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Research Article

# Benefits for the bunker industry in adopting blockchain technology for dispute resolution

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ABSTRACT

The bunker industry has faced negative perception to their trust and credibility in recent times. This is further compounded by the need for the industry to answer new challenges to meet the requirement of the International Maritime Organization 2020. The aim of this work is to illustrate how blockchain technology may be adopted for aiding in bunker dispute resolution.

To demonstrate how blockchain may aid in disputes within the bunker industry, this paper first examines the existing bunker supply process, which involves the formation of contracts under English law, the Bunker Delivery Notes, the different types of disputes that may arise during a bunker transaction and the methods of dispute resolution utilised by the industry. Furthermore, the current literature in relation to blockchain technology and blockchain smart contracts is examined. Finally, interviews and surveys within the industry have been conducted to identify the benefits and challenges in adopting blockchain technology.

The research found that blockchains may benefit the bunker supply chain offering the effective resolution of bunker quality disputes. Furthermore, blockchains may also serve as a verification tool for electronic bunker delivery notes, which may aid quality and quantity bunker disputes as well as compliance with the new International Maritime Organisation 2020 requirements. As a result, despite the research having shown blockchain to be situationally dependent and having an element of legal uncertainty, blockchain does offer a solution to aid in bunker disputes and for improving the trust and credibility within the bunker industry.

## 1. Background

In global trade, approximately eighty percent by volume is carried by sea which equates to over seventy percent by value [1,2]. The bunker industry trades and supplies the bunkers used to power the vessels of the maritime transport sector, making it integral to global trade [3]. In recent years though, there have been issues that revolve around the perception of credibility and trust within the bunker industry due to a lack of transparency and a history of fraudulent claims [4–6]. Examples of this are the OW Bunker which went bankrupt in 2014; in 2018 there was the bunker contamination incident; and in the same year the Aegean company filed for bankruptcy. Of particular importance to the bunker industry was the collapse of OW Bunker and the resulting *Res Cogitans* [7] case of 2016 which had significant impact on the English Common Law [8–10]. Furthermore, different disputes related to the incident are still occurring, e.g., the case *Cockett Marine v ING Bank* [11], which was heard before the English High Court on between the 11–12th June 2019. Another example was the bunker contamination incident in 2018 which affected more than one hundred vessels; this occurred despite the fact that the bunker supplied, heavy fuel oil, passed the standard ISO (International Organization for Standardization) 8217 residual marine fuel test. This incident is still under investigation, with the cause still unknown. Furthermore, multiple bunker supply ports were affected by the bunker contamination incident in 2018 [12]. A final example is the Aegean Marine Petroleum company which filed for bankruptcy after revelations that three hundred million dollars were lost due to fraud at the end of 2018 [4]. Furthermore, in 2020 the International Maritime Organisation (IMO) regulated new emission standards which came into force in January 2020 [13–15]. Consequently, MARPOL Annex VI has updated the necessary information required to be included in the Bunker Delivery Note (BDN) to reflect these amendments, thus allowing the BDN to act as evidence of compliance with the new emission and consumption

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reporting requirements [15]. One possible solution for these challenges may be technological solutions. This is bolstered by the favourable view of technology in the English judiciary, which was acknowledged in the case of *Glencore International AG v MSC Mediterranean Co SA* [16].

> *'It may be that a system whereby delivery against a PIN code is valid, even if presented by a thief, is sensible because of the benefits of using modern technology in place of paper. But, if that is to be done, it requires, in my view, either appropriate contractual provision or statutory imposition.'* Sir Christopher Clarke [16].

One of the modern technological solutions that is being trialled for possible adoption in the bunker industry is blockchains [4,6,17]. Blockchain technology, including the integration of smart contracts, has evolved from its origin in Bitcoin in 2008, and the impact of blockchain has been compared with that of the Internet [18]. However, unlike the centralised nature of the Internet, the blockchain is a decentralised technology [19]. Specifically, blockchain is, in principle, a 'distributed append-only timestamped data structure' technology [20]. The benefits of blockchain, according to the stakeholders advancing the technology, are transparency, governance, building trust digitally and compliance with international standards [4–6]. As such, this paper aims to highlight, from a legal perspective, how transitioning from a traditional method of forming a contract to a smart contract on a distributed ledger may aid the bunker industry.

## 2. Purpose of research

### 2.1. Existing research

This paper focuses on how blockchain technology may benefit the bunker industry in mitigating the risk of disputes arising and dispute resolution. Blockchain technology builds trust and credibility between parties [21], as the contractual process is, in effect, social agreements that are legally binding [22]. Furthermore, blockchain technology may aid the maritime industry with compliance of emission standards and consumption reporting requirements of IMO 2020 [13,23]. As a result, this research paper may be categorised as a socio-legal research paper. This area of research is an extension of the already existing research surrounding the blockchain smart contract adoption into other industry sectors from its origin as a digital currency platform. The areas that relate to the bunker industry include the following: logistics and trade, governance and legality, finance and data management [18,20]. Out of the research generated in these sectors, there has been no specific blockchain research that has focused on how blockchain may aid the bunker industry in dispute resolution. In terms of research into the bunker industry, outside of industry published articles and books, the Res Cogitans [7] case has been the main focus of current legal research due to its impact on the bunker industry and the wider implication to commercial law [3,10,24,25]. As such, this paper fills the research gap of the bunker industry, which is an industry that would benefit from the adoption of blockchain technology.

### 2.2. Justification of research

This research will benefit the industry by illustrating how blockchain technology may aid in dispute resolution. This may offer the bunker industry a technological solution to the challenges of credibility and trust that the industry is facing. This is further supported by the fact that the bunker industry handles numerous large volume transactions which have a history of fraudulent claims. This offers a platform for blockchain technology, with integrated smart contracts, to increase transparency and improve governance to reduce the risk of disputes arising. Furthermore, blockchain allows an opportunity for tracing the source of the bunker fuel [4–6]. It is worth nothing that the English maritime and judicial sectors are exploring how transitioning to digital technologies, like blockchain, may be beneficial [26,27]; this indicates that the timing of the research is relevant. This is further supported by the transition to low sulphur bunkers in 2020, which may benefit from blockchain technology [6]. Consequently, research into what benefits blockchain may offer the bunker industry is applicable based on both the recent and upcoming circumstances that are affecting the industry. This is further supported by the timing of the research, which is linked to other stakeholders and organisations that are exploring the benefits of digital technology, like blockchain, to sectors linked to the bunker industry. These factors make research into blockchain technology application in the bunker industry not only relevant in context of timing, but also with regards to positing a possible technological solution to the challenges being faced by the industry.

## 3. Literature review

### 3.1. Bunker contracts and contract law

Bunker contracts have the same basic requirements of all contracts under English Common Law. The High Court Case Blue v Ashley [28] offered the latest definition of a contract under English Law.

> '*The basic requirements of a contract are that: (i) the parties have reached an agreement, which (ii) is intended to be legally binding, (iii) is* supported *by consideration, and (iv) is sufficiently certain and complete to be enforceable.'* The Hon. Mr. Justice Leggatt [28].

These basic requirements for formation of a contract are judged based on an objective test, meaning that the intentions of the parties when forming a contract are judged by their words, conduct and intention of the terms of the contract [29,30].

The goal of the bunker contract is designed for supplying bunkers to the vessel. The term bunkers have multiple definitions, but bunkers may be defined as 'a fuel intended for consumption in the engine, or auxiliary engines, on board a vessel [31]. However, the terms of the bunker supply contracts are complex, as there may be various terms that are used in the sale and supply of bunkers. To reduce the confusion of these multiple contract terms, BIMCO, alongside various stakeholders in the maritime and bunker industries, developed a new standard term for bunker contracts. The BIMCO Bunker Terms 2018 are intended to reduce contractual disputes through the use of standardised terms and conditions [32,33]. Furthermore, there is an election sheet which clarifies certain aspects of the contract and allows for additional terms to be included into the contract, e.g., the clause in regards to the payment of bunkers between contractual supplier and physical supplier [32]. This election sheet has precedence over the standard terms and conditions stated in the BIMCO Bunker Terms 2018. Additionally, the election sheet allows parties to agree which will be the applicable law that applies for dispute resolution and agree the method, arbitration or litigation, for dispute resolution. An argument may be made that arbitration is a more cost-effective option for the parties, since BIMCO has developed the Terms with industry experts [34]. Consequently, this allows the contract parties' flexibility when deciding on the terms of the bunker supply contract. The final step for contracting under the BIMCO Bunker Terms 2018 is the confirmation note, which has precedence over the election sheet, thus allowing both contract parties with a set of Terms that may be modified to satisfy their individual requirements [32,33].

### 3.2. Forming a relationship between parties

The nature of maritime trade means that a vessel which receives bunkers in a port, may only call at that specific port once. This makes forming a relationship between the two parties challenging. Consequently, two entities have developed within the bunker industry, i.e., bunker brokers and bunker traders. These two entities have key legal differences when acting in their respective roles. The bunker broker is an

agent that brings the two parties together but does not adopt credit risk in the transaction. The bunker trader is a subcontractor who purchases the bunkers from the local supplier and sells the bunkers to the buyer, i.e., the owner or charterer of the vessel. The bunker trader may have multiple contracts of sale for the purchase of the bunkers prior to the final bunker contract between the buyer and the trader [3,31,35]. This system may work, but, as demonstrated in the *Res Cogitans* [8] case, there may be risk of double payment of the bunkers for the buyer [9]. However, in the case of bunker agents, as the buyer contracts directly with the supplier, there is no risk of double payments arising [3].

### 3.3. Bunker delivery note

The BDN acts as a delivery receipt for the bunker supply contract. Additionally, the BDN acts as evidence of the quality and quantity of bunkers delivered to the vessel [26]. The minimum standard is based on the emission regulations as laid out under MARPOL Annex VI, which the ISO bunker standards reflect in their requirements [36]. Furthermore, the BDN is required to be stored for a minimum of three years under MARPOL Annex VI and producible for inspection by Flag and Port State authorities [37]. Furthermore, the BDN also addresses the use of non-compliant bunkers through the means of alternative compliance methods, e.g., an exhaust gas cleaning system, fitted onto vessels. Consequently, buyers who order bunkers that do not meet the new standards are required to provide documentary evidence to the supplier of the alternative compliance methods, prior to the signing of the contract [38].

The other role of the BDN is to allow vessel owners, or operators to comply with the IMO mandatory bunker data collection and reporting requirements that came into effect as of 01 January 2019 [38]. Though, it is important to note that the standard test cannot determine all possible contaminants, as the bunker contamination incident in 2018 demonstrated [12]. These aspects make the BDN a critical evidentiary document with multiple roles, not only for contractual purposes but also for evidence for compliance with international requirements.

## 4. Types of dispute resolution

For bunker supply contracts, disputes between parties shall be resolved through arbitration in London, as per BIMCO Bunker Terms 2018 Clause 24 [39], and guided by the Arbitration Act 1996. Arbitration offers parties the advantage of resolving disputes privately, without granting public access and review [40]. The arbitration jurisdiction may be changed if agreed by the parties and if it has been stated in the election sheet. The Arbitration Act 1996 Section 1(a) states, '*the object of arbitration is to obtain the fair resolution of disputes by an impartial tribunal without unnecessary delay or expense.*' During bunker transactions, disputes may occur because of payment, quantity or quality issues [31]. Additionally, a maritime statutory claim may be issued in bunker disputes, with the right to arrest vessel governed by Section 21(4) of the Senior Courts Act 1981 as an action *in rem*, 'against a thing'. The type of dispute, and whether it is classed as a maritime statutory claim, may be determined during the arbitration tribunal and based on assumed facts agreed by the parties. However, if the arbitration agreement is to be challenged in the courts, it must do so under Section 10 of the Arbitration Act 1996. This makes arbitration the principal form of dispute resolution within the bunker industry, with litigation for bunker disputes the secondary method of dispute resolution, which is presided over by the Courts of the Queen's Bench.

### 4.1. Blockchains

The term blockchain was originally used as a shorthand term for 'chain of blocks of transactions' [41] and is based on Distributed Ledger Technology (DLT) that uses a protocol which focuses on the value of exchange through a programmed set of governance rules and regulations. However, DLT predates, and has been utilised, prior to blockchains [41]. DLTs have four fundamental attributes, which are transparency, traceability, trust and distributed governance [42]. Furthermore, the concept and application of the blockchains have evolved since the cryptocurrency (cryptographically secured digital currencies) [20,42,43]. Blockchain generations may be identified by the implementation of blockchains into different sectors. Consequently, this means that blockchain is neither a fundamental development, nor an object, but rather a combination of variables as per diverse performers, benefits and existing innovation stages, to make a 'shared administration of a distributed registry'. They have facilitated the creation of a decentralised digital system based on trust in software [41,42,44].

### 4.2. The blockchain verification process

The authenticity of the data contained on the node needs to be verified to ensure the validity of the data prior to a node entering the blockchain; this is done through a type of protocol, e.g., the 'Proof-of-Work' (PoW) protocol. However, the consensus protocol also causes the main issues with blockchain, e.g., scalability, transfer speed (refer to Fig. 1) and sustainability [20,42,45,46]. As a result, other consensus protocols have been developed to address the issues of PoW, e.g., 'Proof-of-Stake' (PoS). PoS works by splitting the stake in blocks equally among the 'miners', a term used for the persons that 'mine' the data on the blockchain. This method of achieving consensus improves scalability and lessens the environmental impact of a blockchain. In conclusion, to achieve sustainability, other measures may be necessary, e.g., the process called 'sharding' that partitions the blockchain to allow off-chain computations [42].

Another method would be to turn to other DLT based technologies, e.g., 'Directed Acyclical Graph' (DAG). DAG does away with the mining completely by having the verification process on the 'tangle', a 'blockless' DLT that integrates the consensus protocol into its architecture [42]. Therefore, regardless of how the consensus protocol evolves, it will remain a primary component of the different types of blockchains for data verification.

### 4.3. Blockchain smart contracts

Smart contracts add an additional computer interface to the consensus of a blockchain, which may either be 'on-chain' or 'off-chain' [20,47]. Although smart contracts are not unique to blockchains, the inclusion in blockchains may change how contract law is perceived and undertaken digitally. Specifically, the ability for both parties to automate the process of contractual performance means that blockchain smart contracts are fundamentally different from traditional smart contracts [48]. Notwithstanding this, smart contracts have issues under contract law and are closer to social agreements between the parties [49]. Furthermore, they have legal issues. For example, smart contracts cannot create legal obligation; a party may not breach a smart contract due to the principle of 'code is law'; the smart contract's validity may not be affected by vitiated consent or intention; the nature of smart contracts does not offer protection to weaker parties; smart contracts are unable to differentiate between legal and illegal subject matters; and the autonomous nature of smart contracts allows them to exist outside the framework of a legal system [48,50]. Accordingly, all these factors may need to be addressed, if blockchains are to be considered legally binding contracts under the law.

The legal challenges of blockchains may be addressed through different solutions [47]. Another aid to assist in the legal issues that blockchain smart contracts face may be the codification of law into machine-readable language. This would allow simpler transposition of contractual obligations into digital contract code, thereby simplifying the design of legally binding smart contracts [51]. Accordingly, there are two possible digital solutions for aiding in forming legal binding of blockchain contractual transactions. These are changing the programme

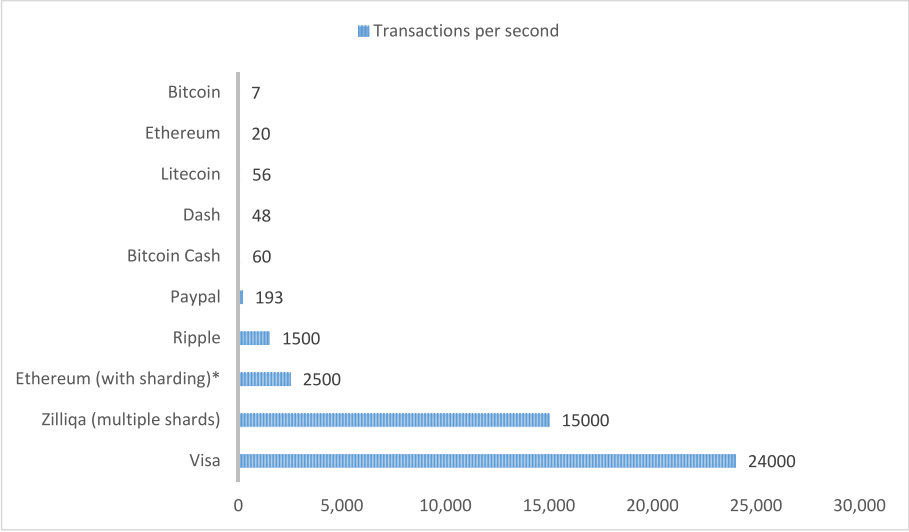


**Fig. 1.** Service or Blockchain Transaction Speeds for Payment Services. *per shard. Note: 'sharding' is a protocol change that has not been realised and is placed in the chart to demonstrate potential improvement to speed of blockchain verification. Source: adapted from Crist and Schechtner [42], 2018, p.39.

language used and codification of law into machine-readable language. While this may be true, the challenges faced by blockchain contractual processes are not limited to only digital challenges [48,52,53]. The issue of legal enforcement for blockchain transactions may be illustrated by how different states and international bodies classify cryptocurrencies [54]. Hence, there exists legal uncertainty for blockchain transactions.

This uncertainty is being aided in the English legal system by the Law Commission's projects on 'Electronic Execution of Documents' and 'Smart Contracts'. The electronic execution of documents is in the policy development phase; while the smart contract report is in the initial phase [27]. However, the 'Smart Contract Report' has been paused, because of the creation Law Society's LawTech Delivery Panel in 2018 which the Law Commission deemed to have similar objectives [55]. Additionally, these are further supported by the Electronic Communications Act 2000 (EC). Specifically, Part II covers electronic signatures, electronic seals, electronic time stamps and electronic documents. Furthermore, ISO has been working on a set of standards for blockchain and DLT since 2016. Consequently, the reports by the Law Commission and the LawTec Delivery Panel, the existing EC and the development of an international standard may support the governance and legal validity of blockchain smart contracts within the English legal system.

### 4.4. Summary

This paper is an extension of the existing research surrounding the blockchain smart contract adoption into other industry sectors from its origin as a digital currency platform [18,20]. More specifically, it is linked to the 'Internet of Agreement' (IoA) first introduced at the World Government Summit in Dubai in 2017 [20]. The IoA primary concern is with fair governance in a decentralised global environment [56]. Out of the research generated in these sectors, there has been no specific focus on the bunker industry. Furthermore, the principal areas of research in blockchain technology and the law, have focused on the following issues: how to make blockchain smart contracts legally binding; the governance of blockchain smart contracts; and the use of blockchain smart contracts as a method of dispute resolution [20,56]. Thus, this paper fills a gap within the research by addressing the bunker industry, which may be benefited by the adoption of blockchain technology for dispute resolution. Consequently, two research questions may be asked to fill the identified gap in research. Specifically, they are: 'How may blockchain technology alter, and/or be adapted, for dispute resolution in the bunker industry over traditional bunker contracts?' and 'Will they aid in reducing and/or resolving disputes in the bunker industry?'

## 5. Methodology

### 5.1. Method

The research area of this paper involves how a specific technology may be utilised in an area of law. This falls into the category of socio-legal research, which may be defined broadly as 'law in action', but there is no set conclusive definition to, nor scope of, socio-legal research [57]. This allows flexibility when adopting this type of law research method. Despite the fact that the overarching theme of the paper is socio-legal, this did not inhibit utilisation of 'black letter' research to achieve the aims and objectives. The reason for this is that 'black letter' research is defined as law in books [57]. This definition means areas of this research involved 'black letter' research to define an understanding of the law that presently governs the bunker sector. This was necessary to understand the way technology may affect the area of law through an interpretive philosophy of the data gathered to support the argument.

The existing literature on the application of blockchains, which incorporates smart contracts, utilised different methodologies, e.g., quantitative, qualitative or mixed method. This offered flexibility when selecting the methodology to achieve the aims and objectives of the paper. Moreover, as this paper is discussing a legal area, the types of law research needed to be examined. These are categorised as 'black letter' research and socio-legal research [57]. The authors' own viewpoints and understanding of the topic being researched also influenced the reason for the chosen research methodology [58,59].

This flexibility allowed the authors to answer the proposed research questions using a pragmatic approach. The holistic nature of a pragmatic philosophy [58] allowed the research questions to be answered. Notwithstanding this, the nature of the research paper was predominantly socio-legal research [57], which used primarily an interpretivism philosophy combined with mixed method research [58]. The flexibility of the pragmatic approach allowed for holistic approach for the research. This then allowed a path to generate the necessary data to answer the research questions. In summary, this is a mixed method socio-legal research paper that uses a pragmatic philosophy, with strong interpretivism philosophical leanings, which applies a mixed method survey. The results of the mixed method survey were assessed for reliability and validity using the triangulation method [60–64].

### 5.2. Data reliability and validity

To ensure that the results of this research are both reliable and valid,

different techniques were employed. The triangulation, or correlation strategy was utilised to prove both the reliability and validity of the findings from the online questionnaire, which used the Likert Scale for the questions (Appendix A). This strategy compares the results of two or more different research strategies that utilise qualitative and quantitative data. The end result is demonstration of independent results which are in agreement [60–64].

Furthermore, secondary strategies for determining the reliability and validity of the qualitative data (Appendix B) were utilised alongside triangulation. In this research paper the face-to-face interviews were recorded, thus retaining the original data source. This was transcribed and the transcription was sent to the interviewees for approval of the final transcript to be utilised in the research, known as 'member check', to ensure the validity of the data therein. These are recognised methods of reliability and validity checks for qualitative data [65]. Consequently, by using triangulation in combination with other independent test for validity and reliability, the research findings may be argued to be both reliable and valid, despite the low sample size of the questionnaire.

## 6. Results

### 6.1. Demographic of respondents

The qualitative survey was conducted with interviewees that were selected based on their background and experience. The interviewees were primarily from a legal background, with one interviewee having a technological background and working in a marine consultancy firm. Furthermore, the interviewees were a very experienced group and have a range of understanding of both the bunker sector and blockchain that starts out with, as a minimum, general understanding of the main topics of this research paper. The findings were supported by an online survey, by a wider demographic of experts, with nine of the fourteen stating familiarity with blockchain smart contracts. The number of respondents was low, but the demographic represents a group of highly experienced individuals within their respective fields that are familiar with the topic of the research paper.

### 6.2. Results

The sections below present results within the area of interest in the research.

#### 6.2.1. Adoption

For a traditional sector like the bunker industry, the question of the possibility of adopting blockchain technology in different scenarios was discussed. From the online survey, the majority indicated a neutral response in regard to the possibility of adoption; however, this majority equalled the number of respondents who indicated a higher likelihood of adoption. From the perspective of the interviewees, the theme of blockchain adoption was connected with the intent of the blockchain stakeholders and the area of adoption.

Interviewee 1 stated: *'They will have to have a desire to achieve a certain result. Collective desire, unless that collective desire exists or is forced upon them by regulatory authorities: it won't happen.'*

Interviewee 4 stated: *'If you're a ship owner saying, "I'm concerned about quality", then you might be more prone to buy from a supplier that can show you the blockchain trends interact with blockchain transaction of the source of the bunkers you are selling.'*

Interviewee 2 stated: *'In other words, everybody's got to join in or it's not going to fly either. So, there's a long way to go.'*

Hence, adoption of blockchain technology may be a challenge due to the fractured nature of the bunker industry and the objectives of the different stakeholders.

Interviewee 1 stated: *'I think it still is called a fractured business. There are different players: there's the oil majors; then there's the traders; then there are physical players in different ports or offshore. This is just on the supply side, without looking at the buying side. On the buying side you have time charterers and ship owners and the ultimate consumers will be the ship owners. So, would it help? I don't know, it really depends what they want to do; it'll certainly help some people.'*

This argument is supported by the findings of Sarker et al. [66]. Consequently, there is uncertainty surrounding the possibility of adoption, which may be depended on either the end-goal of the blockchain technology adopters, or the technology being foisted on them by authorities.

#### 6.2.2. Adopting blockchain technology for bunker transactions

The formation of bunker transactions utilising blockchain technology was discussed based on the possible advantages they have for the bunker industry. The responses from the online questionnaire indicated strong positive agreement amongst the respondents for the different benefits that blockchain may have for the bunker industry. Furthermore, traceability offers parties the ability to audit processes.

Respondent 11 stated: *'Having an auditable trace of the transaction.'*

These questions were asked based on the benefits of blockchain raised in the literature review, specifically, traceability, transparency, immutability and digital trust [32] and how they may best be utilised by the bunker industry.

Interviewee 6 stated: *'(a) Benefit of traceability. (b) Benefit of cost effectiveness. (c) Time effectiveness. Contracts can be automatically validated, signed and enforced.'*

This is further reinforced by the concept of blockchain immutability, which is linked to ensuring the evidentiary probity, traceability of the bunker supply chain and validating the quantity of bunkers supplied.

Interviewee 5 stated: *'In terms of probity and then you render the dispute later, you should have a record that cannot be altered.'*

Interviewee 3 stated: *'I think legal system will be very keen on it, because it promotes certainty.'*

Interviewee 1 stated: *'For MARPOL and sulphur schemes, I can see that ship owners might find it useful, to have a central repository of bunkering information.'*

Consequently, the nature of blockchain technology is inherently linked to the benefits the bunker industry may gain in terms of dispute mitigation and resolution and compliance with international regulations, specifically, the IMO 2020 and MARPOL Annex VI.

Furthermore, the transparency that is offered by the blockchain offers parties the ability to trace payments in bunker transaction, thus reducing the risk of double payment occurring through the ability to audit the transactions. This may be considered the 'traded level' of the bunker supply, with different bunker traded along a contract chain.

Interviewee 1 stated: *'It may assist, because there will be a record of what they have agreed to buy and there has to be a measure of what they received.'*

Accordingly, building trust is based on the fact that all parties are able to access the same information simultaneously, which may aid in reducing risk of disputes arising.

Interviewee 2 stated: *'It's an improvement on a number of fronts, one in that there is an immediacy to it and that all stakeholders receive a copy simultaneously.'*

Overall, there was consistent agreement in the findings between the two survey methods when discussing the possible benefits for the bunker industry by adopting blockchain technology, thus indicating that the adoption of blockchain technology would benefit the industry through increased transparency, traceability and probity of the evidentiary chain and the evidence therein.

#### 6.2.3. Bunker delivery note on blockchain

From the online survey, the majority of the respondents indicated moderately high to high that it would be beneficial, thus indicating the benefits that adopting blockchain technology would have for verification and secure storage of the BDN.

Interviewee 6 stated: *'The application of the blockchain technology ensures end to end traceability of marine bunkering transactions. This provides*

*increased assurance to ship-owners, shippers and charterers who benefit from a decentralised distributed digital ledger. The bunker industry involves a significant number of transactions and consequently it provides an ideal platform to examine where blockchain technology can be utilised to increase transparency and create better compliance and strong governance.'*

Additionally, the possibility of meeting the requirements of IMO 2020 through the adoption of blockchain validated BDN was another area which was indicated as a possible benefit to the bunker industry by the interviewees and respondents.

Interviewee 5 stated: *'Then all the detail that they're looking for in the reporting scheme already be there. So, if you give your flag state access to your blockchain, then everything they want to know, be it the bunkering bunker delivery notes, which they usually use to determine the consumption, is there.'*

Hence, the responses received from the survey strategies agree with the information provided in regard to the blockchain benefits in relation to validating the data the BDN provides. Notwithstanding this, the traditional BDN, which is paper based, would hinder the benefits that blockchain technology would have.

Interviewee 2 stated: *'Traditional BDN poses a number of problems; for one they're all handwritten unless by the largest companies.'*

Interviewee 4 stated: *'But in order to get that data in to the blockchain transaction, now, it has to be hand inputted, which is not feasible because of a lot of things including timing and the accuracy of the input. So, having an electronic BDN which can be more or less instantly incorporated into the blockchain data is critical.'*

This indicates the need for transitioning to eBDN for the purpose of using blockchain technology with BDN to offer the greatest benefit for the industry.

The main reason would be to assure the data quality on the blockchain, which is a necessary element of a ledger.

Interviewee 1 stated: *'In the broad sense, you will have to explain why it is infallible, and therefore it cannot be false: what is recorded is true, but it's the same for any ledger, whether it be a paper ledger, logbook, anything.'*

Furthermore, the amount of data necessary to be inputted into a BDN indicates that the process must be first completed off-chain. The reason for this is that BDN and blockchain serve different purposes: BDN is a type of form, while blockchains are ledgers.

Interviewee 2 stated: *'It* (blockchains) *makes a ledger, people need forms.'*

Consequently, the BDN is only verified and secured by the blockchain but needs to be completed as a separate process.

#### 6.2.4. Risk for the bunker industry in adopting blockchain technology

There may be risks involved when an industry adopts new technology, thus restricting the possible benefits offered by the technology; e.g., based on the inherent nature of blockchain technology, four possible risks were identified: "breach or corruption of the data through cyber-attacks"; "breach or corruption of the data due to human error"; "putting trust in technology versus a physical entity"; and "possible future threats to blockchain technology". Furthermore, an additional risk was identified during the qualitative survey process.

*'One of the disadvantages is connectivity in terms of being able to complete and sign electronically things on a ship when data signals are poor. I imagine most chief engineers would be very reluctant to sign electronic documents, if they're not going to get a paper copy straight away, or an electronic copy straight away.'* I.5.

This indicates that one of the challenges may be ensuring stable access to the Internet for issuance of an eBDN for the vessel and, possibly, the bunker barge. Additionally, a valid BDN is evidence of the bunker delivery and compliance with MARPOL Annex VI.

*'Because you can't leave a bunkering session without the delivery of a bunker delivery note.'* I.2.

Another aspect of digital risk was that of cyber-attacks, which were indicated to be moderately low. Conversely, the majority of respondents indicated future threats to be a moderately high risk. Significantly, for a digital technology, these future threats may be from an unknown type of cyber-attack, e.g., the '51% Rule'. This is an inherent weakness of the blockchain due to the proof-of-work protocol that blockchain technology utilises to secure the data entries, also making it susceptible to this form of attack. By controlling the majority of the mining power, an entity may take control of data on the blockchain [67]. Furthermore, despite the online survey indicating that cyber-attacks are a moderately low risk, the fact that blockchains are a web-based technology means that they are inherently vulnerable to cyber-attacks.

*'Anything that is digital is a candidate* (for cyber-attacks) *and to that end, anything that's web-based, is even more of a candidate.'* I.2.

*'Cyber security is another concern, which is probably the least founded one because blockchain is supposed to be secure, because you have the multiple ledger system. But making sure that the access to it is secure, is important.'* I.4.

Consequently, there are two types of digital risk that may need to be considered in developing a blockchain adoption strategy. The first is the technical digital challenge of ensuring connectivity for successful utilisation of blockchain during bunkering operations. The second, and possibly the more important of the two, is the fact that blockchains are vulnerable to cyber-risk due to their inherent nature, and this vulnerability may be further compounded by unknown digital threats in the future.

Another threat that was investigated in the qualitative survey was human error. From the aforementioned online survey results, there are close to equal number of respondents who identified this threat on the lower end of the scale as there where those who selected the higher end of the scale. This indicates general disagreement in regard to the level of risk human error may represent. Conversely, there was general agreement amongst the interviewees in regard to the importance of data quality, which is possibly affected by human error; e.g., with blockchain being a DLT, it means that the quality of data is an important factor for ensuring the probity of data.

*'It's* (referring to a ledger) *only as good as the input data going into the record.'* I.1.

This was further supported by both I.2 and I.4 when discussing the issue of the traditional format BDN identified earlier, and why it is important to transition to eBDN for reducing the risk of incorrect data entries that may occur with the traditional BDN. Another possible source for human error is in the coding language, e.g., the Ethereum blockchain platform attack in 2016, where the attacker exploited the code [68]. This type of attack is known as 'Zero Day' attack [69]. Consequently, the fact that blockchain is a DLT may make it more vulnerable to human error, either from incorrect data entry or errors within the coding language itself.

#### 6.2.5. Aiding in dispute resolution

The bunker industry traditionally resolves disputes between parties in arbitration, though litigation is available when arbitration fails to resolve the issue. The three types of disputes, quantity, quality and payment, which may arise during a bunker transaction were identified in the literature review. Furthermore, the supply of bunkers may also be governed by the Senior Courts Act 1981 in cases involving maritime statutory claims. The majority of respondents from the online survey answered either moderately high or high for the different circumstances for aiding in the different mediums that are used for dispute resolution. Hence, blockchain offers contracted parties' transparency and traceability throughout the transaction process.

Interviewee 6 stated: *'Blockchain platforms could be used to record the parties' negotiations and terms of settlement. Blockchain technology could potentially provide the parties with a traceable and secure record of their settlement agreement.'*

The ability of blockchains to aid in dispute is linked to the traceability of the transactions by the contracted parties. Therefore, blockchain may assist in securing and validating the probity of evidence for the different dispute resolution methods.

Interviewee 5 stated: '*In terms of probity and then you render the dispute later, you should have a record that cannot be altered.*'

Interviewee 4 stated: "*In both arbitration and litigation, you have to*

*gather the evidence, and so much of the challenge that we have is that the disputes arise sometime after the bunkers are blended, or after they are loaded, or when the vessel is in the middle of the ocean. Therefore, the samples are spread all over the place and so, you have to go collect everything; and many times, the information is lost. Consequently, if you have the data in one place, then that certainly makes it easier to resolve the dispute, making dispute resolution less expensive and time consuming. It may also avoid some disputes too, because you can look at it and say, 'Here's where it happened."'*

However, for 'other types of disputes' and 'maritime statutory claims' circumstances, respondents also selected the neutral response on the Likert Scale questionnaire, which equalled the number of respondents that selected moderately high option. This may indicate that in certain circumstances, the effectiveness of blockchain technology may be situational.

Interviewee 1 stated: *'It depends on what disputes you're looking at.'*

Hence, dependent on the situation, blockchain technology may be less effective in resolving the disputes. Nevertheless, blockchain technology may aid with disputes in the majority of circumstances that may arise within the bunker industry.

### 6.3. Legal challenges

The possible legal challenges, identified in the literature review, were included in the online survey. The results indicated either a majority neutral stance by the respondents, or responses closely distributed along the scale that shows a variety of opinions. The reason for these responses may be because there are, presently, no judicial precedent or Acts that refer to the legality of blockchains. The only Act, presently, that may relate to blockchain transactions is the Electronic Communications Act 2000, and that only ensures the legality of digital signatures and stamps when used as part of blockchains. Hence, the lack of law governing blockchain transactions may be a factor for the legal uncertainty.

Interviewee 6 stated: *'Inadequate regulatory framework.'*

Respondent 14 stated: *'The overlapping of international legal requirements and local legal requirements as a high legal challenge.'*

However, the legal issues may be dependent on how the contract is constructed and coded onto the blockchain, as well as the skill of the person drawing up the actual contractual terms.

Interviewee 1 stated: *'It depends on how it's set up, who sets it up and how good their documentation as it were of that blockchain technology.'*

Consequently, identification of the possible legal risk for the bunker industry is more challenging due to the present legal status of blockchain smart contracts.

## 7. Discussion and conclusion

### 7.1. Bunker supply chain

The traceability of the bunker supply chain is an area that would benefit from blockchain technology. The reason is that the bunker supply chain is complex, with multiple stakeholders involved at the different stages along the chain (refer to Fig. 2 below for a simplified example). For the consumers of the bunkers, being able to trace their bunker supply back to the source may be beneficial. Specifically, it may aid in quality disputes and reduce the risk of contaminated bunkers, like in the bunker contamination incident of 2018. Of greater importance, it may aid in vessel safety through ensuring the quality of the bunker prior to delivery to the vessel. This is in contrast to the traditional way bunkers are handled, with bunkers delivered to the vessel, the quality of which is only indicated based on the bunker order. Once delivered, the bunkers are sent to a lab for an ISO 8217 residual marine fuel test to verify if the quality of bunkers delivered corresponds with the quality requested in the bunker order. In spite of this, as is evident from the bunker contamination incident of 2018, it does not guarantee that the bunkers are fit for consumption [12]. In short, blockchain adoption for use in the tracing of bunkers may reduce the risk of contaminated bunkers being delivered to the vessel, which is both financially beneficial and, more importantly, improves vessel safety.

### 7.2. IMO 2020

Ensuring the quality of the bunkers may also aid in compliance with the impending IMO 2020 standards. These standards include the requirement of submitting emission data to the IMO, similar to the EU MRV scheme in place in the ECA Zones of the Baltic and North Sea regions. In Europe, the Mediterranean Sea area may become an ECA Zone in the near future [4], based on the results of a recent report [70]. There are additional ECA zones noted in MARPOL Annex VI. Similarly, the new bunker consumption reports requirements for the monitoring of carbon dioxide emissions. The BDN is one of the documents used by vessel owners to provide the information for IMO 2020 [23]. Through validating the BDN through blockchain technology, the information becomes evidence of compliance. Hence, the probity of quantity and quality data offered by blockchain technology may aid ship owners and charterers in complying with international regulations. Likewise, it offers the authorities the ability to identify non-compliance through access to the relevant data on the blockchain.

### 7.3. Dispute resolution

The findings of the survey and interview identified the ability of blockchain to both reduce the risk of disputes arising between parties and aid with dispute resolution through securing the probity of evidence. The reason for this is that blockchain offers both parties transparency and traceability of the transaction throughout the entire process. Nevertheless, the benefits may become situational in actual arbitration and litigation matters, because the benefits of blockchain technology end with the presentation of the evidence to either the arbitrators or the Courts.

The benefits offered by the technology may be further complicated, dependent on the type of dispute, with quantity and payment disputes being possibly the less complicated. The reason is the straightforward nature of these disputes, either you have delivered the quantity, or made the payment, or you have not. However, in terms of quality disputes, there are more grey areas once the bunkers have been bunkered. This is due to both influences from operational practices and the complex chemical makeup of the bunkers. Consequently, additional information may be required to be collected beyond what is available on the blockchain. Notwithstanding the situational nature of quality disputes, the blockchain may provide parties involved in bunker disputes with: an improved chain of evidence, probity of evidence, transparency of the transaction and greater efficiency when resolving disputes, which is linked to reducing the overall cost of disputes.

### 7.4. BDN

The findings found that recording the information onto the blockchain may ensure the probity of data stated on the BDN. However, the present medium of data entry onto the BDN is paper based, meaning that the validity of the data may still be challenged by parties in dispute, even if blockchain is verified. Hence, for BDN to be successful, a step towards adopting blockchain may be the requirement for the bunker industry to transition from a paper based BDN to eBDN. This may allow the eBDN to use blockchain technology for verification and distribution of information to the parties, and provide secure storage for the three-year retention

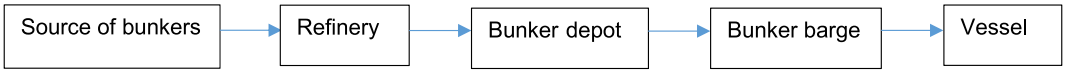


**Fig. 2.** Simplified bunker supply chain. Source: authors.

period requirement of MARPOL Annex VI. Consequently, though the two technologies, eBDN and blockchain smart contracts are different, and their adoption may be reliant on the successful adoption of both technologies by the bunker industry.

### 7.5. Legal issues for blockchain adoption

The legal issues were identified as one of the hindrances to adoption of blockchain technology within the industry. This is further compounded by the lack of guidelines for blockchain governance if issues do arise, which may be further complicated by the issue that completing transactions through blockchain technology may give rise to new types of disputes. This is exemplified by the uncertainty on what these legal issues may be from the respondents in the online survey, based on the identified legal challenges taken from the literature review.

### 7.6. Cyber threats

Blockchain is a web-based technological application. This fact alone means that, regardless of the cryptographic security available, it is open to cyber threats, e.g., the '51% Rule' discussed in the results section. Furthermore, the results also indicated that unknown threats may further increase the risk of cyber threats; e.g., an unknown threat that may occur is in the coding language that is used to develop smart contracts. These may have an unknown weakness that makes it susceptible to Zero-Day attacks [68], e.g., the Ethereum blockchain platform attack in 2016. As a result, blockchain technology may always be susceptible to cyber threats. Moreover, the nature of the cyber threat may be unknown.

### 7.7. Data quality

The quality of data entered on the blockchain is key to the success of the blockchain. With poor or limited data, the blockchain's success may be limited. Coding the contract into digital language is one possible area that may affect the data quality. Another area is changing the medium of data, e.g., from paper to digital format, because data from a paper record may lead to questions on the validity of the data by authorities. Finally, in the bunker industry there may be different operational requirements that have the potential to introduce erroneous data onto the blockchain. Certainly, with blockchain being a DLT, the same principle as traditional ledgers holds true: the need for quality data entry is necessary to ensure the trust of the data on the ledger.

### 7.8. Comparative analysis

The research focus of this paper broadens research on blockchain in the maritime sector by focusing on the bunker industry and narrowing down the research to dispute resolution in different areas of the bunker supply chain. This paper differs from other studies on blockchain technology adoption in the maritime sector, which focused on the container supply chain and port applications [71] and corruption in the wider maritime industry [66] by focusing on the bunker supply chain and how blockchain technology may aid in dispute resolution. This paper offers practical insight on how blockchain may aid the maritime industry and the wider logistic sector by demonstrating how blockchain technology may aid in dispute resolution, as well as possible limits of blockchain technology for dispute resolution.

The findings of this paper have also filled a gap in the research as identified by Falwadiya and Dhingra [71] by highlighting legal barriers to adopting blockchain in the bunker industry. Furthermore, the need of the bunker industry to transition from a paper recording system to a fully digital system would be applicable in other sectors looking to adopt blockchain technology and may be seen as phase one to the successful adoption of blockchain technology in other sectors that still focus on paper over digital for recording critical data. The transition to digital records may also aid some regulatory issues in adoption of blockchain in other sectors.

### 7.9. Research limits and future areas of research

The main issue of the findings in this research was the demographic of the respondents. The bunker industry is an international industry; however, it was only possible to interview six people for the collection of qualitative data. This was bolstered by the fourteen qualified responses that were received as part of the online survey. The small number of respondents was offset in part by their experience. Furthermore, though the majority indicated familiarity or understanding of blockchain smart contracts, only three respondents had a technological background. Future research may benefit from broader field of interviewees and respondents to the online survey.

The research focused on adoption of blockchain for dispute resolution, however, a more in-depth study for risk analysis of adopting blockchain technology in the bunker industry would be beneficial for the industry to understand possible threats for blockchain adoption specific to the industry. Consequently, expanding on the points raised on cyber threats in the results and discussion section above would be beneficial. This would allow discussion on possible methods to minimise the risk caused by cyber threats, which was not the focus of this research. It would also allow demonstration and further research into benefits of blockchain outside of the dispute resolution focus of this paper to weigh the benefits versus the offset risks.

The other issue noted is that the research focused only on the English judicial jurisdiction. Though English judicial jurisdiction is the main jurisdiction for the purpose of resolving bunker disputes, other jurisdiction may be chosen by the parties in a bunker transaction. Hence, though this study has illustrated benefits of dispute resolution, it may differ in other judicial jurisdictions.

### 7.10. Conclusions

The research has highlighted clear benefits to adopting blockchain technology for use within the bunker industry by focusing on the different types of disputes and possible reasons why they may occur. However, this necessitates the need for greater digitalisation across the bunker industry prior to ensuring the validity of data for blockchain entries. Furthermore, being a technological solution, there is a risk of cyber threats, some of which are known but others in the future unknown.

Above all, blockchains offer a technological solution for improving the bunker industries' trust and creditability image, consequently reducing the risk of disputes occurring by making the numerous actors along the bunker supply chain more connected with greater access to information during the bunker supply process. Consequently, this offers parties the ability to trace payments in bunker transaction at the 'traded level', thus reducing the risk of double payment occurring through the ability to audit the transactions. Moreover, it may aid the industry with the challenges that may arise with IMO 2020 and MARPOL Annex VI through the adoption of an eBDN verified by blockchain and a method to verify the fuel quality along the supply chain. Furthermore, blockchain adoption would offer similar benefits for alternate fuel supply chains. In summary, the key benefits that blockchain technology offers the bunker industry are: the ability to ensure transparency and traceability of the bunker transaction process and the numerous actors therein, reduce the risk of double payments highlighted in the *Res Cogitans* case and ensure the quality of bunkers via a verified supply blockchain, thus aiding in quality disputes; ability to adapt blockchain verified supply chain to alternate fuels; and compliance with IMO 2020 by utilising an eBDN verified by blockchain.

## Data availability statement

The data that support the findings of this study are not available due to them containing information that could compromise research participant privacy/consent.

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## Disclaimer

This paper is the personal opinion of the authors and does not represent the views of Liverpool John Moores University.

## Author contribution

**Daniel Adam:** Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing—original draft, Writing—review & editing. **Dante Benjamin Matellini:** Conceptualization, Writing—review & editing, Supervision, Project administration. **Anna Kaparaki:** Conceptualization, Writing—review & editing, Supervision.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Appendix A. Quantitative survey questions

Using Blockchain Smart Contracts in the Bunker Industry.
I agree to take part in the above study.[1]

a) Yes
b) No

I wish to remain anonymous for the purpose of this survey.

a) Yes
b) No

Background Questions[2]
If you do not want to remain anonymous for the purpose of this survey, please state your name.

1) Which of the following best describes your organisation?[3]
   a) Bunker supplier
   b) Bunker broker
   c) Bunker trader
   d) Ship owner
   e) Charterer
   f) P&I Club
   g) Maritime Law Firm
   h) Marine Consultancy Firm
   i) Other
2) How long have you been working in the maritime bunker industry?
   a) 0–5 Years
   b) 6–10 Years
   c) 11–20 Years
   d) More than 20 Years
3) Are you familiar with any of the following?[4]
   a) Bunker contracts, including the Bunker Delivery Note
   b) Electronic Bunker Delivery Notes
   c) Blockchain Smart Contracts
   d) Online Dispute Resolution

Survey Questions[5]

4) In September 2018, the first bunker delivery utilising blockchain technology was completed. What is the possibility of this technology becoming more widely used within the bunker industry?

Possibility of adoption.
[Likert Scale From 1 (Lowest) to 5 (Highest)]

[1] Respondent required to answer question.
[2] Respondents required to answer all questions.
[3] Respondent may select multiple answers.
[4] Respondent may select multiple answers.
[5] Respondents required to answer all questions.

5) Which of the following blockchain types would be most appropriate for use in the bunker industry?[6]
   a) Private
   b) Consortium
   c) Public
6) In terms of the risk in adopting blockchain technology for legal proceedings, and secure data collection and retention, rate the following.
   a) Breach or corruption of the data through cyber attacks
   b) Breach or corruption of the data due to human error
   c) Putting trust in technology versus a physical entity
   d) Possible future threats to blockchain technology (e.g., quantum computing technology)
   e) Other[7]

   [Likert Scale From 1 (Lowest) to 5 (Highest)]

7) The literature review identified several legal challenges to overcome in regard to blockchain smart contracts; rate these challenges based on how difficult they would be to overcome from a legal perspective.
   a) The inability of smart contracts to create legal obligation.
   b) A party may not breach a smart contract due to the principle of 'code is law'.
   c) The smart contract's validity may not be affected by vitiated consent or intent.
   d) The nature of smart contracts may not offer protection to weaker parties.
   e) The inability of smart contracts to differentiate between legal and illegal subject matters.
   f) The autonomous nature of smart contracts allows them to exist outside the framework of a legal system.
   g) Other[8]

   [Likert Scale From 1 (Lowest) to 5 (Highest)]

8) The literature review also identified possible areas in the bunker transaction that may be benefited by the adoption of blockchain technology; rate these benefits in order of importance.
   a) Traceability of the fuel supply chain for quality of the fuel sourced.
   b) Offering immutable evidence on quantity.
   c) Reducing the risk for double payment of bunker fuel.
   d) Reducing the cost of arbitration through the possible use of Online Dispute Resolution as an alternative arbitration method.
   e) Reducing the risk of an invalid Bunker Delivery Note.
   f) Ensuring all evidentiary information is in one secure location.
   g) Building trust between parties digitally.
   h) Other[9]

   [Likert Scale From 1 (Lowest) to 5 (Highest)]

9) How beneficial would blockchain technology be in resolving disputes in the following circumstances?
   a) Dispute resolution through arbitration in matters involving quality.
   b) Dispute resolution through arbitration in matters involving quantity.
   c) Dispute resolution through litigation in matters involving quality.
   d) Dispute resolution through litigation in matters involving quantity.
   e) Dispute resolution through litigation in other matters (e.g., a case similar to the Res Cogitans Case).
   f) Statutory maritime claims and maritime liens for bunker supply.
   g) Other[10]

   [Likert Scale From 1 (Lowest) to 5 (Highest)]

10) How beneficial would adopting blockchain technology solely for the Bunker Delivery Note be in the following circumstances?
   a) Evidence for compliance with IMO 2020 emission standards.
   b) As a tool for mandatory reporting schemes for emissions.
   c) Secure storage for the three-year retention period of Bunker Delivery Notes.
   d) Other[11]

## Appendix B. Qualitative survey questions

1. Would it be acceptable to you to have this interview recorded?
2. Would you like to remain anonymous?

[6] Respondents only allowed to select one answer.
[7] This choice is optional, requires respondent to specify what 'other' is.
[8] This choice is optional, requires respondent to specify what 'other' is.
[9] This choice is optional, requires respondent to specify what 'other' is.
[10] This choice is optional, requires respondent to specify what 'other' is.
[11] This choice is optional, requires respondent to specify what 'other' is.

3. What is your professional background?
4. How familiar are you with bunker contracts?
5. How familiar are you with blockchains and blockchain smart contracts?
6. What benefits are there to having a bunker contract completed on a blockchain smart contract?
7. Are there any disadvantages in using blockchain smart contracts to complete bunker contracts?
8. Only for the purpose of the bunker delivery notes, would they benefit from use of a blockchain? (Mention IMO and EU reporting scheme if not raised.)
9. Are there any legal issues for adopting blockchain smart contracts in forming a bunker contract?
10. What is your opinion on the ruling made in the OW Bunker case?
11. Would the use of blockchain in the bunker industry aid in resolving disputes arising from bunker claims? (If double payments not mentioned, ask opinion on this subject.)
    a. In case not covered in the answer, expand on the following:
        i. Arbitration versus litigation
        ii. Quality disputes
        iii. Quantity disputes
        iv. Maritime Liens
12. Would ODR be useful in the bunker industry as an ADR method?
13. Follow question 9: If so, how?

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