evaluate voyage-level carbon intensity. The feasibility of using historical voyage data to create representative emission benchmarks also depends a lot on whether the shipowner has previously utilised his own tonnage to fulfil most voyages or if he relies heavily on chartering in external tonnage (as would be generally done by an asset-light ship operator).

We must also recognize that speed and capacity utilization can, for example, jointly explain up to 85% of the variation in EEOI values for sister ships trading on identical routes (Zhang et al., 2021). Thus, speed choice and capacity utilization must be factored into all emission benchmarks derived from historical data, perhaps by establishing distinct benchmarks for different speed–capacity utilization combinations. Otherwise, the representativeness of the emission benchmark suffers and freight rate adjustments might occur randomly rather than based on actual energy efficiency changes controllable by the shipowner. After all, speed choice and cargo intake are often decided by the charterer (at least if laden speed is specified beyond ‘utmost despatch’), so the shipowner should not receive a reduced freight rate based on his counterparty’s voyage decisions (Int. 11). Regarding cargo intake, the charterer should also be incentivised to maximize capacity utilization (or at least not penalised with an upwards freight rate adjustment) (Int. 12), because this improves operational efficiency. As noted by Interviewee 12, the shipowner himself will anyways receive higher total freight income as a result of more cargo intake if the freight rate is quoted on a $/tonne basis.

Using historical voyage data for creating benchmarks also requires ensuring that previous market abnormalities (e.g. COVID-19 effects on bulk shipping) do not bias future emission benchmarks (Int. 12). As a result, significant data cleaning might be necessary to render the benchmarks representative of normal market conditions. Given how much weather affects voyage-specific emission performance, current industry proposals suggest a sea margin for the emission benchmark so that some deviation between the carbon intensity benchmark and the achieved carbon intensity is tolerated before affecting the freight paid (Int. 11). However, a static sea margin might easily capture either too much or too little of the weather effects, so rewarding voyage-level operational efficiency, versus the agreed benchmark, very accurately under real-world operational conditions is impossible. Alternatively, past meteorological data could also be utilised to normalize historical voyage data for at least extreme weather events (Wang et al., 2021b), but weather and sea conditions influence all vessels differently.

Another method for defining emission benchmarks, more tailored for spot fixtures, relies on the prediction of voyage-specific emissions for individual vessels as enabled by fleetwide historical voyage data (Int. 8). This is slowly becoming feasible as commercial maritime technology is starting to achieve up to 90–95% accuracy in predicting fuel consumption with advanced machine learning (ML) (Int. 8, Int. 9). In short, third-party prediction of voyage-specific emissions, from the preceding ballast leg until last discharge port, serves as a more neutral starting point for benchmark establishment (Int. 8). However, while black-box ML models can provide good predictive performance and learn from new training data, they have poor interpretability (Yan et al., 2021), which can make it harder to establish industrywide trust in ML-based benchmarks, particularly when this can determine the freight paid.

For instance, one industry proposal suggested a market-based emission benchmark that could be created by first assessing, based on real-time Automatic Identification System (AIS) data, which suitable vessels are geographically available to meet a specific laycan window for the desired voyage and then predicting the voyage-specific emissions of each vessel if they were fixed to carry the given cargo (Int. 8). Thereafter, the emission benchmark for the fixed vessel could be defined by the average predicted emissions of all candidate ships for that cargo (Int. 8). However, significant deficiencies in publicly available fixture data (Adland et al., 2018b) mean that this market-based benchmark would ignore vessels' commercial status (i.e. 'open' or 'fixed') and thereby misrepresent the average emission performance of ships that are actually available in the spot market. Additionally, if a voyage charterparty is fixed much before its laycan window, agreeing on a market-based benchmark can be harder as the pool of suitable vessels that could theoretically meet the laycan window can be too extensive and therefore unsuitable for defining a fair emission benchmark for the planned voyage.

As a market-based benchmark does not directly reflect the expected emission performance of the fixed vessel, efficiency-based freight rate adjustments could, in this case, result from either (i) the vessel's technical specifications (superior fuel efficiency versus relevant peers) or (ii) better usage of operational measures. Prediction-based benchmarks must also account for weather and sea conditions through a sea margin or by incorporating forecasted weather into the underlying prediction model. However, the feasibility of using weather forecasts to improve predictive accuracy reduces as (i) the lead time between benchmark establishment and voyage execution grows and (ii) the total voyage duration increases. Regardless of how weather and sea conditions are accounted for, the maximum 90–95% accuracy of predictions still leaves a substantial error margin that likely biases all prediction-based benchmarks. It is unclear whether shipowners and charterers would be willing to accept such an error margin.

Measurement and settlement of emission performance

The validation of realized voyage-level emissions, proxied by bunker consumption, is also crucial for the settlement of freight rate adjustments. However, adjusting freight rates based on voyage-specific fuel consumption observed from noon reports is suboptimal due to this data source being imprecise and prone to human errors (Smith et al., 2013). After all, a large part of the global fleet does not yet have continuous monitoring sensors and noon reports remain a key data collection source (Yan et al., 2021). The low frequency of noon reports also restricts shipowners in properly monitoring and predicting whether they are on track to achieve the agreed emission benchmark. Moreover, Poulsen and Johnson (2016) found that crews may sometimes intentionally misreport fuel consumption due to personal motives or shoreside requests. This implies that, particularly in the low trust context of spot fixtures, fuel consumption could also be deliberately under-reported by shipowners to achieve higher efficiency-adjusted freight rates, thus creating further problems caused by market failures.

One practical method of validating noon reports is applying predictive modelling to flag instances where the reported fuel consumption deviates significantly from the estimated fuel consumption under known weather conditions (Int. 8, Int. 9). This validation procedure should be completed by an independent third party to identify data errors and deliberate misreporting (Int. 8). However, a crucial problem with modelling-based flagging of noon reports is that substantial deviations in daily bunker consumption (versus the predicted consumption) can also result from weather events or indeed achieved through efficient ship operations instead of being created by crew misreporting. This highlights another weakness of efficiency-adjusted freight rates in the absence of more accurate monitoring sensors.

Without a global carbon price for shipping, the carbon cost, which determines how much the freight rate is adjusted per unit difference to the benchmark, must also be agreed bilaterally (Int. 12). While the EU ETS expansion will create a regional carbon price for shipping, this carbon cost is only directly relevant for voyages calling at EEA ports (Int. 11). Additionally, the dynamic nature of allowance prices creates variability around the carbon cost, which may be undesirable. Since the willingness to price carbon differs between market actors, agreeing on a bilateral carbon cost is thus far from straightforward. Finding a mutually acceptable carbon cost should, however, be easier under long-term charters than one-time spot fixtures.

Potential influence on vessels' energy efficiency

Efficiency-adjusted freight rates under long-term chartering contracts (e.g. multi-year CoAs) increase shipowners' incentives to not only optimise ship operations by all available means, but also to undertake technical retrofits that can be financed through the upwards freight rate adjustments. For example, the KCC–South32 CoA could also help finance KCC's further fleet upgrades, which lower the carbon footprint of future voyages executed for South32. At the level of individual voyages, the freight rate adjustment further incentivises shipowners to undertake all available operational measures, including optimisation of ballast legs (in terms of both speed and ballast distance), and/or charter in fuel-efficient tonnage to achieve higher freight rates. It also increases shipowners' incentives to agree to JIT arrivals since the potential economic benefits now include not only fuel savings, but also reduced voyage-level carbon intensity and thus a higher freight rate. Efficiency-adjusted freight rates also further penalise shipowners through a reduced freight rate if they pay less attention to minimising voyage-level carbon intensity during periods of low bunker prices. Speed-related obligations and demurrage-related incentives for rushing to wait will of course continue to exist unless these are resolved separately. However, if both contracting parties have already committed to efficiency-adjusted freight rates under a long-term chartering contract, shipowner–charterer collaboration on solving these problems should be more achievable than normally.

For efficiency-adjusted freight rates on spot fixtures, another desirable outcome would be the formation of a two-tier spot market in which ships that achieve better emission performance, due to either their technical superiority or higher usage of operational measures, are better compensated than their more inefficient peers (Int. 8). Of course, this market-level effect could materialise only if the agreed voyage-specific benchmark depended on the expected emission performance of other available vessels. A two-tier spot market would incentivise shipowners to also invest into technical retrofits that could enable them to enter the premium market segment (Int. 8). However, a large share of the major charterers within a market segment would likely have to include efficiency adjustment clauses in their charterparties before additional investments would become attractive for shipowners and a two-tier spot market might emerge. Indeed, earlier research (Alizadeh & Talley, 2011a, 2011b; Tamvakis & Thanopoulou, 2000) has found that a two-tier spot market does not exist yet, likely due to the emissions of voyage charters remaining irrelevant for most charterers and cargo owners as long as cargoes are transported safely and promptly. Interviewee 8 argued that more charterers are likely to become interested in paying a premium for voyage charters with a lower carbon footprint, through efficiency-adjusted freight rates or otherwise, once the marginal abatement costs of other possible decarbonisation projects grow higher than paying a premium on freight rates to reduce Scope 3 emissions. First-movers would probably be large charterers within the tanker segment (Int. 8), but the market has yet to reach this stage.

In summary, efficiency-adjusted compensation is currently most feasible for long-term contracts (e.g the KCC–South32 CoA) where the contracting parties are both committed to reducing their shipping emissions in the long-run. At the same time, efficiency-adjusted spot rates face significant obstacles due to, for instance, a lack of mutual trust and likely problems with agreeing on a suitable carbon intensity benchmark or a bilateral carbon cost. While receiving a higher freight rate for better energy efficiency should, in theory, be attractive to shipowners (Int. 8), they may also hesitate to risk variability on freight income given how significantly external factors such as weather and port delays can affect voyage-level carbon intensity. Under long-term CoAs, the contracting parties can build confidence in the freight rate adjustment by first testing it without financial consequences (Int. 11), but such a trial phase not feasible on spot fixtures. Thus, agreeing on efficiency-adjusted spot rates is more challenging as the contracting parties may lack confidence in the fairness of the contractual mechanism. Policy measures such as mandatory carbon pricing or the CII regime also do not directly affect the appeal of efficiency-adjusted freight rates since this contractual instrument is entirely bilateral and depends on charterers' willingness to pay more for lower emissions.

6.2 Multilateral collaboration

The previous contractual solutions have been restricted to bilateral charterparties, but another pathway to tackling operational inefficiencies involves multilateral contractual collaboration. In fact, Interviewee 6 argued that the doctrine of privity, meaning that a contract bestows rights and obligations only upon the signatories, is at the heart of misaligned incentives relating to rush-to-wait behaviour as bilateral contracting cannot alone align the conflicting interests of all charterparty and sale contract stakeholders. Crucially, the freedom of contract also allows for multi-party contracts if all contracting parties agree (Int. 6). A recent example is the Blue Visby (BV) Solution, which seeks to provide a multilateral alternative to bilateral JIT arrival clauses that does not rely on active portside support and involves all stakeholders from charterparties as well as sale contracts (NAPA, 2022). Our discussion on multilateral collaboration, enabled through contractual arrangements, utilises the BV Solution as an example case, but is also relevant more generally. Another example is the concept of cargo coordination platform between bulk cargo owners and shipowners, which would allow for complementary cargoes on similar routes to be easier combined to both improve vessels' capacity utilization and lower per unit freight costs for cargo owners (Schwartz et al., 2020).

Multilateral collaboration, through the BV Solution or otherwise, has the advantage of generally not requiring onboard installations or large capital outlays (by e.g. shipowners) since the efficiency gains are achieved operationally (Int. 6). NAPA, a maritime technology company involved in the project, has estimated the median emission reductions of the BV Solution to be only slightly smaller than those of perfect JIT arrivals, while avoiding the port-related issues of traditional JIT arrivals (NAPA, 2022). The contractual infrastructure of the BV Solution involves both (i) changes to bilateral sale contracts and charterparties as well as (ii) a multi-party contract that connects all the relevant stakeholders in a multilateral agreement (Int. 6). As a result, this two-level approach enables bilateral enforcement of multilateral collaboration without requiring any regulatory or statutory intervention.

Multi-party contracting addresses the reality that contractual obligations of a sale contract, mainly concerning the timely delivery of cargo, often form the underlying framework for the operation of a chartered vessel (Int. 6). As a result, a multi-party contract can create a direct contractual relationship between the FOB seller/CIF buyer and the shipowner, so everyone can benefit from adjusting vessel speed to reduce waiting times and contractual structures enable this. Moreover, demurrage terms can be aligned multilaterally so that no stakeholders are able to benefit unfairly at the expense of others based on demurrage, even if trading leads to multiple cargo buyers and sellers being involved. Importantly, bilateral sale contracts must also include contractual provisions that allow for enforcement of a multi-party contract once an associated fixture has been secured (Int. 6), thereby requiring a motivation for tackling operational inefficiencies to already exist amongst the sale contract signatories.

Technologically, the BV Solution also uses coordination between ships to enable multilateral voyage optimization (NAPA, 2022). Most vessels have traditionally sailed to their next port without regard for other ships heading to the same destination, thereby placing ports and terminals into a key role for facilitating JIT arrivals (Stephenson Harwood & NAPA, 2022). By contrast, the BV Solution's technological platform does not depend on portside actors for direct information about berth availability, but instead supplies participating vessels with dynamically optimized target arrival times that factor in general port and weather conditions as well as the position of other vessels heading to the same destination (NAPA, 2022). As a result, port waiting times can be reduced without explicit coordination with portside actors, which renders the BV Solution more scalable than traditional JIT arrivals since it can be easier implemented across a broader range of ports (Stephenson Harwood & NAPA, 2022).

Challenges with multilateral collaboration

Firstly, due to not involving direct ship–port coordination, the success of the BV Solution can be hindered by free-rider vessels that are not participating in multilateral collaboration (Int. 6). In practice, free riders could actually achieve reduced waiting times at port due to their competitors slowing down to meet their target arrival times, whereas participating ships may face longer total voyage durations due to free riders jumping them in FCFS queues.

This means that, if the FCFS principle is still maintained and there is no strong coordination with ports, the BV Solution requires high market penetration to ensure that non-participating vessels do not undermine the appeal of multilateral voyage optimization and disadvantage participating vessels in port queues (Int. 6). This highlights how high market penetration can be crucial for the success of multilateral collaboration in bulk shipping more widely as well.

Moreover, the BV Solution is more feasible for certain vessel segments than others. Higher market fragmentation makes it harder to achieve necessary market penetration, so the BV Solution is most suited for large and medium-sized bulk carriers (Int. 6). However, although larger vessel sizes might have lower market fragmentation, charterers and cargo owners on these trades may not be interested in multilateral collaboration. For example, Interviewee 6 explained how oil majors would have enough market power to bring multilateral voyage optimization into tanker trades, but might still be uninclined to cooperate with their direct competitors, even if this unlocks systemic efficiency gains. Similarly, a cargo coordination platform that improves ships' capacity utilization would likely reveal commercially sensitive cargo information to competitors, which also hinders this form of multilateral collaboration. More generally, multilateral collaboration between market actors must be carefully designed to avoid legal issues regarding competition law and anti-competitive behaviour (Int. 6).

Lastly, while aligning all stakeholders' interests towards higher operational efficiency, the economic benefits of multilateral collaboration are unlikely to be always high enough on their own to ensure that all parties are consistently left better off compared to the status quo (Int. 6), at least if high carbon prices are not a global reality. As an example, while bringing sale contracts and charterparties under a multi-party contract reduces traders' possibilities to make further profits on the misalignment of contractual terms (namely demurrage), the likely financial benefits of the BV Solution may not always match these lost profit opportunities. Consequently, Interviewee 6 argued that market interest for the BV Solution, or other forms of multilateral contractual collaboration, must instead derive from shipowners, charterers and cargo owners needing to reduce their emission footprints due to regulatory or reputational concerns. In terms of shipowners and time charterers, the CII regime increases the BV Solution's appeal since it could provide another cost-efficient path to regulatory compliance (Int. 6). For cargo owners, the BV Solution's environmental merits are mainly relevant for minimizing Scope 3 emissions (Int. 6). However, this requires a critical mass of cargo owners, at least within a given market segment, to become concerned enough about their shipping emissions to act decisively. Of course, under a carbon pricing system, the economic appeal of the BV Solution also increases similar to traditional JIT arrival clauses.

6.3 Other contractual revisions

The following contractual changes, proposed by industry experts, are mainly intended to enable more efficient ship operations rather than creating further incentives for stakeholders to improve energy efficiency. Firstly, Interviewee 10 proposed that, for tanker voyage charters with stated C/P speeds, shipowners could be more proactive in informing charterers during pre-fixture negotiations about specific vessels' optimal speed ranges under different operational conditions. After all, ships' true speed–consumption curves are far more diverse than would be suggested by the traditional 'cubic law' and are also significantly influenced by, for instance, loading and maintenance conditions (Adland et al., 2018a; Adland et al., 2020). The agreed C/P speed could therefore be based on a data-driven approach instead of charterers demanding the same C/P speed regardless of the vessel (Int. 10). This could further improve ship-level operational efficiency and also help shipowners achieve CII compliance, but might be challenging to implement due to the bargaining power of large charterers and the importance that specific C/P speeds may have for inventory scheduling on behalf of cargo owners (Devanney, 2011; Plomaritou & Papadopoulos, 2017). After all, if C/P speeds fluctuated more dynamically depending on individual vessels and freight market conditions, cargo owners would also need more flexible inventory management as cargo transportation times would become less standardized due to varying C/P speeds on the same charterer's fixtures. Moreover, higher variability on agreed C/P speeds might also necessitate more explicit and transparent pre-fixture negotiations regarding the freight rate–speed choice relationship to render this economically attractive to charterers as well (Int. 8).

Other interviewees also suggested moving beyond static C/P speeds and revising voyage charters such that shipowners' main contractual obligations would revolve around the cargo pick-up (i.e. laycan window) and cargo delivery dates, which are often most relevant to traders and cargo owners (Int. 8, Int. 10). As a result, explicit speed-related obligations, including static C/P speeds on tanker voyage charters, would be relaxed to provide vessels with higher operational flexibility (Int. 8). This contractual revision specifically tackles the speed-related inflexibility discussed in Section 3 since it enables vessels, also under voyage charters, to adjust speed more dynamically based on advanced weather routing advice (current and expected weather) at different stages of the voyage and e.g. slow down near the end of a laden leg if it becomes clear that the agreed arrival window (i.e. cargo delivery dates) can be met. Such a change must also account for bills of lading given their common incorporation of 'utmost despatch' obligations as well (Rehmatulla & Smith, 2015a).

According to a dry bulk operations professional, voyage charters with only 'utmost dispatch' obligations already provide a slightly higher degree of speed-related flexibility (Int. 3), which suggests that the efficiency gains of transitioning to binding arrival windows would probably be smaller on these trades. The efficiency gains would also be reduced for vessels that are already sailing close to their minimum speed due to unfavourable market conditions since further downwards speed adjustments, in response to weather routing advice, would be limited. Transitioning to binding arrival windows is least feasible on voyages where the vessel's final destination and desired arrival time remain undecided at the time of fixture. Regardless of the underlying charterparty, binding arrival windows could also help improve charterers' and cargo owners' planning of portside cargo operations in case vessels' binding arrival windows were short enough to allow for reducing buffer times across supply chains. However, similar to traditional laycan windows, there would be conflicting interests between shipowners, charterers and cargo owners regarding the duration of binding arrival windows. Whereas shipowners would prefer longer binding arrival windows to minimize their risk of contractual breaches, charterers and cargo owners would rationally prefer shorter cargo delivery windows as this could enable more precise planning of portside logistics.

For shipowners to agree to replacing speed obligations with binding arrival windows, they should first be able to accurately quantify the likelihood of meeting the guaranteed arrival window, while not being left financially worse off than agreeing to strict speed obligations such as a static C/P speed (Int. 10). A high level of certainty on meeting the arrival window is necessary for both (i) safeguarding the shipowner against a breach of contract and (ii) ensuring that the charterer or cargo owner is not disadvantaged by delayed cargo delivery. Interviewee 10, who works on data science solutions in the tanker sector, argued that newer modelling capabilities, combined with increasingly accurate short-term weather forecasting, are starting to render it realistic to account for weather risks and guarantee an arrival window based on more precise voyage planning. Of course, this estimation task is complicated by canal passages and several loading/discharge port being involved in voyage execution as these represent additional non-weather delay risks. Thus, shipowners must establish strong trust in their predictive models before they may have the confidence to expose themselves to new contractual obligations (Int. 10). Interviewee 10 noted that chartering and operations employees would also have to be trained so they trust such new data-driven decision-support tools. More generally, Interviewee 1 also noted the technology disparity across market actors within bulk shipping, which implies that binding arrival windows could primarily be acceptable to larger shipowners that have the technological capabilities for quantifying these new risks. As the feasibility of binding delivery dates depends so much on shipowners' risk management capabilities, they would need to take a key role in proposing such contractual changes. However, it remains unclear whether further investments into improving voyage planning and risk management capabilities would be justified by the expected efficiency gains, which is a prerequisite for making this a cost-effective change (Sorrell et al., 2004).

Additionally, if a shipowner quotes a fixed freight rate at fixture, the binding arrival window should be also adjusted during voyage execution in response to how long each port call takes versus the allowed laytime. Otherwise, unexpected port delays, which the charterer should be responsible for, would force the vessel to sail faster to meet the original arrival window and waste more bunkers than estimated when quoting the freight rate. However, defining the start and end of laytime (and possible exceptions to counting laytime) has been a historically contentious topic due to its demurrage implications (Jia & Adland, 2019). In practice, this means that agreeing on how much the binding arrival window should be adjusted right after a port call could prove challenging. After all, a vessel must be informed of its updated arrival window immediately after leaving its latest port call, so it can effectively optimise its routing and speed choice to the next destination. This dynamic adjustment of arrival windows would likely be most dispute-prone in dry bulk trades since dry bulk cargo operations are more frequently disrupted by weather and port-specific considerations, so common exceptions to laytime counting on the charterer's account are more complicated (Johnson & Styhre, 2015).

Finally, under the FCFS principle, ships would still be incentivised to rush to 'get in line' if the binding arrival window was specific to berthing since the vessel cannot affect the waiting line-up. Thus, the vessel should be registered as having met the binding cargo delivery dates once it arrives to the port area, even if a suitable berth is not immediately available (Int. 8). Once again, demurrage-related incentives might still encourage shipowners to rush to port as early as possible within the agreed arrival window regardless of known port congestion. However, this misaligned incentives problem could be resolved by entitling the charterer to request a later arrival window due to known port congestion, similar to traditional JIT arrival clauses, although the same challenges with fair benefit sharing would remain.

7. Discussion

Our findings indicate that efficiency-oriented contractual revisions are difficult to popularise due to (i) the short-term orientation of most modern-day chartering contracts, (ii) mutual distrust between market actors and (iii) a shortage of external pressure on key stakeholders (namely cargo owners and charterers) to revise contractual structures. This supports earlier research that has also found long-term chartering contracts to be most conducive to energy efficiency improvements (Poulsen & Johnson, 2016; Rehmatulla et al., 2017), although short-term charterparties continue to dominate the marketplace. Similar to Poulsen et al. (2021), this study finds that both shipowners and charterers should bear larger financial and reputational costs for inefficiency to drive stakeholders to reduce operational inefficiencies such as rush-to-wait behaviour, unoptimized ballast legs and partial capacity utilization. At the organizational level, we also find that chartering employees could be further incentivised to consider voyage-specific emissions, alongside freight costs, in their chartering activities.

We argue that policy interventions, represented in this study by carbon pricing and the CII regime, could create these additional costs, but the regulatory burden (e.g. carbon costs or ensuring CII compliance) must be appropriately allocated within charterparties to incentivise higher energy efficiency. However, while carbon costs (if allocated based on 'polluter pays') can directly encourage more efficient ship operations on time charters, voyage charters will nevertheless continue to suffer from inflexible contractual structures that hinder operational efficiency unless the carbon costs, reflected indirectly through freight costs, are high enough to motivate a widespread shift in charterers' fixture behaviour and interest in revising chartering contracts. This finding aligns with Rehmatulla and Smith (2015a) who argue that market-based measures are likely cost-ineffective due to the persistence of market failures, also manifested through contractual structures that create misaligned incentives. We expect that charterers in trades where freight costs represent a larger share of cargo value to be most open to adapting contractual structures and their fixture decisions, in response to e.g. carbon costs, to tackle operational inefficiencies and reduce their own freight costs. Unfortunately, however, the most developed market infrastructure for contractual solutions such as JIT arrivals exists in the tanker segment where cargo value is often very high relative to freight costs. As a result, we agree with authors like Jia (2018) and Poulsen et al. (2021) who argue that further transparency on cargo owners' shipping emissions is required to grow public pressure on them to take action. This would increase the reputational costs of operational inefficiency for cargo owners as well given that many regulatory measures for shipping, including the upcoming CII regime, only target shipowners directly.

Our findings also show that, although the CII regime has some potential to encourage more efficient ship operations on both voyage and time charters, it also suffers from large design shortcomings (e.g. being based on the AER), which can indeed drive higher vessel-specific carbon emissions under certain circumstances. We also expand the literature on CII-related criticism (Polakis et al., 2019; Wang et al., 2021a) by arguing that design flaws such as the lack of sanctions for non-compliance can hurt the efficacy of CII-related rider clauses likely incorporated into future time charterparties. Unfortunately, many of the CII regime's flaws are hard to resolve due to their controversiality, but first steps might be to replace the AER with e.g. the EEOI and create enforceable sanctions for non-compliance. Naturally, this would also require the IMO DCS' reporting requirements to be modified, which is difficult.

Regarding JIT arrivals specifically, we agree that policy measures such as carbon pricing and the CII regime will be necessary for more widespread adoption to occur, particularly under voyage charters. However, as most ports and terminals do not actively facilitate JIT arrivals, we find that these third parties should also be provided with stronger incentives to enable JIT arrivals through e.g. better ship–port coordination and more sophisticated queuing systems. Based on evaluation of common benefit-sharing mechanisms for JIT arrivals, this study also broadens the literature by suggesting practical ways in which a balanced benefit-sharing mechanism could be established, while avoiding the precise estimation of theoretical fuel savings. Moreover, whereas much of the previous literature has focused on shipowners and charterers when examining the challenges with JIT arrivals (Poulsen & Sampson, 2019; Rehmatulla & Smith, 2015a), this thesis also demonstrates that conflicting demurrage-related interests amongst sale contract signatories and the absence of proper coordination between chartering contracts and sale contracts may hinder the elimination of rush-to-wait behaviour. As a result, multilateral initiatives such as the BV Solution could prove pivotal for tackling rush-to-wait behaviour, particularly if ports and terminals do not get more actively involved.

In terms of newer contractual innovations, we find that the main value of efficiency-adjusted compensation lies currently in equipping industry frontrunners with a bilateral mechanism to encourage further efficiency improvements, mainly under long-term chartering contracts. However, it is presently unlikely to have a large-scale impact on fleetwide energy efficiency. After all, this contractual instrument still leaves the 'usage problem' unsolved under voyage charters and does not provide an economic win-win outcome for charterers that do not care about their shipping emissions. Additionally, establishing fair emission benchmarks and verifying actual voyage-specific emissions is further complicated by market failures such as misaligned incentives and information asymmetries, which can mainly be overcome through long-term contracting and stronger bilateral trust. Efficiency-adjusted compensation could, however, have a brighter future, even under spot fixtures, as cargo owners' sustainability priorities evolve and the accuracy of voyage-specific emission predictions further improves.

To our knowledge, there is no earlier literature on the challenges and potential of leveraging multilateral contractual collaboration to enable more efficient ship operations. However, this study demonstrates how, despite the cost-efficiency of multilateral initiatives such as the BV Solution, free-rider behaviour and issues with collaboration among direct competitors could restrict the success of multilateral collaboration in tackling operational inefficiencies. While bulk shipping markets have already witnessed collaboration between shipowners through commercial pools that improve vessels' utilization rates and revenues (Haralambides, 1996), multilateral initiatives such as the BV Solution also necessitate charterers and cargo owners to at least indirectly collaborate with their competitors, which can hold back adoption. Hence, we believe it is crucial for collaborative initiatives such as the BV Solution to first prove themselves in pilots by strong charterers and shipowners so that participation becomes 'industry standard' and a critical mass can be attained. After all, network effects, achieved through high market penetration, are the main source of efficiency gains achievable from, for example, multilateral voyage optimization or more transparent cargo coordination.

Finally, our findings also expand the discussion on the role of technological innovations for energy efficiency in shipping beyond the typical focus on CO_2-reducing technical measures that are fitted onto vessels. Concretely, this thesis showcases the importance of maritime data analytics for also enabling contractual revisions as exemplified by the BV Solution's target arrival times, the technological prerequisites of successful efficiency-adjusted freight rates or the advanced modelling capabilities required for replacing speed-related obligations with binding arrival windows under voyage charters. Especially in terms of binding arrival windows, we need to, however, again highlight the power of inertia in hindering industry adoption of contractual changes. More generally, we find that technological disparities between market actors can also serve as a key barrier to more elaborate contractual solutions being adopted industrywide as many counterparties still lack the technological wherewithal to confidently commit themselves to highly technology-reliant contractual mechanisms.

8. Conclusion

This thesis has examined the challenges and potential of revising chartering contracts to both encourage and enable more efficient ship operations with regards to emissions. On a general level, we outlined the common barriers to contractual revisions in bulk shipping. We also examined the practicalities of benefit-sharing under JIT arrival clauses and discussed the key challenges preventing widespread elimination of rush-to-wait behaviour. Thereafter, this study analysed the extent to which the CII regime and carbon pricing, if incorporated into bilateral contracts, could encourage stakeholders to pursue more efficient ship operations by all means possible. Finally, this thesis critically evaluated the feasibility of newer contractual innovations to understand the challenges they need to overcome.

We conclude that, although the aforementioned policy measures are most likely necessary to facilitate contractual changes, they also have their shortcomings and are not enough on their own to ensure that all of the operational inefficiencies discussed in Section 3 are tackled. This is largely, because charterers and cargo owners are key to revising charterparty terms, but they have differing responsiveness to price signals and varying interest in reducing their own shipping emissions. Contractual solutions are, in many ways, closely intertwined with policy facilitation as they can be either necessitated or further encouraged by regulatory measures. Furthermore, when discussing the role of contractual obligations in hindering or enabling efficient ship operations, one must also recognize that charterparty provisions (regarding e.g. 'utmost despatch') differ significantly across trades and market segments. The involvement of third parties such as portside actors and charterers' sale contract counterparties can also complicate the adoption of efficiency-improving contractual changes as illustrated by, for example, the challenging history of JIT arrival clauses thus far.

Additionally, we must acknowledge that, while this study has focused been on improving energy efficiency through contractual means, charterers and cargo owners that endeavour to reduce their shipping emissions can also utilise non-contractual tools such as altering their chartering strategy or making larger adjustments to their supply chain. This means that contractual revisions (e.g. JIT arrival clauses), when not forced by policy developments, may not always be prioritised by even emission-conscious charterers and cargo owners when considering the easiest ways to reduce their emissions. We also cannot forget that another crucial path to maritime decarbonisation relies on improving technical efficiency (through retrofits and efficient newbuilds), which naturally takes longer than tackling operational inefficiencies through contractual means due to vessels' long economic lifespans.

The findings of this study also have other limitations that must be recognized. Firstly, the number of conducted interviews was relatively limited, which limits the generalizability of the interview findings to a broader market population and leaves open the possibility that a more extensive interviewee pool may have revealed more inter-expert disagreements. Secondly, neither the CII regime nor carbon pricing (through the EU ETS or otherwise) are implemented yet, so we cannot assess how market actors will, in practice, incorporate these policy measures into bilateral contracts and how (in)effective they will be in encouraging higher operational efficiency. Thirdly, since our focus has been on operational inefficiencies, this study has not examined how time charterparties could perhaps also be revised, alongside further transparency regarding vessel's true operational efficiency, to facilitate fuel-efficient vessels being better rewarded in the time charter market. Finally, our evaluation of newer contractual innovations in Section 6 has been constrained by their recentness given that all of the discussed solutions remain at the level of pilot projects or only conceptual proposals.

Lastly, since this study has taken a qualitative approach, we suggest that future research also empirically examines whether, for instance, the CII regime actually has its intended effects on vessels' carbon emissions and operational behaviour under different charterparty types or if its design shortcomings actually lead to higher ship-level emissions and more operational inefficiencies under certain market conditions. Future qualitative studies could also explore how the CII regime and the EU ETS expansion are, in practice, incorporated into charterparties by market actors using their freedom of contract. Finally, future research could take a more detailed look at the BV Solution once it becomes fully public and is offered market actors as an alternative contractual infrastructure for bulk shipping. It would be valuable to examine how various stakeholders perceive the promise and limits of multilateral collaboration, including the BV Solution, in reducing GHG emissions from bulk shipping.

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Appendix

Appendix 1: Generic interview guide (adjusted for specific interviewees)

Challenges with revising chartering contracts

- How are charterparty terms agreed on, in practice, during pre-fixture negotiations?
- What do you see as key barriers to revising charterparties to further encourage and enable efficient ship operations (with regards to emissions)?
- Which stakeholders do you see as having a key role for revising charterparties?

Current status of just-in-time (JIT) arrivals

- Have you utilised JIT arrivals previously? If yes, in what circumstances?
- What is your understanding of the current status of JIT arrivals across bulk shipping?
- What do you see as key challenges for JIT arrivals? How can these be overcome?

Policy interventions and their role in revising chartering contracts

- What role do you see for policy interventions in motivating contractual changes?
- How do you think the CII regime / EU ETS expansion will affect charterparties?
- Have you incorporated CII regime / carbon pricing concerns into your charterparties?
- Do you see some challenges for encouraging higher operational efficiency through incorporating CII regime / carbon pricing considerations into charterparties?

Other efficiency-oriented changes to chartering contracts

- What do you see as key contractual barriers to efficient ship operations and why?
- How could we revise chartering contracts and shipowners' traditional contractual obligations to enable higher operational efficiency?
- Are you aware of some recent contractual innovations that change the contractual infrastructure of bulk shipping and provide new solutions to reduce inefficiencies?

Relationship between chartering contracts and maritime technology

- What role do you see for maritime technology (hardware or software) in enabling the revision of traditional contractual obligations within charterparties?
- Are there some key challenges with leveraging maritime technology to enable more efficiency-oriented chartering contracts?