The Limits of Coase:

A Study of Financial Distress in the Shipping Industry*

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Abstract

The shipping industry provides a unique laboratory for examining the limits of Coase for resolving financial distress since the industry is largely detached from sovereign bankruptcy procedures. We find that private contracts and institutions have evolved to resolve coordination failures: for example, we find a low incidence of vessel seizures, ports that compete to enforce creditor rights, and small fire sale discounts. However, we report significant spillovers of financial distress for other stakeholders, particularly environmental, who bear the costs of under maintained vessels, including oil spills, and abandonment of derelict ships, which end up in toxic breaker yards.

"*There is only one law in shipping: there is no law in shipping*".

Sammy Ofer (shipping magnate)

1 Introduction

In a somewhat contentious article, Stigler (1989) describes the Coase 'Theorem': "when it is to the benefit of people to reach an agreement, they will seek to reach it." To the question "does the proposition require proof" he answers "one would think not." He later concedes that "[this] cannot be the entire story" since "there are people who do not care for wealth, more who do not reason well, and vastly more who are incompletely informed, though it is unlikely that such people govern important markets." Using corporate bankruptcy as our laboratory, we address the limits of Coase with data from the shipping industry where the resolution of financial distress is largely distanced from sovereign bankruptcy procedures such as the US Chapter 11. The fact that ships operate across different jurisdictions, or on the high seas outside any jurisdiction, has loosened (although not completely eliminated) the grip of national bankruptcy laws. Advocates of legal activism might expect to find an industry plagued by coordination failures, costly seizure of assets and liquidations at large fire sale prices. In contrast, Coase would expect private institutions to evolve so as to resolve private disputes and limit any deviations.

The focus of our paper is on the potential costs of financial distress. First, the financially distressed vessel owner as the residual claimant would find that once its equity stake is depleted, so is its incentive to retain ownership. A testable implication of the Coase Theorem is that upon default the transfer of title is 'voluntary', that is, without the explicit intervention of a law-enforcement agency the creditor can 'buy' the owner's cooperation. Failing cooperation, a coercive transfer of title would take place, requiring direct legal costs and, more significantly, a loss of charter income. In this event, a creditor has the right to arrest a vessel in a port, that involves the vessel's "colours being [literally] nailed to the mast." While some ports are inefficient and corrupt, there are a significant number that are not, and they compete on the basis of the efficiency of the repossession process.[1]

Second, any practical interpretation of the Coase Theorem has to accept that incomplete information imposes a constraint on the arrangements that can be reached to the mutual benefit of the parties. Market frictions will inevitably prohibit some arrangements which would be feasible in a first-best world. One

[1]The Gibraltar Maritime Authority on its website describes itself as: "Widely recognized for its speed and efficiency in handling ship arrests, Gibraltar provides shipowners and mortgagors with a tried and tested maritime legal system based on English law conducted in English."

friction for example, might be the coordination failures among creditors resulting in the arrests and forced sales of vessels of financially constrained firms. A second is the quality impairment of a vessel caused by its under-maintenance while its operator is in distress. We interpret under-maintenance as an example of Myers (1977) under investment problem, where a distressed operator chooses to under-maintain, knowing that some of the cost might fall on the uninformed creditors and, on other stakeholders who have a weak, or no, contractual connection with the firm, including the environment, ports, and seafarers.

We have four main findings. First, we investigate the incidence of oil spills and other environmental disasters as illustrated by the explosion in 2020 caused by the *Rhosus* vessel abandoned in the port of Beirut, which resulted in both loss of life and enormous damage to the city. We find that under maintained vessels owned by firms that are either in financial distress or bankruptcy are more likely to be the cause of oil spills and other environmental incidents. Such problems often cannot be resolved by private agreements and call for interventions by public law-enforcement bodies. For example, the United States will not allow any vessel into its ports that cannot show in advance a proof of adequate insurance (i.e. the COFR certificate), and the European Union has passed laws permitting port authorities to arrest a vessel whose physical conditions pose a hazard. In response, the shipping industry has created mutual insurance companies that pay for the costs of oil spills and other environmental incidents, where a vessel's insurance proves inadequate. This has increased the incentives to co-monitor the quality of vessels by all the other shipowners in the mutual insurance club.

Second, we identify the arrest of 3,206 vessels where the borrower has defaulted on their debts, thereby leading to the immobilisation of the vessel. In the case of 318 of these financially distressed vessels the arrest was followed by a compulsory sale by the port, with an average immobilisation of 5 months. The arrests are frequently costly since they add to the operating costs as well as imposing delays to the owners of any cargo being carried; this is clearly a violation of Coase. Third, we also measure the fire sale discount on vessels owned by distressed operators, where the vessel is either sold after a port arrest or voluntarily by the operator. Such vessels have an average value of $7.9 million compared with the average value of $10.7 million sold by non-distressed operators. We find that after controlling for vessel characteristics, such sales involve a large raw fire sale discount of about 23%, although about one half is accounted for by under-maintenance. The fire sale discount after adjusting for the lower quality of arrested vessels is around 12%. This is significantly lower than that documented in other asset markets, for example by Pulvino (1998, 1999) in aircraft, and Campbell et al. (2011) in houses. The quality adjusted fire sale discount is influenced by the institutional quality of the port of arrest: for vessels sold in low corruption ports the discount is 11%, compared with 20% in high corruption ports.

The final cost relates to that of abandoned vessels, which is often borne by the crew and port authorities. Financial distress is usually accompanied by unpaid crew wages, who have little means of sustenance when abandoned in a foreign port. They must await the sale of the ship and the proceeds of realisation to stand any chance of repayment and repatriation to their home port; such delays often span several years. In about 50% of abandonment cases, the absence of sufficient residual value, has meant that the vessel had to be towed at the port's expense to a breaker's yard. Such breaker yards are often distant from the port and are low-cost yards with unsafe environmental and labor practices.

We link these findings to three contractual and institutional innovations. First, the registration of the vessel is often made in flag-states, like the Marshall Islands, that compete with one other by offering a register of ownership and liens that protect the integrity of the parties' contractual rights. It is a common practice in the shipping industry to register (or flag) vessels which are usually outside the jurisdiction of the beneficial owner; about 73% of the world's fleet by tonnage are so flagged. However, we document that some flag states offer inadequate protection and regulation of other stakeholders including the crew and the environment, often resulting in under maintained vessels and oil spills.

Second, is the formation of holding companies for shipping groups, where each vessel (or a group of vessels) is owned by a different subsidiary of the holding company, so that default on one vessel does not entitle the creditor to seize another vessel in a different subsidiary. In our sample, the average number of subsidiaries increases with the size of the fleet, reflected in the fact that 86% of the subsidiaries hold only one vessel. An advantage of this organizational form of ownership, is that it reduces the risk of co-ordination failures since creditors of a single vessel are relatively less dispersed than for the group as a whole (Bolton and Scharfstein (1996), Gertner and Scharfstein (1991)). However, it also means that the owner with multiple vessels is able to shield itself from the costs borne by some parties that cannot adequately contract with the firm, for example, abandoned crew and the victims of oil spills.

Separate subsidiaries have also been combined with a third innovation, referred to as the "double mortgage," which permits the lender, in the event of default, to take both a mortgage on the physical vessel, and a lien on the shares of the subsidiary which owns the vessel. This allows the lender to sell their ownership (i.e. the shares) in the event of default, without disrupting the operations of the ship arising from an arrest, thereby, reducing the costs of distress. We describe the mechanism in greater detail using the Eastwind case, a large US operator that became distressed and formally entered US bankruptcy procedures in 2009. Its main lender held a double mortgage on 13 of the company's vessels and when default occurred, ownership of the shares in the companies holding the vessels were transferred to the

lender, prior to bankruptcy, without the need to arrest the vessels in port. On gaining ownership rights the lender was able to immediately sell the ships to another operator to repay the debt outstanding.

In summary, our paper documents how creditor rights have evolved in an industry which is largely unregulated by sovereign bankruptcy laws. Contractual innovations and jurisdictional competition have largely had the effect of strengthening creditor rights, although at the expense of negative externalities. The analysis and evidence are relevant to the debate between those advocating competition between jurisdictions and those advocating harmonization. Romano (2002, 2005) has argued for competitive federalism in US securities regulation instead of a centralized SEC. LoPucki and Kalin (2001) have responded that competition between states is intended to minimize tax liabilities within Chapter 11 filings and has led to a race to the bottom. This debate between competition and harmonization extends to laws between different sovereign jurisdictions. The European Union has strongly supported harmonization, developing common standards in a wide range of financial activities including insolvency law and banking regulation.[2] We also see this debate in the more general context of the "spontaneous" generation of law and institutions through the decentralized interaction of traders within competitive markets: see Hayek (1982), Bernstein (1992) and Greif et al. (1994).

Our paper also contributes to the debate on judicial activism in bankruptcy. We provide empirical evidence on this debate by examining the resolution of financial distress in the shipping industry that largely operates under the freedom of contracting regime. The last thirty years have witnessed a significant expansion of judicial activity in corporate bankruptcy. Many countries have modeled law reforms on Chapter 11 of the US Bankruptcy Code, which grants courts the discretion to protect companies from creditors to increase their prospects of continuation. In particular, creditors can exercise their security interests only to the extent that these rights are not stayed by the court.[3] These mandatory bankruptcy codes have been justified by reason of mitigating coordination failures and large fire sale discounts. According to Jackson (1986), bankruptcy, by its very nature, raises a common pool problem. As a result, creditor runs destroy companies' value through underinvestment and premature asset sales. These problems are exacerbated by insufficient market liquidity, so that forced sales of assets are not fairly priced (Shleifer and Vishny (1992)).[4] It seems that these developments have been driven by a strong conviction that in the absence of vigorous court involvement, freedom of contracting is destined to be plagued by

[2]See for example, Regulation (EU) 2015/848 on insolvency law which came into law in 2017, and The Single Rulebook, a phrase coined by the European Council in 2009 which seeks to provide a single regulatory framework for the EU financial sector that would complete the single market in financial services.

[3]No doubt, there are important cross-country differences in the court's discretion, as well as in their willingness to exercise it (see Davydenko and Franks (2008) and Djankov et al. (2008)). Even in the United States, the trend towards more court involvement has not been entirely consistent: see Baird and Rasmussen (2002) and Ayotte and Morrison (2009).

[4]Shleifer and Vishny (1992) make the connection to bankruptcy law: "assets in liquidation fetch prices below value in best use ...Hence, automatic auctions..., without the possibility of Chapter 11 protection, is not theoretically sound."

market failures. However, the empirical evidence for these convictions is sparse. Indeed, Warren and Westbrook (2004) complain that "thus far the debate over whether parties should be able to contract out of bankruptcy has been entirely theoretical" (p. 1201).[5] The empirical evidence is not helped by the paucity of jurisdictions that rely on freedom of contracting regimes.[6] Our paper tries to bridge this gap by analyzing the workings of private institutions and contracts in the absence of state-mandated bankruptcy laws.

Our paper is related to the literature on the impact of firms' financial health on the welfare of different stakeholders, like employees, the environment, and customers. In the airline industry, Rose (1990) documents that airlines with low operating margins are more prone to experience accidents. Phillips and Sertsios (2013) report that financially distressed airlines are more likely to mishandle baggage claims, and more flights experience late arrivals. Cohn and Wardlaw (2016) and Nie and Zhao (2017) document evidence of high workplace injury and fatality rates in firms with high leverage ratios. Cohn and Deryugina (2018) document a negative relationship between a firm's ability to finance investment and the number of environmental accidents the firm experiences. Our paper finds consistent evidence of negative externalities imposed by financial distress in the shipping industry, particularly oil spills and abandonment of crew and derelict ships. Further, we find that underinvestment in maintenance by financially distressed operators drives these results.

While the shipping industry provides an interesting laboratory to test the Coase theorem, because of the absence of sophisticated state bankruptcy procedures, the question remains, whether our results extend to other industries. There are several important features of the shipping industry that may contribute to an efficient resolution of distress without the aid of mandatory bankruptcy procedures: the fact that ships consist of discrete assets which allow them to be separated from each other for the purposes of limited liability and collateral, the fact that assets can be marketed to potential buyers around the world thereby increasing the liquidity of the market for second-hand ships, and that the intangible value of a ship may be relatively low compared with other assets. This will be a much more of an issue for companies with significant intangible assets, like technology companies and pharmaceuticals that rely on teams. While generalizing our findings to all other industries is beyond the scope of this paper, there are several industries that exhibit similar characteristics to shipping, such as real estate, airlines, oil and gas, and mining companies.[7]

[5] Legal scholars like Jensen (1989), Schwartz (1997), and Schwarcz (1998) have made theoretical arguments in favor of freedom of contracting around bankruptcy laws.

[6] An exception is an interesting literature on Scandinavian bankruptcy laws; see Strömberg (2000) and Eckbo and Thorburn (2008). See also Franks and Sussman (2005) for a discussion of English bankruptcy procedures.

[7] Congress has already recognised the value of limiting the intrusion of bankruptcy law into some of these industries by exempting them from an automatic stay, for example, aircraft under the Capetown Convention (Section 1110, 1994

The rest of the paper is organized as follows. In section 2 we discuss the institutional structure of the industry including how property rights are registered and enforced particularly in the case of an arrest of a ship. Section 3 tests whether coordination failures can explain vessel arrests and provides some evidence of the economic costs of arrest, immobilization and abandonment. In section 4, we explore the externalities imposed by the industry on other stakeholders, including crew, port authorities, and the environment. Section 5 estimates the fire sale discount for arrested and distressed vessels. Section 6 concludes the paper.

2 Institutional Description

The shipping industry is responsible for 90% of global trade.[8] Until the 1970s, the industry was largely controlled by maritime states, and in the case of oil tankers was dominated by the oil majors. Now both have largely been replaced by independents, including Greek and Norwegian shipowners.[9] Couper (2000) has described the pre-1970s period as one "of relative stability and prosperity for shipowners... although since 1970s shipping has become more international but much less stable. There is now virtually unimpeded international mobility of capital and labor in the industry, few barriers to entry and a free choice to shippers of competing ships." Technological changes in ship building have had a dramatic impact on the size and cost of ships: oil tankers have increased in size almost ten times, from 28,000 DWT pre-1970s to 250,000 DWT (supertankers), and containerization has revolutionized cargo traffic. All this has resulted in huge capital investment in both ships and port facilities. At the same time crew size has been reduced from an average of 40-50 per vessel to 20-30, an important factor in an industry where the crew accounts for 40% of operating costs. During the same period the financing in the industry has radically changed. As recently as the 1950s it was largely equity financed, and in recent decades it has become highly levered and very dependent on bank finance, as we describe below.

In the rest of this section, we discuss the influence of legal jurisdictions and the enforcement of creditor rights through an arrest in port and through more innovative contractual procedures.

Bankruptcy Act), and private-label mortgage collateral (2005, BAPCPA); see Lewis (2023). In addition, Section 363(b) of the US Bankruptcy Code allows a company to sell its assets outside the ordinary course of its business during Chapter 11 bankruptcy proceedings.

[8] See Frankel (1989) and UNCTAD Review of Maritime Transport Report (2017)

[9] "Greek shipping accounts for 20% of the world merchant shipping fleet" New York Times, May 27, 1997

2.1 Ship Registration, Jurisdiction and Flags of Convenience

Ships must be registered in a jurisdiction; like the registration of a house, it confirms 'title' or ownership. However, while houses are usually registered in the jurisdiction of the owner, ships are not necessarily attached to any particular nation state, by virtue of the fact that they are for the most time on the high seas, outside any jurisdiction. Thus, the practice has emerged of registering the ownership of a ship outside the jurisdiction of the owner, and in places that are not necessarily near any maritime route; the places of registration are often known as flags of convenience. One such flag-state is The Marshall Islands, which has developed a highly efficient register of vessels despite it having less than 100,000 inhabitants and being far from any shipping route. In 2020, 73% of vessels by tonnage were registered with flags of convenience, outside the country of their beneficial ownership. Table 1 illustrates this dispersion in the country of vessel registration and its ownership. 3 of the world's largest flags - Panama, Marshall Islands and Liberia account for 44% of ship registrations, but only account for 0.3% of vessels' beneficial ownership (columns (2) and (4)). We also find that the top 6 countries dominating vessel ownership, own around 58% of vessel fleet by tonnage, but account for only 11% of the registered fleet.

The flag is important because owners and creditors do not wish the ownership to be tampered with. Since this threat of tampering is perceived as sufficiently important, the mortgage deed or loan will frequently specify a particular flag-state that is recognized for its efficiency and honesty. The mortgage and any other liens will be registered side by side with the registration of the ship. The public register of ownership and mortgage together protect the buyer against a fraudulent change of ownership, and lenders against any sale of the ship that does not recognize their financial interest.

The flag states, like The Marshall Islands, are the primary regulators of vessels flying their flags, and the flag states set out the conditions that ships must meet to retain their registration (for example, the insurance of ships, minimum safety conditions, environmental standards, and crew conditions). Some flag states specify low standards or more often tolerate sub-standard ships and poor conditions for the crew. The flexibility of flags also allows shipping firms to hire labor from international markets, whereas, the traditional places of registration like the UK restricted the employment of foreign nationals and maintained minimum wages. This is important as the monthly wage of a Chief Officer from an emerging country is only $2000 compared with $7500 for western European officers.[10]

[10] Although safety and conditions of service for the crew will be specified by the flag, there are other societies that certify the safety of ships like Lloyds and Bureau Veritas. These societies inspect the ships to ensure minimum standards of maintenance.

The uneven quality of regulation imposed by flag states, has led to efforts by UN agencies and state blocs like the EU, to prevent the dilution of safety standards or a race to the bottom.[11] International regulations by the UN and EU in theory permit the enforcement of these regulations when vessels enter the port-state of those countries which are signatories to the international rules. However, ships spend only a short time in port, and they have some discretion to choose ports with lax enforcement.

A consequence of jurisdictional choice is that a single ship may be subject to a multiplicity of jurisdictions that may affect enforcement of creditor rights, as well as the enforcement of other rules and regulations. The owner, with the agreement of the mortgage holder, may choose the flag, the port-state, and in the event of disputes between creditors and the owners, the place of arbitration e.g. Singapore or the Virgin Islands. International agreements, like the UN or EU provide a potential fourth jurisdiction.

In addition, there is significant competition between jurisdictions, particularly for those ports wishing to attract ships for refueling and maintenance, or flags wanting to attract the registration of ships. Owners of ships may 'flag hop,' although creditors may have incentives to prevent it. Port competition is important to creditors who, in the event of default or non-payment, may wish to have the ship arrested in a friendly port where it will be quickly seized, and then sold with the proceeds distributed to the creditors. This multiplicity of jurisdictions has the potential to produce a race to the bottom in the face of jurisdictional conflicts, and coordination failures resulting in creditors 'asset grabbing' and immobilizing the ships. Lenders might respond to these chaotic conditions by offering low levels of leverage or high interest rates.

2.2 Competition between Ports for Arrests and Enforcements of Creditors' Claims

Conditional on default, a creditor may instruct the port authorities to arrest a vessel and organize its sale to repay creditors. The choice of port of arrest will be influenced by the location of the vessel at the time of default. The task of locating a vessel and identifying the closest ports, is greatly facilitated by the development of GPS technology which allows every vessel to be tracked, and the data to be made public and continuously available.

To initiate an arrest, most port authorities will need to verify that the creditor has a valid contractual right to seize the vessel, execute a sale (if no settlement between debtor and creditor is reached) and dis-

[11] For example, the convention on health and safety of the crew, ILO 147 (1981), has been ratified by only about half of the countries operating the world's fleet and even then surveyors of ships often do not have the time to review thoroughly the conditions of the ship, particularly those pertaining to the crew.

tribute the proceeds among the creditors according to their priority. There are some material differences in procedures across ports. Some, for example, Gibraltar, place great stress on the speed of arrest and subsequent sale of the vessel. In their port handbook, they state "In general, these matter are addressed with a minimum of delay and inconvenience... Modern IT technology is used to speed the process of appraisal and sale once the court has made the relevant order. Particulars of an arrested ship can be made available online within days of a survey." In addition, Gibraltar allows a sale by private treaty where the creditor identifies a buyer and the sale is executed without a public auction, at a price that the Admiralty Court deems fair on the basis of expert opinion. A sale by private treaty can be resolved in a matter of days. Other ports, such those in the Netherlands, accept only a public (Dutch) auction. There are also important differences in the speed of implementing the procedure, with some ports being more sensitive to the costs imposed by the immobilization of the vessel. Other ports have proven corrupt and inefficient and are to be avoided by creditors where possible, eg Lagos in Nigeria.

Six countries stand out for the effectiveness of their arrest procedure: Gibraltar, Hong Kong, Singapore, South Africa, The Netherlands and the UK. As a result, there are more arrests, initiated by creditors, in these specialized ports, relative to the volume of trade. Using our data on 3,470 arrests, Table 2 shows that these six ports' share of the world's cargo trade is only 11%, while they have 34% share of arrest activity. In contrast, in some of the world's busiest ports, such as Japan, China or the USA, the arrest volume is small relative to the volume of trade, in part at least because their arrest and sale procedures are not conducive to a speedy resolution. Arrest specialized ports also provide relatively quicker resolutions, with typical arrest durations ranging from 2-4 months (column (4)).

As described above, competition between ports is targeted at creditors who wish to seize their collateral. Over the period of our sample the average duration of arrest to resolution declines from roughly 250 days in 1995 to around 40 days in 2020.[12] The intensity of competition between ports is illustrated by the case of Rotterdam, which until recently, was willing to arrest ships without independent evidence of debts outstanding, and obliged the owner to sue the creditor for the costs in the event of wrongful arrest. This illustrates how competition between jurisdictions can 'over-tighten' creditor rights. As we show later, strong creditor rights may enhance the borrowing capacity of shipping firms, and thereby influence the way the industry is organized, in terms of both its size and ownership structure. Although higher borrowing capacity is valuable it might be offset by a more costly ownership structure, for example, one that is widely fragmented.

[12]This decline in the duration of arrest over time is robust to controlling for the port of arrest, vessel type, and trigger for arrest. Results are available on request.

The sale of ships is facilitated by specialist dealers who have had long experience as shipping valuers and brokers. They disseminate information about the ship's quality and condition, the equivalent of housing survey reports, to would be buyers around the world.[13] Using a sample of hand collected data on UK shipping auctions, we found that the average number of bidders is 8, which is consistent with the view that the second-hand vessel market is a liquid one. In one auction, the number of bidders reached 23.

In principle, any creditor may arrest a ship, including the mortgage holder, the crew for non payment of wages, a ship's supplier (a bunker supplying fuel or a ship's 'chandler'), or a bank with an unsecured claim. An important difference between defaults in other industries, is that the arrest of a vessel immobilizes the asset, incurring direct costs and the indirect opportunity costs of lost business. In most other industries a creditor can lay a claim against a company but not stop its operations. One exception is airlines, where creditors can seize an aircraft in some jurisdictions.

2.3 Contractual Innovations and Organizational Form

Here, we describe the corporate organization of a typical shipping company, and important features concerning collateral and the seniority of particular creditors' claims.

A shipping operator is frequently organized as a holding company with multiple subsidiaries, each one owning a single vessel or a group of vessels. A creditor facing a debtor default may try and immobilize a ship through a port arrest and an auction of the ship. In the event the ships are sold by the arresting authority, they will advertise the sale and reach out to potential creditors before they distribute the proceeds. The distribution will be made according to the priority of the claims.

Table 3 describes organization of ownership structure in the shipping industry. Using data on detailed multi-level ownership, we aggregate vessels across all subsidiaries of a holding company (or firm). Table 3 is a snapshot of the industry at the end of 2020. There are about 5,000 shipping firms in the industry, and about a third of these firms own only 1 vessel. We partition the shipping firms on the basis of their fleet size, and find that the average number of subsidiaries (or silos) increases in lockstep with the increasing size of the fleet. Thereby, the median number of vessels per subsidiary fluctuates around 1, irrespective of the size of the firms' fleet. This is further reflected in the fact that 86% of the subsidiaries hold only 1 vessel. Creating single vessel silos, ensures that the number of creditors on a single vessel is relatively

[13] An example in the UK is CW Kellock who are internationally recognised ship valuers and auctioneers of ships. Founded in 1820, they have acted for the Admiralty Marshall of the Courts of Justice of England and Wales as brokers and valuers for more than 150 years. They have a worldwide data base of shipping sales going back more than 50 years.

less dispersed than for the group as a whole. It is also evident from Table 3 that bigger firms maintain a much younger fleet and operate larger size vessels. The average fleet size for the top 100 firms in the industry is 76,000 DWT, compared with the industry average fleet size of 28,000 DWT.

Where the debts are non-recourse, the creditors can only pursue claims against the particular company or subsidiary with the debts outstanding. In this case each ship, or sometimes a group of ships, will be held in a separate company with the shares of the company held by the group. It is likely that the ships will be financed with a mortgage secured on the physical vessels (known as a maritime mortgage). In that event a creditor of one company may not pursue a claim against ships in a different company in the group. In shipping, a significant proportion of the lending tends to be on a non-recourse basis using ship mortgages.

The holder of the mortgage, like any secured lender, has the most senior claim on the ship, with some important exceptions. Most state-ports like the UK have introduced a maritime lien, which has the effect of making the crew's claims for wages and other benefits senior to most other creditors, including the mortgage holders. The rationale for this seniority (for what is normally an unsecured claim in bankruptcy), is that while ships are on the high seas, the crew may desert the ship in the event of non payment of their wages. This might threaten the value of the vessel and the cargo, but also pose a risk of collision with other shipping. This may expose the owner (and in some circumstances the lender) to a lawsuit. In addition, the maritime lien in many states protects the cargo owners, since their claim is also made senior to the mortgage holder. In a survey report of maritime laws and policies across 18 major jurisdictions, Rutkowski (2014) reports that the pollution claims and damages are also a part of the maritime lien, and these claims have priority over ship mortgage holders and other secured/unsecured creditors. The maritime lien was a contractual innovation originally introduced by private contract, and subsequently standardised by statute in many countries.[14]

A second contractual innovation in shipping is the double mortgage. Assuming the ship is owned by a company which is financed on a non recourse basis, and the shares are held by the holding company, a lender with a mortgage on the physical vessel may also take collateral on the shares of the subsidiary that owns the particular vessel. Thus, the lender has both a mortgage on the physical vessel and on the shares of the company owning the same vessel; this is the basis of the 'double mortgage'. We describe in the Eastwind case study below how this double mortgage can, in the event of default, allow the lender to repossess a ship on the high seas. The double mortgage is executed by the lender, at the time the loan is agreed, and permits the lender to acquire the collateral of the shares and signed but undated

[14]Refer to Teiniu (2013) and Hill (1998) for a historical background of maritime liens.

letters of resignation of the owner's board of directors. When default occurs, the lender dates the letters of resignation and appoints its own board of directors, thereby acquiring ownership and control of the shares on the vessel from the borrower. The lender is then in a position to sell the vessels, discharge the mortgage without sailing it to a port and having it arrested. The result is that this procedure minimizes the costs associated with enforcing its collateral by seizing the ship in port. This is even more important if the nearest efficient port is some days sailing.[15]

The costs of arrest and auction include the direct costs of sale, the port fees and crew costs while in port prior to sale, or until the creditor discharges the debts by some other means. Most of these costs can be avoided by the exercise of the repossession rights on the high seas using the double mortgage. Also, because the sale of the ship can take place without the participation of the state-port, this will reduce not only direct transactions costs, but also reduce any potential fire sale costs associated with a sale undertaken by the port authorities, who may try for a speedy sale. Finally, if the ship is laden with cargo, seizing a ship in a port, other than that designated in the cargo contract, exposes the creditor to a lawsuit in the event of a delay in the delivery of the cargo and possible damage in transit.[16] As a result, it is a rule in shipping that a creditor should try and avoid an arrest when the vessel is laden with cargo. There are no such constraints on repossession on the high seas using the double mortgage.

2.4 Abandonment, breakup of vessels and oil spills

While contractual innovations have strengthened the rights of creditors, both secured and unsecured, they may have had unintended consequences for other stakeholders, including the crew, ports, and the environment. It is well documented that when owners have little or no equity in the vessel, they may abandon the vessel. At the same time the crew may also share the cost of abandonment through unpaid wages, and an absence of maintenance support while in port. If the creditors see some value in the abandoned vessel they will arrange for its sale. In that event, the proceeds of realization would first be used to repay the crew debts, and any port fees under the maritime lien. However, if the vessel is of sufficiently low value and creditors have no residual value in the vessel, the crew wages will not be paid, and the port will be responsible for the ultimate fate of the vessel. In this event, the port will have to pay for the ship to be towed to a break-yard, probably in Pakistan or Bangladesh.

A third stakeholder is the environment. Low valued and under-maintained vessels are particularly prone to oil spills and other costly environmental incidents. In Figure 1, we show that an increasing

[15] The port authorities will want to see evidence of default, usually provided by a lawyer for the shipping firm

[16] It is for this reason that seizures and arrest often take place in the port where the cargo has been discharged; if, however, the port is corrupt or inefficient that may not be possible.

proportion of vessels are being broken up in countries with low environment standards, in particular Bangladesh, India, Pakistan and China.

In Table 4, we analyse all incidents of crew and vessel abandonment in our sample period, from the incident narratives collected by ILO. We find in Panel A that between 1995-2020, there were 1,047 incidents of crew abandonment, involving more than 10,000 seafarers. We report that the average age of vessels at the time of their abandonment was 21 years, and the average size of these vessels was only 21,000 DWT (median size of 7,600 DWT). The abandoned vessels are much older, and lower valued compared with the industry averages reported below (an average vessel in the industry is roughly 16.6 years old, weighs 32,000 DWT, and is valued at $10.7 million).

In Panel B, we split the abandonment incidents by an arrest. In around 50% of the cases, the abandoned vessel was arrested, and typically had some residual value that was realized upon its sale. The crew members were unpaid and were deserted in foreign ports for 1-2 years, while they awaited their outstanding wages and repatriation. These are some of the better cases in our sample. In the remaining 50% of the cases, involving around 9,500 seafarers, the abandoned vessel had little or no resale value, and the crew were not paid. Panel B of the table also shows that arrested vessels are significantly younger, bigger, and higher valued.

Table 5 describes the oil spills and marine pollution incidents in our sample, for the time period 1995-2020. Panel A summarizes the serious casualty incidents that led to oil spills and marine pollution. We find that 41% of the incidents resulted from mechanical damage to the vessel, 31% of the incidents were due to collisions, while 20% were caused by abandoned or stranded vessels. The remaining 8% of the incidents resulted from an explosion or fire in the vessel containers carrying oil, liquefied gas, or other chemicals. We also report the characteristics of vessels involved in serious casualty incidents. The average age of vessels at the time of incident was 17.1 years, and the average size of these vessels was around 27,000 DWT.

Panel B summarizes flag-level yearly casualty incidents, fleet statistics, and country performance indices. The average flag state is responsible for 6.64 serious casualty incidents every year, although the median number of incidents is much smaller at 1. This indicates a large dispersion between the quality of vessels flagged under different jurisdictions, with some flag states being responsible for the majority of the incidents. The average flag has around 440,000 DWT of fleet registered under its jurisdiction. Across years roughly 22% of the flag states are on at least one of the *targeted* flag lists published by port state authorities (of Paris MoU, Tokyo Mou, or UNCG).[17] Therefore, inspections reveal that vessels flagged by

[17]These three lists of *targeted* flags were published by port authorities from the beginning of 1999.

these *targeted* jurisdictions might not meet the international safety standards. Panel C explores this issue by splitting the sample between incidents for which *targeted* flags were responsible, versus incidents for which other flag states were responsible. We find that the average number of yearly casualty incidents by vessels sailing under *targeted* flags is much higher at 11.6, compared to an average of 4.2 incidents (and a median of 0 incidents) for non-targeted flags, while, on average *targeted* flags are also responsible for maintaining a larger fleet. On average, compared to non-targeted flags, the *targeted* flags have a much lower corruption index (indicating higher corruption), and a slightly lower law and order index (indicating weak rule of law).[18]

2.5 How is the Industry Financed?

Notwithstanding the contractual innovation, there may remain considerable uncertainty surrounding the enforcement of creditor rights in particular jurisdictions. One response by creditors might be to reduce lending to this industry. However, the evidence suggests that the industry is the most highly levered among the transportation industries. Drobetz et al. (2013) show that debt has traditionally been the most important source of external financing for the industry where, "More than 80% of all external funding needs in the shipping industry were traditionally covered by debt finance." The study reports leverage ratios of large listed shipping companies as being more than two thirds higher than the average of other industrial firms. For a sample of companies spanning a period from 1995 to 2020, they report leverage ratios of 41% compared with 25% for other firms.

These findings tell only part of the story, since typically shipping companies are formed as groups with multiple subsidiaries, where debt is netted out at the subsidiary level. To investigate the impact of this netting out, we obtained private data from a shipping consultancy firm for the financial accounts of 27 subsidiaries of various shipping firms, registered in several jurisdictions; see Table A.1.[19] The average loan to value ratio, at the inception of the loan, was 65% (median 70%). The loans had original maturities of between 4 and 12 years, amortized quarterly, although some also had balloon loan payments. The average interest rate spread (above LIBOR) on the loans was 2.35 percent.

To better benchmark against other industries, we use COMPUSTAT (North America and Global), comparing a sample of 647 shipping firms with 923 firms in other transportation industries (e.g. airlines, railroads, and trucking companies). The interest rates in shipping average 6.5% compared with 7.7% in other transportation industries, although leverage in shipping is higher at 40.4% compared with 35.2%

[18] One caveat of using these indices, is that The Law and Order and Corruption indices are not available for several island countries (that are independent flag states).

[19] We are grateful to Captain Kaizad Doctor for supplying us with these data.

in other transportation firms. In Table A.2, we regress the leverage ratio and interest rate, respectively on firm level controls such as asset tangibility, profitability and an indicator variable for whether the firm belongs to the shipping industry. We find that leverage ratios in shipping firms are higher than other transportation firms, even after accounting for leasing.[20] Also, the interest rates in shipping are significantly lower than other transportation industries.

2.6 Data Sources and Summary Statistics

We combine data from several sources for the empirical analysis that follows in the paper. This section describes the key features of our data and the sample construction process.

Ownership and Vessel Database: Our main data sources are Lloyd's List Intelligence (henceforth LLI) and IHS Markit SeaWeb. LLI was originally part of Lloyd's of London, the famous syndicate of insurance underwriters.[21] Our sampling window begins in 1995 and ends in 2020. We focus on merchant vessels (bulk, containers, reefers and tankers), but exclude passenger ships and highly specialized technical vessels (e.g. oil exploration vessels). We also exclude small vessels below 10 dead-weight tons (DWT). Effectively, this is a survey of the world fleet during the sample period. The data contain information about both active and scrapped vessels.

Each vessel is identified by an International Maritime Organization (IMO) number, which is attached to the body of the vessel, and remains intact when the vessel changes owner or name. IHS Markit is the sole issuer of IMO number to any vessel in the entire world under the authority of United Nations. This ensures high level accuracy of the vessel-level data, as it is collected from vessels' registration and ownership details at the time of issuing the IMO number. Technical information for the vessel, including the vessel type, size, hull type, country of built, built date, and scrap date are also included in the database.

Vessel ownership is identified by the LLI and IHS databases at multiple levels. The 'registered owner' of a vessel is the legal title of ownership of the vessel that appears on the ship's registration documents.[22]

[20] Leverage Ratio inclusive of capital and operating lease obligations is computed using definition from Graham et al. (1998). That is, operating lease is defined as the discounted sum of minimum rental commitments over the next 5 years.

[21] The intelligence unit is currently owned by Informa, a publisher. Lloyd's List, is an industry news bulletin, in existence since 1734 and Lloyd's vessel register has been in existence since 1764. The data in the electronic format is only available since the mid 1990s.

[22] Registered owner may be an owner/manager or a wholly owned subsidiary in a larger shipping group; or a bank or one ship company vehicle set up by the bank; or in many cases, it may be a "brass plate" company created on paper to legally own a ship and possibly to limit liability for the "real" owners and/or benefit from off shore tax laws. It may also be created to satisfy a legal requirement of the flag state with whom the ship is registered for the legal owner to be a company registered in that country.

In our empirical analysis, we link the registered owners (that are generally *brass-plate* companies) of the ships to their parent companies or the group-level beneficial owners.[23]

Vessel Arrest Database: The data on vessel arrest is also collected from Lloyd's List Intelligence. This database provides detailed information about vessel arrests including, the vessel IMO number, port of the arrest, and the duration of arrest along with the arrest start date and arrest end date. In many cases the database contains a short narrative describing the circumstances of the arrest. As we will describe below, we use this information in the narratives to classify the trigger for arrest and the resolution of arrest.

Transaction Level Database: The vessel transaction data is collected from Clarkson Research Services Limited (CRSL), a shipping broker, which supplies price information for secondary market transactions. This database includes the vessel IMO number, date of sale, sale price, and the seller and buyer identity. Technical characteristics of the vessel that impact its sale price are also included: these are details on vessel age, size, length, depth, special units, draft and freeboard. Appendix 6 reports the definitions of these vessel related variables. The CRSL, IHS and LLI data sets are merged through IMO numbers, to identify the vessel sales of arrested vessels. Our sample period is from 1995 to 2020.

Oil Spills Casualty Data: The IHS Markit Casualty database reports vessel-level casualty incidents responsible for marine pollution and oil spills. These casualties include accidents, collisions, machinery damage, and other incidents of marine pollution. Incident reports include vessel name, vessel IMO number, location of the incident, and flag and registered owner of the vessel at the time of incident.

Vessel Abandonment Database: A database on vessel and crew abandonment incidents is maintained by the International Labour Organization (ILO). The data includes information on abandoned vessels' IMO numbers, specific details on the seafarers that have been abandoned, and the resolution or current status of the incident.

Records of Arrests in UK Ports: We augment our LLI arrest database with detailed records of a sample of vessel arrests in UK ports. This vessel survey is carried out by the Admiralty Marshal, an officer of the maritime courts. The records provide more detailed information about the direct costs of the arrest, including those for keeping the vessel in port and auctioning it, as well as a description of the state and quality of the vessel provided to all potential bidders in the auction, and finally, the value of all the bids submitted.

[23] A group beneficial owner is a parent company of the registered owner. It represents the controlling interest and it is the ultimate beneficiary from the ownership. A group beneficial owner may or may not directly own ships itself as a registered owner.

COMPUSTAT: Financial data for the transportation industry is collected COMPUSTAT North America and COMPUSTAT Global. Annual financial data on firms is collected from 1965-2018. In this sample we have 647 shipping firms, and 923 other transportation firms (including airlines, railroads, trucking companies, etc.).

With expanding international trade, the world's merchant fleet has grown steadily over the sample period, from 19,424 vessels in 1995 to 34,988 in 2020, an annualized growth rate of 3.2%. Technological advances coupled with the economies of scale of larger ships, have resulted in a steady increase in the average vessel size during our sample period. The merchant vessel fleet in 2020 comprises bulk carriers (34%), tankers (42%), container ships (17%), reefer ships (3%), and roll-on/roll-off ships (4%).

Since the early 2000s the shipping industry has seen an unprecedented boom, with the Baltic Dry Index (tracking world-wide charter rates in bulk carrying, mainly raw materials such as coal or iron ore), increasing more than four times before crashing to half its 2003 level shortly after the 2008 financial crisis. As Figure A.1 shows, charter rates in the tanker business[24] have gone through a similar cycle, albeit of a less erratic nature. Figure A.1 also plots a price index for vessels.

3 Arrests and the Resolution of Distress

In this section, we empirically examine the extent to which the shipping industry is disrupted by frequent and costly arrests of ships. We also identify the type of the creditor triggering the arrest and, the extent to which vessels arrested belong to companies that are financially distressed or bankrupt.

3.1 Involuntary Sales: Arrest of Vessels

An arrest followed by the repossession and sale of the vessel is the ultimate remedy available to a secured creditor to obtain repayment. Therefore, we use arrests as a proxy for coordination failures. Anecdotal evidence indicates that to negotiate a workout, banks prefer to use their right to arrest the vessel as a potential threat. It is often in the best interest of the owner to avoid the vessel arrest and accept a Coasian bargain, unless the owner has lost all hope of recovery. The data presented below is consistent with the view that such Coasian bargains are negotiated in the large majority of the cases, thereby avoiding the direct cost of arrest and any foregone cash flows during the arrest. A simple workout would be a "voluntary" sale of the vessel, sometimes to a buyer found and even funded by the bank, using the

[24] We use the "Dirty tanker" index for crude oil.

sales proceeds to repay the bank, but allowing the owner to operate his remaining, albeit downsized, fleet. We are also aware of more complicated workouts. For example, Pillarstone, a platform set up by KKR to manage the distressed shipping loans for banks, was willing to inject cash into distressed loans. In return, the bank, maybe capital constrained but recognizing the going concern value of the vessel, typically allows the new loan to be senior to the mortgage. Such a Coasian bargain is akin to Chapter 11 debtor-in-possession financing, albeit executed as a privately negotiated voluntary transaction.

During the sample period, LLI reports 3,206 arrests. This is a small number relative to the total capacity of roughly 974,000 vessel-years of the entire industry. Figure 3 plots the fraction of industry capacity, measured in DWT, that is under arrest, computed on a quarterly frequency. Average capacity under arrest, measured in DWT years is roughly 0.14% of the total capacity. Table 6 Panel A summarizes the arrest events, and we find that on average arrested vessels are older and lower valued than the vessels in the industry.

LLI narratives[25] reveal a variety of factors that provoke an arrest apart from financial distress: a drunken shipmaster, contraband, violation of international sanctions, fire, collision with another vessel, or disputes with suppliers. It is necessary to distinguish financial from other factors that might trigger an arrest. For example, a client may have a vessel arrested on the grounds that the owner mishandled a cargo and caused damage. In such an event, it would be easy for a financially sound owner to find a bank that would guarantee payment, and thereby quickly lift the arrest warrant. However, a distressed owner may not be able to obtain such a guarantee, thereby prolonging the arrest and exacerbating its own distress.

In the case of financial distress there are a variety of creditors that might trigger an arrest. Creditors may be divided into several categories: (i) operational creditors, e.g. the suppliers of fuel known as bunker suppliers and, suppliers of ship stores, or ship chandlers, (ii) voyage related creditors, e.g. the crew and cargo owners, (iii) Government creditors, e.g. port authorities, and (iv) financial creditors e.g. mortgage holder(s). While the number of creditors maybe fewer than in other industries their ability to immobilize a vessel via a ship arrest provides far stronger control rights than in many other industries.

Table A.9 classifies arrests by trigger and resolution. The classification is made on the basis of LLI narratives in conjunction with other information such as a transfer of ownership. With reasonable confidence, we identify 538 arrests that are not directly related to debt collection, and another 803 arrests as being unlikely to be related, leaving 854 arrests as being definitely related to the failure to repay secured debt, as well as the wages of the crew and unsecured creditors e.g. bunkers. Of these 854 cases, 20% of

[25] Based on a system of agents that Lloyd's has in major ports all over the world to report mainly insurance-related events.

the vessels are auctioned and the proceeds distributed to the creditors. 11% (of these 854) are "broken up" – industry jargon for scrap, against only 6% for the rest of the population – another indication of low quality in arrested vessels, a matter on which we shall elaborate in the next section. Most of vessel breakups take place in poor countries with weak environmental regulation like Pakistan or Bangladesh. The cost of delivering a vessel for a lengthy journey to a breakup destination might incentivize a distressed owner to abandon a vessel under arrest, biasing the length of arrest statistics.

3.2 Identifying Distressed Firms

In the previous subsection we discussed how failed renegotiations with creditors could often result in acrimonious events leading to costly vessel arrests. However, given the well defined property rights reflected in the structured financing in the shipping industry, one might expect very low arrest rates. An individual vessel or group of vessels are usually placed in a single subsidiary with their own non recourse financing. In addition, the non-corrupt ports responsible for arrests and auction of ships adhere to rules of strict absolute priority when dividing the proceeds of the sale of the arrested vessels among the different creditors. As a result, there are limited incentives for creditors, senior or junior, to arrest a ship particularly given the costly nature of arrests.

We test this hypothesis by identifying a sample of financially distressed firms in the shipping industry. We start by identifying financial distress using news articles from Lloyds List and Factiva, and LLI narratives. The Lloyds News sheet is published weekly and runs articles on events affecting shipping companies including credit default events and bankruptcy filings. Using these news articles and narratives we identify a sample of financially distressed firms that have defaulted on their debt or have filed for bankruptcy protection. Further, we make a list of 660 shipping companies that experienced a contraction of their fleet, referred to as downsizing, of at least 35% of their initial fleet concentrated in a 10-year window. We specifically search for these firms using shipping news articles to identify the reason for their downsizing. Using this approach we identify 326 distressed companies of which 159 filed for bankruptcy. As expected we find that not all distressed firms have an arrest; only 27% of the identified financially distressed firms have an arrest during a 5-year window before the event year (that is, the year of news filing or bankruptcy filing).

Table 6 Panels B and C describe these distress events. We define a bankruptcy or distress episode in the 5-year window before an operator files for bankruptcy or a distress-related news event is published. While the unconditional probability of arrest in the full sample is only 0.14%, it increases to 0.93%

during bankruptcy episodes (Panel B), and 0.28% during distress episodes (Panel C). These comparative statistics confirm the effectiveness of our proxies for identifying distress. While the probability of arrest significantly increases with distress, it remains economically low even in extreme distress events. On average, 50% of the initial fleet is sold during bankruptcy episodes, and 6.2% of the fleet is arrested. In comparison, on average, for distress episodes 45% of the initial fleet is sold, and 7.1% of the fleet is arrested.

In Table 7 we formally test whether distress events are correlated with arrests. We create a panel of all vessels in the industry at the year-quarter level. The dependent variable, *Arrests* is one if the vessel was arrested in a given year-quarter and zero otherwise. The independent variable, *Bankruptcy or Distress* is one in the 5-year window before the news event of the vessel operators' distress and zero otherwise.[26] Regressions include year-quarter fixed effects that control for industry cyclicality and any time series variations driving arrest rates. Ship type and size category fixed effects are also included to control for any variations in the types of vessels affecting arrest rates. In columns (1) – (3), we report that the probability of arrest increases by 0.34% during bankruptcy/distress events. Such events roughly triple the unconditional probability of arrest of 0.15%. In column (3), we include controls for the estimated hedonic price and salvage value of the vessel. The hedonic price is an estimate of the market value of the vessel in a given year-quarter. The salvage value measures the depreciation of a vessel. It is estimated by the proportion of a vessel's current market value as a fraction of its replacement value (i.e. the current market price of an identical new vessel). Using both hedonic price and salvage value, we report that the probability of arrest increases for lower-valued vessels. In columns (4) – (6), the distress-related independent variable is split between bankruptcy and distress events. During bankruptcy and distress events the probability of an arrest increases by 0.75% and 0.13%, respectively.

A potential issue with collecting data on distressed firms is that some firms through amicable renegotiation might not only avoid arrests of their ships but avoid significant publicity surrounding any debt renegotiation. We address this issue by focusing on a set of firms that have experienced large-scale sales of ships concentrated in narrow windows, which we refer to as "downsizing events." The details of the filter used for classifying these downsizing events are discussed in the Appendix G. Using this filter we identify 660 distress events, and in 265 of these, the operators sold more than 90% of their initial fleet. We repeat all our tests with this sample of firms and continue to find that the probability of arrest remains low even during these downsizing events (Table A.5).

[26] All our results are also robust to choosing a 3-year window or 7-year window before the news event.

3.3 Coordination Failures and Arrests

If all vessels were separated into limited liability companies with non recourse lending, we would not expect a coordination failure on one vessel to spillover to another vessel. However, where the financing of vessels is recourse, that is the debt is issued at the holding company level, then we would expect spillovers and to observe multiple vessels being arrested. We draw on the insight presented in Figure 2, tracking Eastwind's decline: that an arrest rate well below 100% throughout the distress cycle, is not consistent with a creditors run. In a run, creditors are driven by a first-mover advantage, and would thus grab any asset that has not already been seized by another creditor. We might infer from Eastwind that either the ships were financed with non-recourse debt or the company was able to strike a Coasian bargain with its creditors. In fact we know that twelve of Eastwind's vessels were subject to a double mortgage with non-recourse financing with Nordea Bank.

In sharp contrast to Eastwind, Adriatic Tankers filed for bankruptcy in June 1996, and 73 of its 86 vessels were arrested. An investigation of the circumstances of Adriatic's failure suggest the company entered formal bankruptcy largely due to economic distress. This culminated in a dispute with an international labour union, triggered by the large scale abandonment of ships by crews in European ports because of non-payment of wages (see Couper (2000)).[27] In addition, a significant amount of the company's debt was in the form of (unsecured) private placement debt with a large number of US insurance companies and pension funds rather than the traditional ship mortgage. One result of this financing would have been the common pool problem described earlier by Jackson (2001), and an increase in coordination failures. For example, in 1995 Lloyds List described coordination failures leading to a creditors run on individual ships of Adriatic: "The unseemly dispute over the Adriatic Tankers VLCC Myrtos Bay, with rival claimants summoning up more and more gigantic salvage tugs to haul the elderly ship under their respective control has the basis of a first class farce. Gilbert and Sullivan would have loved such a plot. But with four powerful units heaving away at the respective extremities of the 1974-built ship, questions of piracy, or the even more colourful charges of mutiny surely become secondary. An involuntary judgment of Solomon, with the ship divided into two crudely severed halves, will surely take place if they carry on tugging. Just as a severed baby was judged of little use to the disputants arguing their case before the wise old King of Israel, some 4.5 tanks apiece would seem to have little functional value to the energetic mortgagees. But bankers being bankers, perhaps they think that if the tugs pull hard enough, the ship will get long enough to satisfy both parties."[28]

[27] "Many of Adriatic Tankers' seafarers fell foul of the police in Rotterdam while abandoned ashore awaiting their wages ... they were required to see that they were repatriated whether they had been paid or not." (page 44 of Couper (2000))

[28] see article by John Beckett in Lloyd's of London Press Limited, 1995.

We apply the analysis in Eastwind and Adriatic to all the distressed firms in our sample. We measure the proportion of ships arrested during the distress episodes, for the firms that have been identified by news events. In the event of a creditors run, we would expect to observe a high proportion of arrests, close to 100%. For each of the distress episodes, we calculate the number of vessels that were arrested as a proportion of the initial fleet size (at the start of the distress episode 5 years before the news event). In Table 6 Panel B and C, we report that the median arrest rate is 0 in our sample of bankrupt and distressed firms. 73% of these distressed firms had no arrests. The average arrest rate in the bankrupt sample is 6.2%, and at the 95th percentile, the arrest rate is 38%. This suggests that coordination failures akin to Adriatic Tankers have a relatively low incidence in our sample. In fact, only 3% of the bankruptcy or distressed sample has an arrest rate above 80%.

Low arrest rates in the industry imply that either most of the firm's debt was non-recourse, or that the firm was able to negotiate a Coasian bargain with most of their creditors. Our analysis also suggests that most of the distressed firms managed to liquidate their assets without resorting to a significant proportion of arrests. The relatively low rate of arrests for the whole industry, and for distressed and liquidating firms in particular, is likely to be a direct consequence of the fact that contractual rights of creditors on individual ships were well defined. Notwithstanding, a very small proportion of distressed firms were subject to a high arrest rate and coordination failures which bore a resemblance to a creditors run. However, there is some indication that these coordination failures may have been more the result of economic distress rather than financial distress. Chapter 11-like procedures are usually justified on the basis of financial distress, so as to avoid premature liquidation of economically solvent firms. Another reason for low arrest rates is that the banks financing the mortgages are usually specialist lenders who understand the industry and are aware of the direct and indirect costs of arrests particularly when a vessel is laden with cargo. In the latter case, an arrest exposes the creditor triggering the arrest to a lawsuit if the cargo is damaged or the delay in delivery results in loss to the cargo's owner.

4 Costs of Financial Distress for Other Stakeholders

We have demonstrated that contracts in the shipping industry have evolved to strengthen creditor rights, and several contractual innovations in the industry have reduced the direct cost of financial distress by lowering coordination failures. However, an excessive strengthening of credit rights in the shipping industry, may have encroached on the rights of other stakeholders, including crew, port authorities, and the environment. In this section, we demonstrate a clear breakdown of the Coase Theorem, owing to

the negative externalities an operator can impose on other stakeholders that, have limited legal means to protect themselves against harm because they are not party to the contractual arrangements.

4.1 Evidence of Quality Impairment

LLI's arrest narratives, which we have used to classify arrests by trigger and resolution (see Table A.9), make frequent references to the poor technical condition of arrested vessels: "auxiliary engines and boiler trouble", "ingress of water into engine-room; hull in bad condition; cargo holds water contaminated", "cracks in hull", "survey revealed unseaworthiness", "bottom damage requiring considerable steel renewal" etc. These descriptions suggest that one aspect of Myers (1977) underinvestment problem is poor maintenance of assets. In this section, we document direct evidence of financially distressed owners undermaintaining their fleets. More specifically, we use duration analysis that measures the vessel's "economic life expectancy", that is the expected number of years of service until it is "broken up", conditional on its "chronological age", that is the number of years since it started service. We first demonstrate a vessel under arrest is effectively older than a similar non-arrested vessel.

Following the methodology of Franks et al. (2024), we proxy for an unobserved quality of the vessel by imputing the life expectancy of the vessel. We denoted the hazard function by $\lambda_i(Age)$. The hazard function provides the hazard rate for a ship i as a function of its age. The hazard rate corresponds to the probability of vessel i breaking up at a certain age conditional on surviving up to that age. Furthermore, we define the economic life expectancy of a vessel at a given age as:

$$L_i(Age) = t + (1 - \lambda_i(Age)) \cdot \lambda_i(Age + 1) + (1 - \lambda_i(Age)) \cdot (1 - \lambda_i(Age + 1)) \cdot \lambda_i(Age + 2) \cdot 2 + ... \quad (1)$$

Using the above method, we calculate the life expectancy and hazard rate separately for the three groups of arrested, distressed and, non-arrested vessels. Vessels are classified as distressed if they were operated by a bankrupt or distressed operator in the 5-year window before the operator files for bankruptcy or a distress-related news event is published. We find that for a ship at any given age, the probability of an instantaneous breakup, i.e. hazard rate, is higher for arrested and distressed vessels relative to non-distressed vessels, as plotted in the top panel of Figure 4. The methodology is described in detail in Appendix B. In the bottom panel of Figure 4, we plot the life expectancy of arrested, distressed and, non-arrested vessels. We find that a 20-year-old arrested vessel has a life expectancy of 26.6 years, compared with a non-distressed vessel having a life expectancy of 27.3 years. This suggests that arrested vessels have a 10% lower remaining life expectancy than non-distressed vessels.

Below, we explore the implications of financially distressed owners operating a fleet of under-maintained vessels and discuss the significant negative externalities these vessels inflict on other stakeholders, such as the environment, crew, and port authorities.

4.2 Marine Pollution and Oil Spills

The International Tanker Owners Pollution Federation (ITOPF) estimates that between 1970 to 2019 approximately 5.86 million tonnes of oil were spilled into marine waters as a result of tanker incidents. Large oil spills from tankers often result from collisions, grounding, structural damage, fire or explosions. The largest oil spill resulting from a tanker incident was caused by *Atlantic Empress*, a Greek oil tanker spilling 287,000 tons of crude oil into the Caribbean Sea in 1979. Oil spills can result in large costs for the responsible firm, insurance company, and affected fishing communities. They also impose very high reputational penalties on firms for environmental violations. For example, in a study of the impact of *Exxon Valdez* spill on Exxon's stock price, Jones et al. (1994) estimated costs to its shareholders ranging from $4.7 billion to $11.3 billion.[29]

In the previous subsection we have documented that financially distressed owners under-maintain their fleet. In Table 8 we test whether distress events are correlated with an increased probability of oil spills and marine pollution incidents. Using a panel of vessels at the year-quarter level, we set the dependent variable, *Pollution Incident* equal to one if the vessel was involved in an incident in a given year-quarter and zero otherwise. The independent variable, *Bankruptcy or Distress* is one in the 5-year window before the news event of the vessel operator's distress and zero otherwise. Regressions include year-quarter fixed effects and ship type and size category fixed effects to control for variations in the types of vessels affecting the risks of an oil spill. In columns (1) – (3), we report that the probability of a pollution incident increases by 0.08% during distress episodes. The unconditional probability of a pollution incident in our sample is 0.60% and a distress event roughly increases this probability by 13%. In column (3), we include controls for the estimated hedonic price and salvage value of the vessel. We report that the probability of an incident increases for low valued vessels, which may reflect the lower maintenance of these vessels. In columns (4) – (6), the distress-related independent variable is split between bankruptcy and distress episodes. We find that during bankruptcy episodes the probability of an incident increases by 0.17% (in column (4)). This reflects an almost 30% increase in the unconditional probability of a marine pollution incident. The increase in the probability of pollution incidents from other distress (non-bankruptcy)

[29] *Exxon Valdez*, an oil tanker owned by Exxon Shipping Company spilled 38,800 tonnes of crude oil in Gulf of Alaska in 1989. It is considered the worst oil spill worldwide in terms of damage to the environment (refer to Exxon Valdez Oil Spill Trustee Council Report, 2010).

episodes are less significant. In Table A.6 we repeat our tests with the sample of firms that downsized, and find that the probability of an incident increases during extreme distress episodes (in which operators sell more than 90% of their initial fleet). Our findings are consistent with the hypothesis that financially distressed operators under-maintain their fleets, which imposes significant costs on the environment by increasing the risks of an oil spill.

These incidents raise the important question of who is responsible for ensuring the seaworthiness of vessels on the high seas, and the certification of crew members operating these vessels? The United Nations Convention on the Law of the Sea (UNCLOS) provides for the primary responsibility for ships to rest with the flag state, particularly when the vessel is operating on the high seas. Every vessel needs to be registered with the flag of a particular state under whose regulatory control it consequently falls. The flag state is, for instance, responsible for the inspection of the vessel and its seaworthiness, ensuring minimum safety standards and pollution prevention, and certifying the crew (Heidegger et al. (2015)). Perepelkin et al. (2010) document that the first line of defense against substandard shipping is the flag state, as rights and obligations under international law are mainly imposed on the vessels via the flag states. Following a series of major oil tanker accidents in the 1970s, port state controls (PSC) have evolved as a second line of defense, allowing port states to conduct safety inspections on foreign flagged vessels entering their ports.[30]

Since some jurisdictions are more tolerant of lower maintenance standards, we analyze whether the seaworthiness of vessels is affected by their flags of registration. Using our data on vessel-level pollution incidents, we link these vessels to their flags of registration at the time of the incident. We find that weak rule of law, and high corruption in the flag state predict higher numbers of pollution incidents for vessels registered with the flag state. Therefore, ships registered in jurisdictions that possess weak administrative power to effectively enforce international regulations or to control the shipping companies are more likely to be responsible for oil spills. Further, we document that a flag state that was *targeted* by port state authorities for its lower safety standards,[31] has a higher probability of causing a pollution incident.

However, to circumvent these regulations *flag hopping* has become a common practice in the maritime industry, which allows ship owners to easily and quickly change the flag of their ships, to reduce costs (see Vuillemey (2020)). This has led to competition between jurisdictions, with flag states competing for ship registrations by offering policies that lower costs and reduce the regulatory burden for owners. We examine whether this practice of jurisdiction shopping by ship owners coupled with the competition

[30] If the vessel while being inspected at a port, does not meet the international safety standards it can be detained by the port state authority.

[31] Flag states are added to the *targeted list* of the port state authorities if inspections reveal that ships registered under these flags have very high detention rates.

between flag states, has resulted in a race to the bottom in the maritime industry, increasing the likelihood of marine pollution incidents resulting from substandard shipping practices.[32]

In Table 9, we analyze whether the seaworthiness of vessels is related to their flags of registration. $NumberofIncidents_{i,t}$ aggregates the total number of serious casualty indices for flag i in year t. We use three separate indices to measure the variability in institutional quality across flag states. Following La Porta et al. (1999), we use the lagged Law and Order, and Corruption indices for measuring the quality of governance in the flag state. We also classify the flag as *targeted*, if it had been targeted by a port state authority in the previous year. $ln(FleetRegistered)_{i,t}$ is the logarithm of the total tonnage (DWT) of fleet registered with a flag. Year fixed effects are included to control for time trends in vessel casualty incidents.

Table 9 tests the environmental implications of some jurisdictions being more tolerant of lower maintenance standards of vessels registered under them. In all specifications the number of incidents significantly increases with an increase in the tonnage of ships being registered under the flag state. In column (1), we find that a higher Law and Order Index predicts a lower number of spills by the flag. In column (2), we find that high corruption (or low corruption index) at the flag state is linked to a higher number of serious casualties by vessels registered under the flag. In column (3) we report that even after controlling for the total tonnage of vessels registered with a flag, vessels registered under targeted flag states are at a greater risk of causing an oil spill. Therefore, ships registered in jurisdictions that possess weak administrative power to effectively enforce international regulations, or to control the shipping companies are more likely to be responsible for oil spills.

The table also presents preliminary research attempting to establish the environmental impact of jurisdiction shopping by firms. We have used oil spills in the shipping industry as a laboratory to address this question, as oil spills have a significant impact on the environment, and firms operating in this industry are free to self select into a jurisdiction that will monitor their safety standards. As described in the institutional details section, there are several players involved in governance and enforcement of safety standards for ships. The role of port states, classification societies, and creditors in ensuring the safety of the vessels is not to be taken lightly. Notwithstanding, the flag states where the vessels are

[32] A key theme across the regulations is that those responsible for discharging hazardous materials are liable for cleanup costs and, in some cases, for any other damages caused by the spill. The *polluter pays* principle is the commonly accepted practice in marine pollution, requiring that those who produce pollution should bear the costs of managing it to prevent damage to human health or the environment. Further, fines may also be imposed on firms that act negligently. In a survey report of maritime laws and policies across 18 major jurisdictions, Rutkowski (2014) reports that the pollution claims and damages are a part of the maritime lien, and these claims have priority over ship mortgage holders and other secured/unsecured creditors. The 1992 Civil Liability Convention (CLC) governs the liabilities of ship owners for oil pollution damages. Under the CLC, the liability of the ship owner increases with the size (gross tonnage) of the ship, with the maximum liability being capped at SDR 90 million.

registered act as the first line of defense against substandard shipping practices. Ships that are certified as *seaworthy* by the flag states, might sail undetected on the high seas, avoiding inspections by strict port state authorities.

4.3 Costs of Abandoned Vessels

In 1999 the IMO published a report on the abandonment of seafarers. The Report recorded that during a four year window, between July 1995 and June 1999, there were 212 cases, i.e. vessels of crew abandonment involving 3,759 crew members. Of the 212 about one third were flying the flag of Panama, regarded at the time as a low quality flag.

Most cases of abandonment occur where a ship has been placed under legal arrest following bankruptcy or insolvency, non payment of bills for example to suppliers or crew. In principle, providing there is some value in the sale of the vessel, unpaid wages of the master, officers and members of the crew are secured by way of a maritime lien, described earlier in the paper. The maritime lien is senior to the mortgage and other charges on the vessel but is of equal seniority i.e. it is pari passu with certain other charges such as port dues.

Using the case study of Adriatic Tankers we illustrate how financial distress and insolvency of an operator may impose costs on labour and other parties. Adriatic Tankers was a Greek shipping company that owned around 100 vessels in the early 1990s. 85% of the fleet was flagged with Panama and only one vessel was registered in Greece. The flag is the primary regulator of the vessel flying its flag. Panama is often chosen as the preferred flag because it exercises no constraint on the nationality of the crew and, it exercises little effective regulation over crew wages and conditions.[33]

In 1993 the ITF (international Transport Workers Federation) identified several forms of complaints directed at Adriatic including non payment of crew wages, and extremely poor working conditions. An IMO Report (1999) reported that for many years prior to 1993 when a strike by crew was commenced, it was common practice for Adriatic to take the crew off the ships when a vessel was arrested, place them in hotels around the world, and not pay their wages. According to the IMO report, most of the time these payments were never paid.

The protracted strike against Adriatic led to the bankruptcy of the company. 85% of the ships were arrested, and some 55 were abandoned by the operator with crews left in foreign ports for months without

[33] In contrast, Greek labor laws require the master, officers, and crew must be Greek for large ships (unless Greeks are not available)

wages or any other means of support. In Appendix C, we reproduce from the IMO report the outcome of 3 arrests in terms of payments to the crew. In all 3 cases the crew were eventually paid by the bank that held the mortgage on the vessels. Their payment is attributable to the fact that the vessel had resale value to the mortgage holder and the wages were paid out of the proceeds of the sale of vessels. However, the crew waited for between 1-2 years for payment and repatriation. There are also several cases where the vessel was abandoned and had no resale value and the crew were not paid.

In Table 10, we extend the analysis on Adriatic Tankers to our entire sample of distressed firms, and test whether episodes of financial distress are correlated with a higher likelihood of vessel and crew abandonment incidents. The data on vessel and crew abandonment incidents is collected from ILO. Using a panel of vessels at the year-quarter level, we set the dependent variable, *Abandonment Incident* equal to one if the vessel or its crew members were involved in an abandonment incident. Regressions include year-quarter and ship type and size category fixed effects. In columns (1) – (3), we report that the probability of an abandonment incident significantly increases by 0.13% during bankruptcy or distress events. The unconditional probability of vessel abandonment during our sample period is 0.03% and a distress event roughly quadruples this probability. In column (3), we include controls for the estimated hedonic price and salvage value of the vessel. As expected, low valued and highly depreciated vessels are more likely to be abandoned by their operators. In columns (4) – (6), we find that during bankruptcy episodes, the probability of an abandonment incident increases by 0.36%. This indicates that a bankruptcy roughly increases the probability of an abandonment incident by twelve fold. In Table A.7 we repeat our tests using the sample of downsizing episodes, and find that the probability of an abandonment incident increases when the owner is liquidating its fleet (and sells more than 90% of its vessels). Although the percentage of abandonment incidents may seem small, around 1,050 vessels were abandoned over a 25 year period; and some of these abandoned vessels caused large environmental damage. For example, the oil tanker FSO Safer was abandoned off Yemen in 2015 with 1.14 million barrels of oil. The UN was forced to purchase a vessel in 2023 to avoid a catastrophic oil spill. Our findings suggest that financially distressed operators are more likely to abandon their low valued vessels, thereby, imposing significant costs on the crew, port authorities, and other stakeholders.

Our results show that the case of Adriatic Tankers is not an exception, and incidents of seafarer and vessel abandonment by financially distressed operators are not infrequent. In case the abandoned vessels has some residual value for its creditors, private parties are incentivized to arrest the vessel, and use its sales proceeds to pay the crew and port dues. While, in the absence of sufficient residual value for the creditors, the vessel and its crew are stranded for several years in the port, until eventually the vessel

is towed at the port's expense to a breaker's yard to be sold for scrap. Aside, from the crew not being repatriated, an abandoned vessel can have devastating consequences on local communities. An example, is the recent explosion caused by the *Rhosus* vessel abandoned in the port of Beirut. The explosion killed more than 200 people and caused enormous harm to the city.[34]

5 Estimating Fire Sale Discount

In the previous section, we have documented evidence of financially distressed firms operating a fleet of under-maintained vessels. Such vessels have a shorter life expectancy, and face a greater risk of environmental accidents. These results suggest that the standard technique of measuring the fire sale discount, pioneered by Pulvino (1998) may be biased as it takes into account assets observed characteristics that affect the price of the vessel or the aircraft, like age or model, but does not take into account unobserved characteristics such as the quality of maintenance. In this section, we proxy for this unobserved maintenance using life expectancy, and price this undermaintenance effect in the standard hedonic price regression. As a result, the Pulvino measured discount is reduced by about one half.

5.1 Hedonic Regression

Fire-sale discounts are measured against a price benchmark: the counterfactual sales price of a given arrested ship, i.e., had the sale not been forced. The price benchmark (referred to as the hedonic price) is based on the observed characteristics of the vessels. The model specification is:

$$log(Price)_{it} = \alpha_q + \alpha_{type} + \alpha_{cb} + \alpha_b + \alpha_s + \beta' X_{it} + \gamma Arrest_{it} + \delta Downsizing_{it} + \epsilon_{it} \tag{2}$$

where $Price_{it}$ denotes the price of vessel i transacted in period t. We include fixed effects for the year-quarter of sale (α_q), the country of built of the vessel (α_{cb}), the buyer country (α_b) and the country of the seller (α_s). Vessel type and size category (Bulk Carrier-Capesize, Bulk Carrier-Handymax, Tanker-Panamax, Tanker-Suezmax, etc.) fixed effects (α_{type}) are also included. X_{it} denotes a vector of technical characteristics (such as DWT, vessel length, breadth, freeboard, hull type, and draft), transaction characteristics (such as whether the transaction was part of a block sale of several vessels and the age (Age_{it}) of the vessel at sale). Definitions of vessel-related variables are provided in Appendix A.

[34]The cargo on the ship Rhosus that exploded was moved from the abandoned vessel to a warehouse on the port

The fire sale discount is measured by the coefficient on the dummy variable indicating whether the ship was involved in a forced sale. We use two measures of forced sale, arrests, and bankruptcy events. The results are reported in Table 11 Panel A columns (1) – (3). An adjusted R^2 of 88% indicates that the predicted ship price from the hedonic model serves as a good benchmark. We examine the fire sale discount on arrested vessels and find that, on average, they are sold at a discount of 22% relative to non-arrested vessel sales. These estimates are quite similar to those reported in Pulvino (1999) on the sale of used commercial aircraft by airlines operating under bankruptcy protection. In column (2), we find a much lower discount of 3% on vessel sales made by bankrupt or distressed firms identified using news events. In column (3), we find that this discount is primarily driven by sales made by bankrupt firms, that sell their vessels at an 11% discount.

5.2 Quality-adjusted Fire Sale Discount

Following the methodology of Franks et al. (2024), we proxy for an unobserved quality component of the vessel by including the imputed life expectancy of the vessel in the hedonic regression. We impute life expectancy using equation 1 (see Figure 4). We can only make this correction because vessels (unlike houses) have a finite life and are eventually broken up.[35] In columns (3) – (6) of Table 11 Panel A, we add the derived *Life expectancy* ($L_i(Age)$) variable to the hedonic price regression. It shows that an extra year of life expectancy commands a 18% higher price and is significant at the 1% level, confirming the importance of imposing a quality correction.

In columns (3) – (6), we control for the estimated life expectancy and report the quality-adjusted fire sale discounts. We find that the raw fire sale discount on arrested vessels reduces from 22.6% to 12.3% after adjusting for the lower quality of the arrested vessel. This suggests that roughly half of the raw fire sale discount is driven by differences in the quality of ships, which we interpret as maintenance-related. After adjusting for the lower quality of the vessels sold during bankruptcy and distress events, we find no significant fire sale discount on these sales.

The higher fire sale discount on arrested ship results from a relatively illiquid market for these ships. This is because the forced cash auction might be accelerating the sale, which could reduce the number of bidders and the auction price compared with distressed sales, where more patience can be exercised during the sale process. In summary, we find that arrested ships generate a raw fire sale discount of roughly 23%, which is similar to what has been documented in prior studies on aircraft and foreclosed homes. Interestingly, however, we find that as much as half of this discount is due to the unobserved low

[35] Such a correction would be difficult in housing because houses do not usually die.

quality of arrested ships. The similarity of the fire sales discount across industries suggests that the costs of delay (and by inference, the benefits of automatic stay) are small in the shipping industry. In the next sub section, we explore some other determinants of the fire sale discount.

5.3 Institutional Quality of Ports and Business Cycles

In Table 11 Panel B, we conduct additional cross-sectional tests to investigate the heterogeneity in the fire-sale discount. This test examines how the fire-sale discount varies with institutional differences such as the quality of the ports. We expect that the low quality of a country's jurisdiction will add some additional costs that the buyer of the vessel might face following the sale, such as higher port charges, payments to suppliers and crew, and any side payments (bribes) to officials. An arrested ship can be sold within six weeks of the arrest in an efficient port while the period of immobilization may take years in an inefficient port (average days of arrest are 213 for corrupt ports and 142 for less corrupt ports). For this purpose, we use a country corruption index described below. We would expect the fire sale discount of the arrested ship to be positively correlated with the corruption index. For defining a corruption index, we use the one devised by La Porta et al. (1999).

We split the data regarding arrested ships into two sub samples, depending on whether they were arrested in high or low corruption countries. A median cutoff is used to separate the two samples, and provides the following two groups of countries.[36] As can be seen in Table 11 Panel B, ships arrested in countries with less corruption, incur a smaller quality-adjusted fire sale discount: 10.9% in low corruption ports compared with 20.4% in high corruption ports; this difference is statistically significant (at the 10% level) and economically significant (columns (3) and (4)).

Another interesting observation is how the fire-sale discount varies with business cycles in the shipping industry. As argued by Shleifer and Vishny (1992), due to a decrease in the number of potential buyers when the industry environment is unfavorable, the fire-sale discount can be higher than that in the boom years. To test this hypothesis, we split the data of all ship sales into three sub-samples depending on the Baltic Dry Index (high index, regular times and low index). The results are presented in Panel C of Table 11. We report that in the relative boom years, the raw fire-sale discount for arrested ships is 15% and after adjusting for quality the discount largely disappears and is insignificant ($Arrest \times High$). In

[36]The high corruption countries include: the Bahamas, Chile, Cyprus, Greece, India, Italy, Malaysia, Malta, Mexico, Panama, Sri Lanka, Trinidad and Tobago, Turkey and Venezuela. The low corruption countries include: Australia, Belgium, Canada, Denmark, France, Germany, Gibraltar, Holland, Hong Kong, Israel, Japan, Montenegro, the Netherlands, the Antilles, South Africa, Singapore, Tahiti, the UK and the US.

contrast, during downturns the raw fire sale discount is significantly higher, reaching 25%. Even after controlling for quality of the ship the discount stays high at 14%.

5.4 Benchmarking the Fire Sale Discount

In this section we discuss whether the absence of state mandated bankruptcy procedures results in larger fire sale discounts on disposition of assets by a firm. We benchmark our results in the shipping industry against fire sale discounts reported in assets operating under different bankruptcy regimes. In Table A.8 Panel A, we show that the 23% raw fire discount on the sale of arrested ships, is comparable to the 27% fire sale discount documented in foreclosed home sales (Campbell et al. (2011)), and the 20-30% fire sale discount documented on the sale of commercial aircraft by airlines operating under U.S. bankruptcy protection (Pulvino (1999)).

The under-maintenance effect on ships raises the question as to whether the same effect could be present in other empirical studies documenting large fire sale discounts. For example, in an analysis of Eastern Airlines' bankruptcy Weiss and Wruck (1998) have noted that "the discount on Eastern's airplanes could be due to many factors including its distressed situation and/or poor maintenance." It is fairly common for airlines to swap engines and other parts of an airplane, and subsequently sell aircraft that have been fitted with second hand parts. Franks et al. (2024) document an under-maintenance effect in aircraft sold by airlines operating under bankruptcy protection. Identical patterns of longevity can be identified for aircraft owned by airlines operating under bankruptcy protection, and such aircraft have a significantly lower remaining economic life expectancy versus the aircraft owned by non-bankrupt airlines. Moreover, these aircraft also have lower flying hours compared to other similar aircraft flown by the new operator.

The quality correction due to under-maintenance is also well documented in the real estate literature. Even though the raw fire sale discount on sale of foreclosed houses is 27%, Campbell et al. (2011) express concerns over the vandalism and poor maintenance of foreclosed houses. They also document around 8-9% poor maintenance discount on houses sold by older sellers. In a separate study of forced house sales in Denmark, resulting from sudden death of house owners Andersen and Nielsen (2017) report an average fire sale discount of 8.9%. In their setup, sudden deaths provide a close to random draw of house owners, which ensures that individual and house characteristics are exogenous. Therefore, we can conclude that the under-maintenance effect is not specific to the shipping industry, rather it has been recorded in other real assets as well.

Pulvino (1999) finds evidence indicating that neither protection under Chapter 11 of the bankruptcy code nor court-supervised liquidation under Chapter 7 of the code are effective at eliminating fire sale discounts. Our paper complements this finding by documenting similar fire sale discounts in freedom of contracting regimes. Empirically the findings are relevant to the issue whether mandatory bankruptcy procedures help mitigate fire sale discounts and improve resource allocation. We observe that after controlling for the lower quality of arrested ships, the quality-adjusted fire sale discount is similar in magnitude to the fire sale discount reported in financial assets (see Table A.8 Panel B).

6 Conclusion

Shipping provides an important laboratory for testing Hayek's natural experiment in "spontaneous order." Because ships move from one jurisdiction to another, and may "go bust" on the high seas outside any country's territorial waters and jurisdiction, the creditor (with or without the debtor's assistance) can arrest and auction a ship at a maritime port. Ideally, they will wish to choose the port of arrest to minimize costs. The proceeds from the auction will then be used to repay creditors, according to the contract.

There are two important qualifications. First, creditors of shipping companies rely on maritime courts to arrest ships, in the event of default, and auction them in a timely and cost efficient manner. Thus, enforcement plays an important role in the debt contract. Second, the courts of some countries, for example the US, may sometimes try to thwart the arrest or auction of ships in foreign ports, where the debtor claims some connection with the US and seeks protection under Chapter 7 or Chapter 11 of the 1978 Bankruptcy Code. However, the exercise of US "imperium" in shipping bankruptcies can and has been mitigated by contractual innovations, as illustrated in the case of Eastwind.

This paper has addressed the question of how costly are bankruptcy procedures? These procedures have largely evolved out of private commercial contracts, with the courts largely playing the role of contractual enforcer. There are three measures of costs. First, how frequently do creditors of distressed and defaulting shipping companies resort to the bankruptcy procedure of arrest and auction in maritime ports? We find a relatively low proportion of arrests, with the debtor frequently resorting to the private sale of ships. Only when the debtor seems to have run out of cash, or when the ships are of such a low value that the debtor or owner's equity is far out of the money, do we find arrests and forced sales taking place.

Second, using a hand-collected sample of ships arrested and auctioned in UK ports, we find that the direct costs of arrest and sale are around 8% of the proceeds of auction. The arrests are triggered by the mortgage holder, crews (who are owed wages) and unsecured creditors including suppliers to the ships.

The third cost is the "fire sale discount." Following Pulvino (1998, 1999) we might expect a significant discount from the arrest and forced sale of ships due to the illiquidity of the market for second-hand ships. We find a discount of 23% on average compared with ships of similar age and use. This is very similar to the discount estimated by Pulvino. However, we also find that ships which are arrested and sold are of lower quality than comparable ships sold outside distress. In forced sales, ships tend to be under-maintained and are therefore of lower quality. In effect this lower quality is equivalent to an age premium of 1.7 years compared with sales by non-distressed companies. Adjusting for this factor reduces the discount from 23% to 12%. This average discount is for ships sold in both inefficient and efficient ports. When we re-estimate the index for arrests and sales at low corruption ports we find the discount is 11%, compared with 20% for high corruption ports.

A few comments are worth highlighting. First, it should be noted that we are not running a horse race between freedom of contracting and Chapter 11. In fact, freedom of contracting could potentially include off the shelf procedures like Chapter 11. Second, we are not making any efficiency claims here.[37] Chapter 11 was introduced based on the rationale that absent such a reorganization mechanism, we would witness severe coordination problems and large fire-sale discounts. There was also a concern that innovation in contracts would be slow under a freedom of contracting regime because of free rider problems. We find that such fears are largely misplaced at least for the shipping industry. That being said, we do believe that state sponsored bankruptcy procedures have a role to play. In particular, such procedures have the potential for solving free rider problems associated with contractual innovation. But we question whether the procedures should be made mandatory or optional. We recognize that in the case of large firm failures like Hanjin, mandatory Chapter 11 might be desirable to internalise the externalities.

Even ignoring the externalities associated with large firm failures, the question remains, whether our results extend to other industries. There are several important features of the shipping industry that may contribute to an efficient resolution of distress without the aid of mandatory bankruptcy procedures: the fact that ships consist of discrete assets which allow them to be separated from each other for the purposes of limited liability and collateral, the fact that assets can be marketed to potential buyers around the world thereby increasing the liquidity of the market for second-hand ships, and that the intangible value of a ship

[37] It is practically impossible for an empirical paper to make normative claims. We understand that ex-post efficiency may be ex-ante inefficient. Moreover, the theory of second best a la Lipsey and Lancaster (1958) cautions us against welfare claims.

may be relatively low compared with other assets. There may be other industries which exhibit similar characteristics to shipping, such as real estate, airlines, oil and gas, and mining companies. Congress has already recognised the value of limiting the intrusion of bankruptcy law into some of these industries by exempting them from an automatic stay, for example, aircraft under the Capetown Convention (Section 1110, 1994 Bankruptcy Act), and private-label mortgage collateral (2005, BAPCPA); see Lewis (2023). In addition, Section 363(b) of the US Bankruptcy Code allows a company to sell its assets outside the ordinary course of its business during Chapter 11 bankruptcy proceedings.

However, there are many industries where asset complementarities make the segregation of assets more difficult. In this respect, we would be cautious in generalizing our results to other industries. Nevertheless, even here we might speculate that contractual innovations and well-developed capital markets might mitigate many of the costs claimed as justifying a mandatory and highly active bankruptcy code.

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Figure 1: Time series of vessel scrapping in low environmental standard countries

In this figure, we show the total proportion of vessels being broken down in countries with low environmental standards, like Bangladesh, India, Pakistan and China.

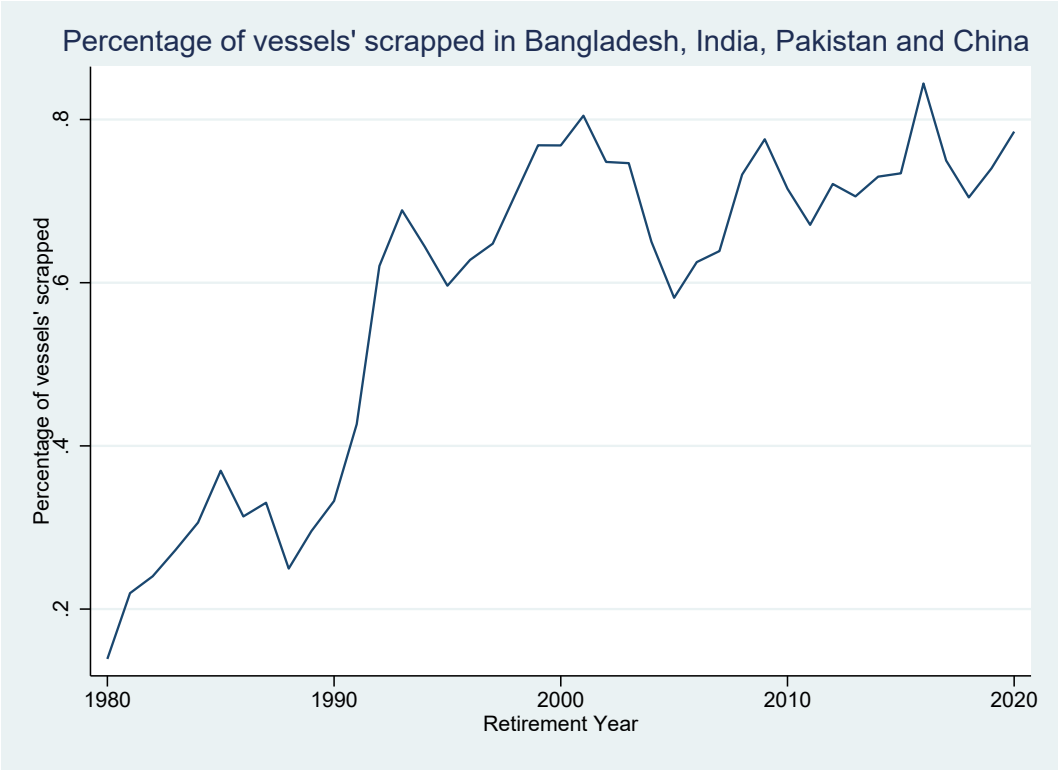


Figure 2: Eastwind's Cycle of Distress

In this figure, we track Eastwind's cycle of distress on a daily frequency. The top (blue) line tracks the company's total capacity (in millions of DWTs) while the bottom (red) line tracks capacity that is immobilized due to arrest.

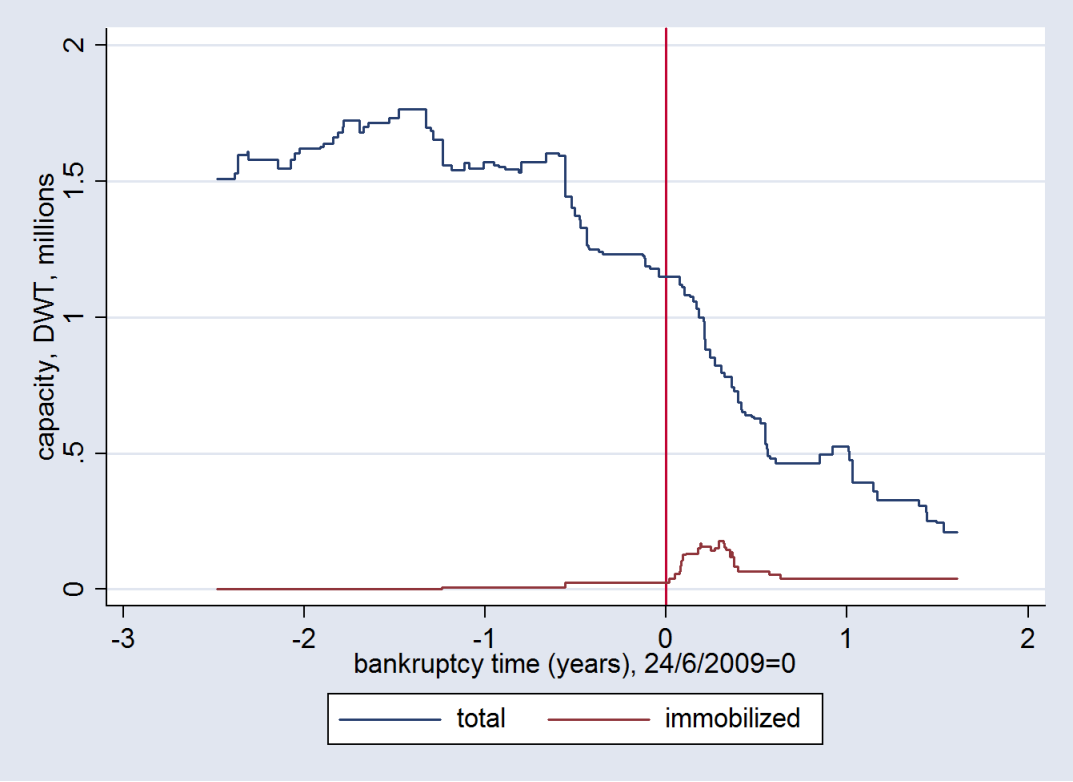


Figure 3: Capacity under Arrest as a Percentage of Total Capacity

In this figure, we track the amount of immobilized capacity (that is, capacity under arrest) as a percentage of total industry capacity, measured in DWT. The percentage of arrested capacity (blue line) is plotted on the left axis. The figure also plots the amount of capacity in distress (that is, capacity under bankruptcy/distress) as a percentage of total industry capacity, measured in DWT. The percentage of distressed capacity (red line) is plotted on the right axis. The shaded grey area plots NBER recession periods.

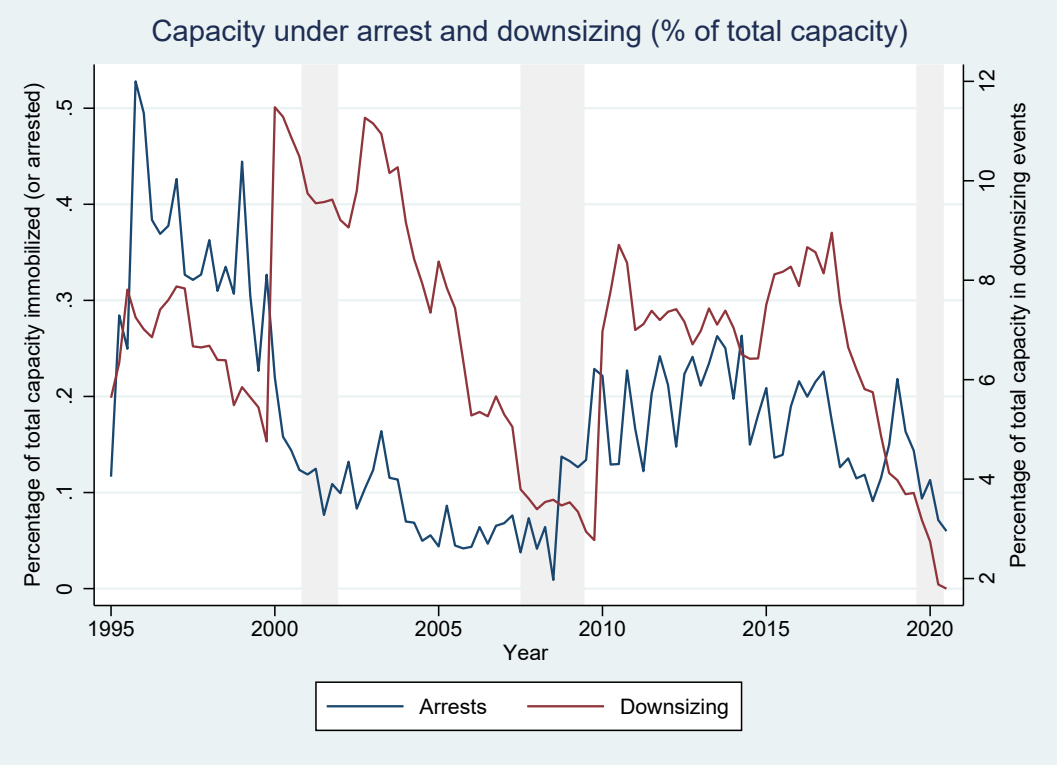
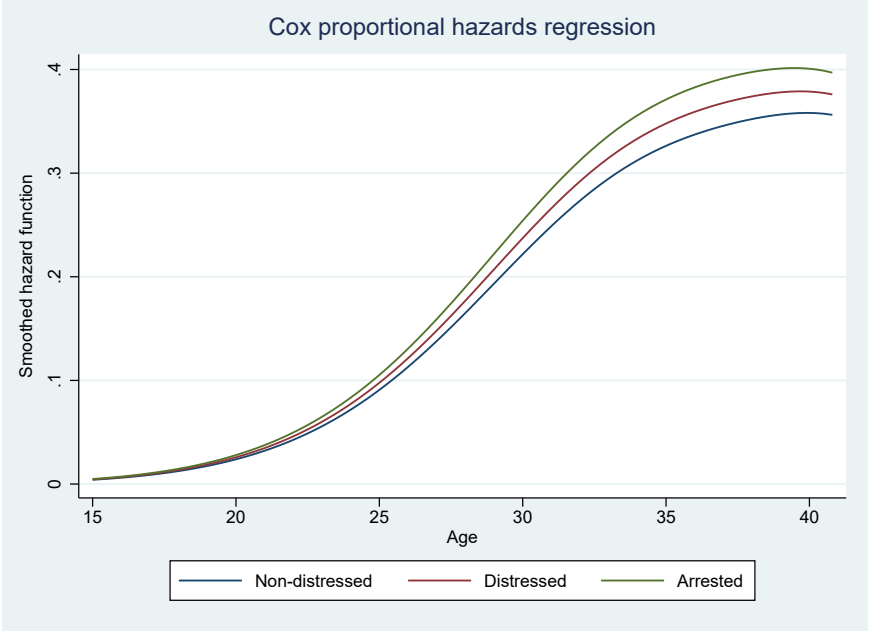


Figure 4: Hazard Rate and Life Expectancy

In the top panel of this figure, we plot the probability of a breakup, i.e. hazard rate, for the arrested (green/top curve), distressed (red/middle curve) and non-distressed (blue/bottom curve) vessels at any given age. In the bottom panel, we plot the life expectancy of arrested (green/bottom curve), distressed (red/middle curve) and non-distressed vessels (blue/top curve). Vessels are classified as distressed if they were operated by a bankrupt or distressed operator in the 5-year window before the operator files for bankruptcy or a distress-related news event is published.



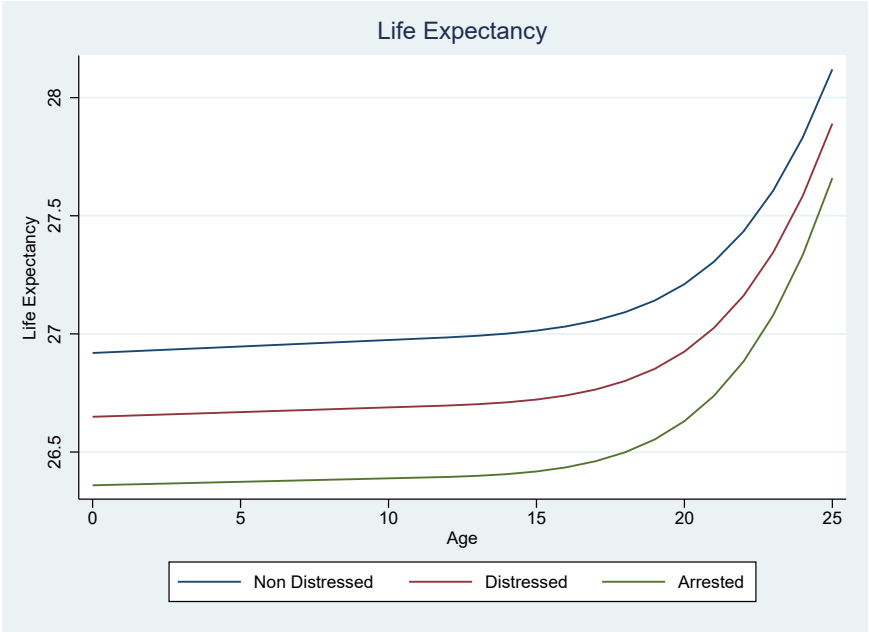


Table 1: Vessel registration and beneficial ownership in some specialized flag states

This table reports the vessel registration and beneficial ownership details for the world fleet in 2020. Fleet statistics are reported for top flag states, and countries with highest share of beneficial ownership. *% World Fleet Registered* reports the number of vessels registered (or *flagged*) with a country as a percentage of the world's total fleet. *% DWT Registered* reports the proportion of world fleet (measured in units of deadweight tons) registered with a country. *% World Fleet Owned* reports the proportion of world fleet owned by firms belonging to a given country. *% DWT Owned* reports the proportion of world fleet (measured in units of deadweight tons) with beneficial ownership in the country.

	(1)	(2)	(3)	(4)
	% World Fleet Registered	% DWT Registered	% World Fleet Owned	% DWT Owned
Flags Specialized for Registration				
Panama	12.8%	15.9%	0.2%	0.2%
Liberia	8.8%	14.1%	0.0%	0.0%
Marshall Islands	8.7%	13.5%	0.2%	0.1%
Hong Kong	6.2%	11.0%	3.0%	3.5%
Singapore	5.6%	7.1%	3.8%	3.9%
Malta	4.8%	6.0%	0.1%	0.1%
Top 6 flags states	46.9%	67.6%	7.3%	7.8%
Others	53.1%	32.4%	93%	92%
High Beneficial Ownership Countries				
China	5.7%	3.8%	11.7%	14.3%
Greece	1.4%	3.6%	10.0%	17.9%
Japan	4.4%	2.0%	13.8%	14.5%
South Korea	1.9%	0.8%	3.7%	4.4%
Germany	0.5%	0.5%	5.7%	3.9%
USA	0.5%	0.5%	2.4%	3.4%
Top 6 ownership states	14.4%	11.2%	47.3%	58.4%
Others	85.6%	88.8%	52.7%	41.6%

Table 2: Arrest and traffic activity in some specialized and high volume ports

This table reports the arrest and traffic activity in some arrest specialized ports and high volume ports. Six countries stand out for the effectiveness of their arrest procedure: Gibraltar, Hong Kong, Singapore, South Africa, the Netherlands and the UK. This table considers all the 3,470 vessel arrest cases from 1995-2020. *N (Arrests)* reports the number of arrests by each port. *% Arrests* reports arrests as a percentage of total arrests. *% Traffic* reports the traffic on the port as a percentage of global shipping traffic. *Duration of Arrest (days)* measures the average length of time taken by the port to resolve an arrest. *Age (years)* reports the average age of vessels that were arrested at a port. *Size (DWT)* reports the average size (measured in deadweight tons) of vessels that were arrested at a port. *Hedonic Value ($ million)* reports the average estimated price of vessels that were arrested in a port.

	(1) N (Arrests)	(2) % Arrests	(3) %Traffic	(4) Duration of Arrest(days)	(5) Age (years)	(6) Size (DWT)	(7) Hedonic Value ($ million)
Arrest Specialized Ports							
Singapore	427	12.3%	5%	84	13.00	55,336	10.22
Netherlands	267	7.7%	2%	119	15.40	34,610	11.38
UK	181	5.2%	1%	63	17.02	24,251	6.30
Hong Kong	104	3.0%	2%	102	14.68	47,638	12.62
Gibraltar	98	2.8%	0%	88	15.84	48,180	8.24
South Africa	90	2.6%	1%	103	15.94	45,384	9.74
Top 6 arrest specialized ports	1,167	33.6%	11%	92	18.03	43,718	9.89
Others	2,303	66.4%	89%	213	18.03	31,779	6.90
High Volume Ports							
China	30	0.9%	28%	173	16.10	50,229	7.10
USA	171	4.9%	7%	75	12.48	36,883	13.65
South Korea	39	1.1%	4%	180	14.56	33,670	10.68
Malaysia	60	1.7%	3%	83	20.00	31,214	5.48
Japan	6	0.2%	3%	46	10.83	19,786	15.99
Germany	28	0.8%	2%	226	17.07	35,014	10.65
Top 6 high volume ports	334	9.6%	47%	110	14.75	36,224	11.04
Others	3,136	90.4%	53%	174	17.16	35,751	7.61
All Arrests	3,470			170	16.93	35,798	7.89

Table 3: Organization of ownership structure in the shipping industry

This table describes the holding company and subsidiary level ownership structure of shipping firms. We classify the shipping firms based on the size of their fleet. The unit of observation is at the holding company level. Columns (1)-(3) report the fleet and subsidiary information for *All Firms* in our sample. In columns (4)-(6), we restrict our sample to holding companies (or firms) that own at least 2 vessels (*Firms: Fleet>= 2 vessels*). In columns (7)-(9), (10)-(12), and (13)-(15), we restrict our sample to holding companies that own at least 5, 10, and 50 vessels, respectively. *Number of vessels* reports statistics (median, mean, and standard deviation), on the number of vessels owned by the holding company. *Number of silos* refers to the number of separate silos (registered owners/subsidiaries), operating under the holding company. *Vessels per silo* reports statistics on the number of vessels owned by each subsidiary of the holding company. *Fleet Age* is calculated as the average age (in years) of all vessels owned by the holding company. *Fleet DWT* measures the average size (in deadweight tons) of all vessels owned by the holding company. *Number of Firms* documents the total number of holding companies in each fleet size category.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
	All Firms			**Firms: Fleet>= 2 vessels**			**Firms: Fleet>= 5 vessels**			**Firms: Fleet>= 10 vessels**			**Firms: Fleet>= 50 vessels**		
	Median	Mean	SD	Median	Mean	SD	Median	Mean	SD	Median	Mean	SD	Median	Mean	SD
Number of Vessels	3	6.98	15.39	5	9.99	18.15	9	16.83	23.29	17	27.14	29.52	69	87.62	52.98
Number of Silos*	1	4.38	10.71	2	6.08	12.79	5	10.05	16.86	10	16.18	22.08	51	52.62	44.00
Vessels per Silo	1	2.18	3.07	1.6	2.78	3.62	1.67	3.71	4.78	1.67	4.54	6.25	1.2	5.85	10.12
Fleet Age	13.67	16.63	9.91	12.6	14.86	8.40	11.63	13.34	6.99	10.82	12.07	6.02	10.21	10.79	4.16
Fleet DWT	8,592	27,874	41,142	13,920	33,185	43,192	28,153	42,444	46,727	40,343	51,138	48,343	72,759	75,919	55,316
Number of Firms		5,012			3,333			1,717			858			98	

Total number of vessels	34,988
Total number of silos	21,790
Silos with 1 vessel	18,699

*Separate registered owners/subsidiaries for ships

Table 4: Crew and vessel abandonment incidents and arrests

This table reports incidents of crew and vessel abandonments by the owner. Panel A, reports our full sample of abandonment incidents. In Panel B, we split abandonment incidents by whether: the vessel was arrested (*Arrested Vessels*), or if it was not arrested (*without vessel arrest*). *Abandonment incidents* reports the total number of abandonment incidents in our sample period, and *Seafarers' abandoned* reports the total number of crew members that were abandoned on these vessels. *Vessel age (years)* reports the age of the vessel at which it was abandoned. *Vessel size (DWT)* reports the size of the abandoned vessel in deadweight tons. *Hedonic Value ($ million)* estimates the market price of the abandoned vessel, in the year of its abandonment. The variable *Salvage Value* measures the depreciation of a vessel, and is estimated by the proportion of vessel's current market value as a fraction of its replacement value (i.e. the current market price of an identical new vessel). The last column reports the p-values for mean comparison tests between the abandoned vessels that were arrested, and those that were not arrested, without the assumption of equal variance

Panel A	**All Incidents**						
Abandonment incidents		1,047					
Seafarers' abandoned		10,197					
Vessel characteristics	Median	Mean	SD				
Vessel Age (years)	21.50	20.74	10.12				
Vessel Size (DWT)	7,576	21,133	38,063				
Estimated hedonic value ($ million)	2.58	5.04	8.05				
Salvage Value	0.18	0.28	0.25				
Panel B	**Incidents classified by vessel arrest**						
	Arrested Vessels			Without vessel arrest			Difference
Abandonment incidents		518			529		
Seafarers' abandoned		711			9,486		
Vessel characteristics	Median	Mean	SD	Median	Mean	SD	p-value
Vessel Age (years)	19.00	18.12	9.85	25.50	24.49	9.31	0.0000
Vessel Size (DWT)	11,998	27,873	46,237	5,214	11,437	17,338	0.0000
Estimated hedonic value ($ million)	3.95	6.87	9.72	1.39	2.41	3.25	0.0000
Salvage Value	0.23	0.33	0.26	0.12	0.20	0.21	0.0000

Table 5: Description of Oil Spills

The table describes the statistics for casualty incidents causing marine pollution and oil spills. Panel A reports our sample of serious casualty incidents that resulted in marine pollution and oil spills from 1995-2020, listing their causes and vessel characteristics. *Vessel age (years)* reports the age of the vessel at the time of the incident. *Vessel size (DWT)* reports the size of the vessel in deadweight tons. *Hedonic Value ($ million)* estimates the market price of the vessel involved in the accident. The variable *Salvage Value* measures the depreciation of a vessel, and is estimated by the proportion of vessel's current market value as a fraction of its replacement value (i.e. the current market price of an identical new vessel). Panel B, reports the summary statistics for flag-level casualty incidents, fleet size, and governance variables. *Number of Incidents* refers to the total annual number of casualty incidents by vessels registered in a particular flag. *ln(Total Fleet Registered in DWT)* refers to the log of total annual tonnage (in DWT) of vessels registered with a particular flag. The *Law and Order Index* from ICRG measures the quality of law enforcement in the flag state, and a high index implies better rule of law. The *Corruption Index* from ICRG measures the level of corruption in the flag state, and a high index implies low corruption in the government. *Targeted Flag* takes value 1 if in a given year the flag state was targeted by the port state control authorities (i.e. by Paris MoU, Tokyo MoU, or USCG). Panel C splits the sample of flag-level casualty, fleet, and governance indices between targeted flags (Targeted Flag = 1) and non-targeted flags (Targeted Flag = 0).

Panel A	**Casualty Incidents resulting in Oil Spills**		
Number of Casualty Incidents		22,356	
Cause of Incident			
Hull/Machinery Damage		41%	
Collision/Contact		31%	
Stranding/Grounding		20%	
Fire/Explosion		8%	
Vessel characteristics	Median	Mean	SD
Vessel Age (years)	16.50	17.10	10.70
Vessel Size (DWT)	9,566	27,069	41,957
Estimated hedonic value ($ million)	4.46	10.06	16.46
Salvage Value	0.27	0.36	0.28
Panel B	**Flag Level Casualty Incidents**		
	Median	Mean	SD
Number of Incidents	1	6.64	15.82
ln(Total Fleet Registered in DWT)	13.28	12.99	2.86
Law and Order Index	4	3.70	1.48
Corruption Index	3	3.00	1.36
Targeted Flag	0	0.22	0.41

Panel C	**Casualty Incidents for Targeted Flags**					
	Targeted Flag = 1			Targeted Flag = 0		
	Median	Mean	SD	Median	Mean	SD
Number of Incidents	4	11.61	22.35	0	4.22	10.41
ln(Total Fleet Registered in DWT)	14.22	14.40	1.87	12.05	12.09	3.19
Law and Order Index	4	3.65	1.11	4	3.78	1.42
Corruption Index	2	2.24	0.87	2.5	2.80	1.25

Table 6: Describing Capacity under Arrest and Distress

This table reports the capacity under arrest and distress as a percentage of total industry capacity. Panel A reports the summary statistics for the entire sample and sample of arrested vessels. Panel B reports the characteristics of firms and vessels involved in downsizing events. Panel C reports these characteristics for firms that sold more than 90% of their fleet during downsizing events. *Total capacity* measures the entire capacity of the industry in 2 units. Total capacity in vessel years, is calculated by multiplying the average age of the vessels with the total number of vessels in service. Total capacity in DWT years (10^6), is calculated by multiplying the average DWT of the vessels with the total capacity in vessel years. *Number of arrest events* reports the total number of arrest events in our sample period. *Avg. duration of arrest (in years)* measures the average time it takes for a port to resolve an arrest event. *Capacity under arrest* measures the arrested capacity in 2 units: vessel years and DWT years. In vessel years, it is calculated by multiplying the average years vessels spend in arrest with the total number of arrested vessels. In DWT years (10^6), it is calculated by summing over the product of DWT of arrested vessels and average years spent by the vessel in arrest (for all arrests). *Probability of arrest* is estimated by dividing capacity under arrest with total capacity of the industry. *Age of vessel (years)* reports the current age of the vessel (for *Entire Industry*), or its age at arrest (for *Arrested vessels*). Similarly, *Vessel size (DWT)* reports the size of the vessels in deadweight tons for each group. *Hedonic Value ($ million)* for the entire industry estimates the current market price of all the fleet in service. *Hedonic Value ($ million)* for an arrested vessel estimates the market price of the vessel, in the year quarter of its arrest. The variable *Salvage Value* measures the depreciation of a vessel, and is estimated by the proportion of vessel's current market value as a fraction of its replacement value (i.e. the current market price of an identical new vessel). In Panel B, we identify firms that have filed for bankruptcy. In Panel C, we identify other distressed firms (that did not file for bankruptcy) from news events. *Percentage of fleet sold* and *Percentage of fleet arrested* report the percentage of initial fleet sold and arrested, respectively by a distressed firm.

Panel A	**Full Sample**					
	Vessel Years			DWT Years (10^6)		
Total capacity	973,648			31,173		
Number of arrest events	3,206					
Avg. duration of arrest (years)	0.437					
Capacity under arrest	1,401			45		
Probability of arrest	0.14%			0.14%		
	Entire Industry			Arrested Vessels		
Vessel characteristics	Median	Mean	SD	Median	Mean	SD
Age of vessel (years)	15	16.65	11.26	18.75	17.98	9.88
Size of vessel (DWT)	9,040	32,017	52,202	17,665	31,552	44,803
Hedonic Value of vessel ($ million)	4.52	10.71	16.82	4.42	7.85	10.77
Salvage Value of vessel	0.32	0.39	0.29	0.24	0.34	0.26
Panel B	**Bankruptcy Events**					
Number of firms	159					
Number of vessels	2,355					
Number of arrest events	162					
Probability of arrest (vessel years)	0.93%					
Firm Characteristics	Median	Mean	SD			
Percentage of fleet sold	0.54	0.50	0.28			
Percentage of fleet arrested	0.00	0.062	0.19			
Vessel Characteristics						
Age of vessel (years)	13.75	15.03	10.15			
Size of vessel (DWT)	17,777	37,651	48,843			
Hedonic Value of vessel ($ million)	7.31	12.82	16.18			
Salvage Value of vessels	0.35	0.42	0.28			
Panel C	**Distress Events**					
Number of firms	167					
Number of vessels	4,166					
Number of arrest events	131					
Probability of arrest (vessel years)	0.28%					
Firm Characteristics	Median	Mean	SD			
Percentage of fleet sold	0.42	0.45	0.25			
Percentage of fleet arrested	0.00	0.071	0.20			
Vessel Characteristics						
Age of vessel (years)	8.75	10.80	8.32			
Size of vessel (DWT)	37,883	54,243	62,624			
Hedonic Value of vessel ($ million)	13.25	19.64	22.00			
Salvage Value of vessels	0.51	0.52	0.27			

Table 7: Probability of Arrests during Bankruptcy and Distress Events

This table reports the probability of arrests during distress episodes. The dependent variable, *Arrests* equals 1 if the ship is arrested and equals 0 otherwise. *Bankruptcy or Distress* equals 1 for the operator 5 years before the bankruptcy/distress news event and equals 0 otherwise. *Bankruptcy* equals 1 in the 5-year event window before an operator files for bankruptcy and equals 0 otherwise. *Distress* equals 1 for the operator in the 5-year window before the distress news event and equals 0 otherwise. *Hedonic Price ($ million)* of a vessel estimates the market price of the ship in a given year quarter. *Salvage Value* measures the depreciation of a vessel, and is estimated by the proportion of vessel's current market value as a fraction of its replacement value (i.e. the current market price of an identical new vessel). The regressions include ship type (and size category) and year quarter fixed effects. The unit of observation is vessel-quarter. Standard errors clustered by ship type are reported in parentheses. *** denotes significance at 1%, ** at 5%, and * at 10%.

	Arrests					
	(1)	(2)	(3)	(4)	(5)	(6)
Bankruptcy or Distress	0.00354***	0.00336***	0.00339***			
	(0.001)	(0.001)	(0.001)			
Bankruptcy				0.00788***	0.00749***	0.00747***
				(0.002)	(0.002)	(0.002)
Distress				0.00132***	0.00122***	0.00129***
				(0.000)	(0.000)	(0.000)
Hedonic Price			-0.000015*			-0.000014*
			(0.000)			(0.000)
Salvage Value			-0.00135**			-0.00134**
			(0.001)			(0.001)
Constant	0.00146***	0.00146***	0.00218***	0.00146***	0.00146***	0.00217***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Year Quarter FE	NO	YES	YES	NO	YES	YES
Ship Type (and Size) FE	NO	YES	YES	NO	YES	YES
Observations	3,737,243	3,737,149	3,635,240	3,737,243	3,737,149	3,635,240
Adjusted R^2	0.000	0.001	0.001	0.000	0.001	0.001

Table 8: Probability of Spills during Bankruptcy and Distress Events

This table reports the probability of an oil spill (and pollution incident) during distress episodes. The dependent variable, *Pollution Incidents* equals 1 if the ship is involved in a pollution incident and equals 0 otherwise. *Bankruptcy or Distress* equals 1 for the operator 5 years before the bankruptcy/distress news event and equals 0 otherwise. *Bankruptcy* equals 1 in the 5-year event window before an operator files for bankruptcy and equals 0 otherwise. *Distress* equals 1 for the operator in the 5-year window before the distress news event and equals 0 otherwise. *Hedonic Price ($ million)* of a vessel estimates the market price of the ship in a given year quarter. *Salvage Value* measures the depreciation of a vessel, and is estimated by the proportion of vessel's current market value as a fraction of its replacement value (i.e. the current market price of an identical new vessel). The regressions include ship type (and size category) and year quarter fixed effects. The unit of observation is vessel-quarter. Robust standard errors are reported in parentheses. *** denotes significance at 1%, ** at 5%, and * at 10%.

	Pollution Incident					
	(1)	(2)	(3)	(4)	(5)	(6)
Bankruptcy or Distress	0.00100***	0.000761***	0.000768***			
	(0.000)	(0.000)	(0.000)			
Bankruptcy				0.00173***	0.00136***	0.00129***
				(0.000)	(0.000)	(0.000)
Distress				0.000631*	0.000451	0.000498
				(0.000)	(0.000)	(0.000)
Hedonic Price			-0.000025***			-0.000024***
			(0.000)			(0.000)
Salvage Value			-0.00107***			-0.00107***
			(0.000)			(0.000)
Constant	0.00634***	0.00633***	0.00678***	0.00634***	0.00633***	0.00678***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Year Quarter FE	NO	YES	YES	NO	YES	YES
Ship Type (and Size) FE	NO	YES	YES	NO	YES	YES
Observations	3,737,243	3,737,149	3,635,240	3,737,243	3,737,149	3,635,240
Adjusted R^2	0.000	0.001	0.001	0.000	0.001	0.001

Table 9: Governance of Flags states and Oil Spills

The table shows how the governance standards of the flag state affect the number of casualty incidents. The dependent variable *Number of Pollution Incidents* aggregates the total annual number of pollution incidents by vessels registered by a particular flag. *ln(Total Fleet Registered)* refers to the log of total annual tonnage (in DWT) of vessels registered with a particular flag. The *Law and Order Index* measures the quality of law enforcement in the flag state, and a high index implies better rule of law. The *Corruption Index* measures the level of corruption in the flag state, and a high index implies low corruption in the government. *Targeted Flag* takes value 1 if in the flag state was targeted by the port state control authorities (i.e. by Paris MoU, Tokyo MoU, or USCG) in the year prior to the incident. Year fixed effects are included in all specifications. The unit of observation is flag-year (flag i and year t). Robust standard errors are reported in parentheses. *** denotes significance at 1%, ** at 5%, and * at 10%.

	Number of Pollution Incidents$_{i,t}$		
	(1)	(2)	(3)
Law and Order Index$_{i,t-1}$	-1.028***		
	(0.189)		
Corruption Index$_{i,t-1}$		-0.475**	
		(0.189)	
Targeted Flag$_{i,t-1}$			1.579**
			(0.647)
ln(Total Fleet Registered)$_{i,t}$	3.093***	2.962***	2.390***
	(0.145)	(0.136)	(0.108)
Year FE	YES	YES	YES
Observations	3,946	3,946	3,142
Adjusted R^2	0.314	0.308	0.307

Table 10: Probability of Abandonment during Bankruptcy and Distress Events

This table reports the probability of vessel and crew abandonment during distress episodes. The dependent variable, *Abandonment Incident* equals 1 if the ship or crew are abandoned by the operator and equals 0 otherwise. *Bankruptcy or Distress* equals 1 for the operator 5 years before the bankruptcy/distress news event and equals 0 otherwise. *Bankruptcy* equals 1 in the 5-year event window before an operator files for bankruptcy and equals 0 otherwise. *Distress* equals 1 for the operator in the 5-year window before the distress news event and equals 0 otherwise. *Salvage Value* measures the depreciation of a vessel, and is estimated by the proportion of vessel's current market value as a fraction of its replacement value (i.e. the current market price of an identical new vessel). The regressions include ship type (and size category) and year quarter fixed effects. The unit of observation is vessel-quarter. Standard errors clustered by ship type are reported in parentheses. *** denotes significance at 1%, ** at 5%, and * at 10%.

	Abandonment Incident					
	(1)	(2)	(3)	(4)	(5)	(6)
Bankruptcy or Distress	0.00127***	0.00130***	0.00130***			
	(0.000)	(0.000)	(0.000)			
Bankruptcy				0.00366***	0.00359***	0.00361***
				(0.001)	(0.001)	(0.001)
Distress				0.00020**	0.00025**	0.00025**
				(0.000)	(0.000)	(0.000)
Hedonic Price			0.00000			-0.00000
			(0.000)			(0.000)
Salvage Value			-0.0003***			-0.0003***
			(0.000)			(0.000)
Constant	0.00020***	0.00020***	0.00032***	0.00020***	0.00020***	0.00032***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Year Quarter FE	NO	YES	YES	NO	YES	YES
Ship Type (and Size) FE	NO	YES	YES	NO	YES	YES
Observations	3,737,243	3,737,149	3,635,240	3,737,243	3,737,149	3,635,240
Adjusted R^2	0.000	0.001	0.001	0.000	0.001	0.001

Table 11: Panel A: Fire Sale Discount

This table reports the fire sale discounts from regressing the log of sales price on ship characteristics and dummy variables indicating distress. Columns (1) – (3) report the raw fire sale discount, and columns (4) – (6) report the quality adjusted fire sale discounts. *Arrested* equals 1 if the ship is arrested and equals 0 otherwise. *Bankruptcy or Distress* equals 1 for the operator 5 years before the bankruptcy/distress news event and equals 0 otherwise. *Bankruptcy* equals 1 in the 5-year event window before an operator files for bankruptcy and equals 0 otherwise. *Distress* equals 1 for the operator in the 5-year window before the distress news event and equals 0 otherwise. Quality adjusted discount is calculated by including the *Life Expectancy* as an explanatory variable in the regression. The *Life Expectancy* is estimated using the Cox proportional hazards model (see figure 4). Controls for ship characteristics including ship age, age^2, log(DWT), log(GT), length, breadth, depth, draught, freeboard, single hull type, and block sale dummy are included in all regressions. The ship characteristics are defined in Appendix D. The regressions include ship type (and size category), country of build, seller country, buyer country and quarter of sale fixed effects. Standard errors clustered by ship type are reported in parentheses. *** denotes significance at 1%, ** at 5%, and * at 10%.

	log(Sales Price)					
	Raw Fire Sale Discount			Quality-adjusted Discount		
	(1)	(2)	(3)	(4)	(5)	(6)
Arrested	-0.226***	-0.222***	-0.219***	-0.123***	-0.125***	-0.122***
	(0.028)	(0.026)	(0.027)	(0.029)	(0.027)	(0.027)
Bankruptcy or Distress		-0.030			0.016	
		(0.031)			(0.031)	
Bankruptcy			-0.111***			-0.066
			(0.042)			(0.042)
Distress			0.017			0.064
			(0.041)			(0.042)
Life Expectancy				0.182***	0.183***	0.183***
				(0.021)	(0.021)	(0.021)
Year Quarter FE	YES	YES	YES	YES	YES	YES
Ship Type (and Size) FE	YES	YES	YES	YES	YES	YES
Country of Built FE	YES	YES	YES	YES	YES	YES
Seller Country FE	YES	YES	YES	YES	YES	YES
Buyer Country FE	YES	YES	YES	YES	YES	YES
Ship Characteristics Controls	YES	YES	YES	YES	YES	YES
Observations	17,392	17,392	17,392	17,392	17,392	17,392
Adjusted R^2	0.880	0.880	0.883	0.886	0.886	0.887

Panel B: Institutional Quality of the Port of Arrest and Fire Sales Discount

This table reports the fire sale discounts on an indicator variable that takes on a value of 1 if the ship is arrested and 0 otherwise. Column (1) and (2) report the raw fire sale discounts, while columns (3) and (4) report the quality adjusted fire sale discounts. Quality adjusted discount is calculated by including the *Life Expectancy* as an explanatory variable in the regression. The *Life Expectancy* is estimated using the Cox proportional hazards model (see figure 4). We further split the sample of arrested ships into high corruption (columns (1) and (3)) and low corruption (columns (2) and (4)) ports. Controls for ship characteristics including ship age, age^2, log(DWT), log(GT), length, breadth, depth, draught, freeboard, single hull type, and block sale dummy are included in all regressions. The ship characteristics are defined in Appendix D. The regressions include ship type (and size category), country of build, seller country, buyer country and quarter of sale fixed effects. Standard errors clustered by ship type are reported in parentheses. *** denotes significance at 1%, ** at 5%, and * at 10%.

	log(Sales Price)			
	Raw Fire Sale Discount		Quality-adjusted Discount	
	High Corruption	Low Corruption	High Corruption	Low Corruption
	(1)	(2)	(3)	(4)
Arrested	-0.321***	-0.218***	-0.204***	-0.109***
	(0.038)	(0.030)	(0.039)	(0.031)
Life Expectancy			0.207***	0.204***
			(0.022)	(0.024)
Year Quarter FE	YES	YES	YES	YES
Ship Type (and Size) FE	YES	YES	YES	YES
Country of Built FE	YES	YES	YES	YES
Seller Country FE	YES	YES	YES	YES
Buyer Country FE	YES	YES	YES	YES
Ship Characteristics Controls	YES	YES	YES	YES
Observations	13,954	14,379	13,954	14,379
Adjusted R^2	0.869	0.870	0.874	0.874

Panel C: Fire Sale Discount during Business Cycles

This table reports the fire sale discounts during business cycles. Column (1) reports the raw fire sale discounts and columns (2) reports the quality adjusted fire sale discounts. Quality adjusted discount is calculated by including the *Life Expectancy* as an explanatory variable in the regression. The *Life Expectancy* is estimated using the Cox proportional hazards model (see figure 4). The business cycles are classified into three categories based on industry cycles (value of the annual Baltic Dry Index): Low Index, Regular Times, and High Index. *Arrest* × *Low* equals one for arrests that take place when the index is in the bottom tercile, and zero otherwise. *Arrest* × *Regular* equals one for arrests that take place when the index is in the mid tercile, and zero otherwise. *Arrest* × *High* equals one for arrests that take place when the index is in the top tercile, and zero otherwise. Controls for ship characteristics including ship age, age^2, log(DWT), log(GT), length, breadth, depth, draught, freeboard, single hull type, and block sale dummy are included in all regressions. The ship characteristics are defined in Appendix D. The regressions include ship type (and size category), country of build, seller country, buyer country and quarter of sale fixed effects. Standard errors clustered by ship type are reported in parentheses. *** denotes significance at 1%, ** at 5%, and * at 10%.

	log(Sales Price)	
	Raw Fire Sale Discount	Quality-adjusted Discount
	(1)	(2)
Arrest × Low	-0.233***	-0.126***
	(0.043)	(0.046)
Arrest × Regular	-0.255***	-0.140***
	(0.030)	(0.032)
Arrest × High	-0.151**	-0.027
	(0.066)	(0.053)
Life Expectancy		0.206***
		(0.024)
Year Quarter FE	YES	YES
Ship Type (and Size) FE	YES	YES
Country of Built FE	YES	YES
Seller Country FE	YES	YES
Buyer Country FE	YES	YES
Ship Characteristics Controls	YES	YES
Observations	15,043	15,043
Adjusted R^2	0.870	0.874

Appendix

A. A Tale of Two Shipping Bankruptcies

In this section we review two shipping companies that entered bankruptcy, Eastwind and Hanjin Shipping. Eastwind entered Chapter 7 in the US while Hanjin Shipping entered bankruptcy procedures in South Korea and in the US. We chose these two companies because they illustrate in one case a very orderly disposal of assets without significant coordination failures and in the other case, a disorderly disposal of assets. The empirical part of our paper is aimed at resolving the question as to which case study better characterizes the outcome of financial distress in this industry.

A.1 Eastwind

The distressed New York based shipping company Eastwind owned, at the time of default, around 90 vessels. Nordea, a Scandinavian bank with an extensive portfolio of maritime loans, had double mortgages on 12 of Eastwind's vessels. These mortgages entitled the company to acquire ownership of the vessels in the event of default. To facilitate these rights, the board members of each of these subsidiaries had pledged, at the time of loan origination, signed but undated resignation letters. In the event of default, the lender could date those letters replacing the board with its own appointees thereby facilitating a rapid and unopposed transfer of ownership and the sale of the ships to a third party.

Although Eastwind was delinquent, Nordea made many attempts to restructure the distressed company without repossession. However, at some point it received news that Eastwind was about to file for bankruptcy in the US. Fearing the direct legal costs as well as the dilution of their rights in bankruptcy,[38] Nordea declared Eastwind in default on June 21, 2009. At the same time they dated the resignation letters of the current Eastwind directors, and appointed new directors for each of the subsidiaries. Simultaneously, the new directors approved the sale of the twelve ships, on behalf of the bank, to Samama's Draften Shipping, a company controlled by the Ofer family. We are informed that the value of the proceeds of sale were more than $50 million.

Eastwind filed for Chapter 7 bankruptcy one day later on June 22. The Chapter 7 Trustee sued Nordea on the grounds that the ships belonged to the bankruptcy estate and were subject to the automatic stay, and therefore Nordea was not entitled to sell the ships. The judge decided that the sale by Nordea of the subsidiaries was valid, and that the pre-default managers lacked the appropriate authority to file for bankruptcy.[39]

There are several issues that this case clarifies. First, that Nordea did not have to arrest the vessels in a port in order to gain control of its collateral and sell the vessels. The immediate sale of vessels on the high seas avoided the cost of sailing the vessels to a port to arrest and auction the vessels. This saved the direct costs of arrest and auction, which we have estimated below at 8% of the vessels value, but it

[38] The fact that Eastwind was an American company is not a prerequisite for a filing of bankruptcy in the US. Any debtor with assets in the US can file for US bankruptcy. In re Theresa McTague, Debtor, 198 B.R. 428. July 15, 1996, a precedent was established to the effect that a non-US company holding a US bank account with $194 qualifies

[39] The case was settled with Nordea paying the trustee $750k, in return for the Trustee's recognition that the sale was valid.

also saved the costs of immobilising the vessels and the opportunity to charter out the vessels. Second, had Nordea delayed by just a day, the entry of Eastwind into US bankruptcy would have triggered an 'automatic stay' on the assets by a US court, with a corresponding delay to the recovery of Nordea's debt and the potential dilution of their claims. Even so, Nordea still had the option of arresting the vessels in a non-US port, despite entry of the company into Chapter 7 and the automatic stay, but that might have placed Nordea in conflict with the US court.[40] The ruling in this case highlights the potential for jurisdictional conflict that the shipping industry has faced on the enforcement of creditor rights. It also shows that although the industry has largely managed to distance itself from national jurisdictions, in a way described below, it has not achieved full separation.

While we have discussed the sale of Eastwind's twelve ships, it is also important to report evidence of coordination failures across its entire fleet of ships. The top line in Figure 2 tracks the company's total capacity (in millions of DWTs) while the bottom line tracks capacity that is immobilized due to arrest. The two time series are plotted against "bankruptcy time," with zero being the day of the Chapter 7 filing. Several points merit elaboration. First, Eastwind started to downsize at least a year before it filed for bankruptcy. That downsizing was achieved with hardly any arrests. Presumably, at that time Eastwind still had equity in the vessels and was willing to cooperate with its creditors. Second, the arrest rate started to pick up following the bankruptcy filing, consistent with the hypothesis that financial distress leads to vessel arrests. Over the entire cycle, Eastwind divested around 1.5 million DWT, while the capacity under arrest amounted to roughly 0.2 million DWT-years. Hence, on average, 13% of the downsized capacity was immobilized for one year. Third, throughout Eastwind's decline, capacity under arrest was well below total capacity. Even at its peak, a few months after the Chapter 7 filing, the arrest to total capacity ratio was only 22%. This finding is not consistent with standard theories of a creditors run, whereby creditors driven by a first-mover advantage would grab any asset that has not already been seized by another creditor. It is consistent, however, with the view that once property rights are efficiently allocated to different mortgages and properly prioritized amongst all other creditors, coordination failures do not occur because no creditor can "jump the queue" by grabbing an asset.[41] We formally test this hypothesis in Section 3 on a large sample of vessel arrests, and a sample of shipping companies that went bust.

A.2 Hanjin Shipping

A more recent bankruptcy, in August 2016, with quite different outcomes, is that of Hanjin Shipping. Hanjin was the seventh largest shipping company in the world operating with 142 ships, 38 under own-

[40] In another case concerning Eastwind, the same federal judge refused to enforce the rights of another creditor. Upon Eastwind's default, the UK insurer to Eastwind had terminated the insurance of its vessels. The Trustee in Chapter 7 litigated against the insurers, arguing that under US law they were obliged to continue the insurance until the bankruptcy procedures were completed. The Trustee's reasoning was that without insurance, vessels away from the home port would be unable to complete their voyages or, the bankruptcy estate would have had to use its scarce funds to pay the insurance. The federal judge, while recognizing that an English court would likely rule in favor of the insurer, applied US law and ruled in favor of the trustee, contrary to the contract which specified that in the event of a dispute English law would apply. The judge dismissed the insurers claim that they did not anticipate such a result, on the grounds that "with more than 30 years experience with US bankruptcy law," they should have been aware of such an event and accounted for the consequences. By forcing the British insurers to continue the contract, their unpaid fees were pooled with other Eastwind's unsecured creditors, and subject to a "haircut."

[41] We do not exclude a run on an individual vessel, although with fewer creditors, this becomes easier to avoid.

ership and the rest under charter. Its business was badly hit by low freight rates, overcapacity in the industry and with bought-in charter contracts with very high daily charges, relative to their spot rates. Hanjin filed for bankruptcy in a number of jurisdictions, including South Korea and the United States, the latter under Chapter 15 of the US code which limited the court's jurisdiction to US-based assets. The Wall St Journal (October 13, 2016) stated that as a result of the bankruptcy, eight vessels had been arrested, 43 were at sea, and 39 were outside ports at risk of arrest.

While many of these problems were resolved within days or weeks of the filing, it is likely that significant costs were imposed on various stakeholders, particularly the cargo owners. For example, Reuters reported that the collapse caused 'worldwide supply chain and shipping disruption as cargo ships were left stuck at ports and canals waiting for cash payments.'[42] Another publication (Ocean Insights) claimed that the bankruptcy stranded more than $14 billion in cargo, ranging from televisions to textiles to spicy kimchi, scattered all over the globe, and represented 3.2% of the world's global container capacity. This case illustrates the costs of externalities associated with the failure of large firms.[43]

It was largely the unplanned nature of the bankruptcy and the way Hanjin was financed that precipitated the crisis and contributed to the costs.[44] The bankruptcy was triggered by a refusal of Hanjin's shareholders and main creditor banks to re-negotiate an out of court restructuring. It is highly likely that they did not internalise the costs of supply chain disruption; nor, could those affected by the disruption, particularly the owners of the cargo, coordinate in a timely manner and participate in any out of court restructuring with creditors. It is likely that an automatic stay and debtor in possession financing would have avoided some of those costs to Hanjin's creditors and customers. The case raises the important question whether state sponsored bankruptcy codes are desirable, and whether they should be made mandatory or optional.[45]

[42] See "Hanjin Shipping files for receivership, as ports turn away its vessels." Reuters. 31 August 2016.

[43] See "Lessons Learned From Hanjin collapse-visibility is the key to success", Matthias Dyck, Oct 18, 2017

[44] A significant part of Hanjin's debt was on a recourse basis, an issue discussed later. See "Lessons Learned From Hanjin Shipping's Bankruptcy", Peter S Goodman, Law 360

[45] Since 2011 there have been approximately ten shipping companies that have filed for Chapter 11 protection. The majority have been non-US companies with virtually no assets in the US, for example, Genco Shipping and Marco Polo Seatrade (see Thomas J. Belknap, 2013, Does Chapter 11 Work for Foreign Shipping Companies, Maritime Reporter and Engineering News, April.) In all, the ten companies that filed for Chapter 11, only those companies that filed with creditor support succeeded in maintaining the company as a going concern. Those companies that filed without creditor support were liquidated (see 'Creditor Support Essential for Smooth Sailing in Shipping Restructurings,' Scott Greissman, White & Case LLP, Marine Money, October/November 2016). In six cases, the company filed without secured creditor support, and 'all vessels were ultimately sold or returned to the applicable secured lenders' (see Greissman, 2016). In four cases, for example Nautilus Shipping, the companies filed with support from secured creditors. These filings were accompanied by pre-packaged plans of reorganization, emphasizing the consensual nature of the reorganization. They were 'large or more complex/non traditional corporate capital structures.' Importantly, these cases attracted support from new investors or existing lenders. One interpretation of these cases is that major creditors have used these State-sponsored procedures voluntarily, as a substitute for private recontracting. It may be that off the shelf standardized procedures provide a low cost way of executing such plans. In this respect, State procedures may provide standardized contracts, which are cheaper than private contracts and which are less open to legal challenge. Such State contracts also avoid the free riding that accompanies contractual innovations. An example was the floating charge privately introduced as part of a debt contract in England in the 19th century and still in widespread use today. The contract was challenged in the courts, and its refinement and standardization took decades to complete (see Franks and Sussman (2005)).

B. Direct costs of arrests and auctions in UK ports

B.1 Direct Costs of Arrests

While the loss of income is the main cost of immobilization, it is not the only one. There are additional direct costs due to port fees, crew wages and supplies while in port, court costs, brokerage fees etc. The existence of these additional fees does not change the analysis: in a perfect Coasian world there would be no arrests and, therefore, no additional costs of arrest. For the sake of completeness, however, we used the files of the Admiralty Marshall (the agency responsible for executing arrest warrants) in London to hand collect data for 22 vessel arrests in England over the 1995-2010 period. The results are described in Table A.3: the median period for which the vessel was immobilized was 71 days or about two months (much lower than the sample mean). The median direct costs of arrest are 8% of the sale price. Consistent with the observation that arrested vessels tend to be small, the median sale value of a vessel is only $1 million, compared with an average value of ships sold of $9 million dollars for our entire sample. The costs of immobilization are not particularly small when we take into account the fact that these do not include the loss of any forgone income during arrests. Bris et al. (2006), in an analysis of direct and indirect costs of US bankruptcies, state "Bankruptcy costs are very heterogeneous and sensitive to the measurement method used...". They document a range of 2% to 20%. Our estimates of direct costs for shipping lie within this range.[46]

B.2 Auctions

An important result in this paper is that auctions of arrested ships result in low fire sale discounts after corrections for under-maintenance and for low quality ports. A key issue here is how efficient the auction process is in high quality ports. One aspect of efficiency is the number of bidders for a vessel that is being auctioned. Using the same hand-collected sample of UK auctions used in Table A.3, Table A.4 shows that the average number of bidders is high at 8, which is consistent with the view that the second-hand vessel market is liquid. In one case, the number of bidders reached 23. The bids come from all over the world. However, the spread between the top two bidders is large, 24% on average.

The liquid market in these auctions reflects the sophisticated dealer network, where dealers are long established and therefore can more easily communicate with potential buyers. Some of these dealers, for example CW Kellock, have been trading in this market for more than 100 years. The ability to survey a ship quickly and accurately, possibly in a distant port, expedites the process of sale. This is particularly important because many of the arrested vessels might have defects and will be of low quality.

C. Description of Seafarer Abandonment cases

Here we describe in detail, the 3 examples from the Adriatic fleet cited by the IMO report.

[46] They cite much longer periods for both Chapter 7 and Chapter 11 bankruptcies. The average time spent in a Chapter 11 bankruptcy is 828 days (median time is 866 days)and 709 days (median time is 672 days) for Chapter 7 bankruptcies.

Annapurna - The vessel flying the Panama flag was abandoned on the ports of Dubai. Crew left for two years on board an arrested vessel. The agent became party to the arrest and decided to stop supplying the ship. The crew survived thanks to the local Mission to Seamen. US Trust (one of the creditors) took charge of the case in early 1996. Conditions of living on board improved dramatically following the visit of a US Trust surveyor and the crew - even ex-crew were later paid and repatriated. Some crew remained on board to take vessel to Hong Kong and they were then paid in full and repatriated from there.

Assos Bay - In November 1994 the crew on board this VLCC were abandoned outside the port limits off Fujairah, UAE. The agent decided to stop supplying the ship with fuel, water and food when the shipowner showed no interest in paying his debts to the agent. Crew were eventually paid and repatriated by the mortgagee bank (US Trust) in November 1995.

Cape Breeze - After the arrest of the ship on behalf of the agents in June 1995 the ship was left with no supplies for the crew on board. In November 1995 the Burmese crew arrested the ship for unpaid wages and eventually were repatriated at the expense of the mortgagee bank. The ship remained under arrest in Valencia, Spain, and the crew remained unpaid until 1997 when the ship was auctioned. In October 1997 the proceeds of sale were remitted from Spain.

E. Vessel-related Variables

Age: Year since year of build at sale.
Block: Indicator which equals to 1 if the vessel is part of a block sale of several vessels, and zero otherwise.
Special Unit: Types of container units, including dry storage container, tanks, drums, car carriers, etc.
DWT: Deadweight tonnage of a vessel.
Gross Weight: The weight of the cargo plus the weight of the container, trailer, shipment or packaging.
Length: The maximum length of a vessel's hull measured parallel to the waterline Breadth extreme The maximum breadth including all side plating, straps, etc.
Depth: The vertical distance between the moulded base line and the top of the beams of the uppermost continuous deck measured at the side amidships.
Draft: The vertical distance between the waterline and the bottom of the hull (keel), with the thickness of the hull included.
Freeboard: The vertical distance from the waterline to the upper deck level.
Hull Type: A ship with a single hull has one layer of watertight structure. This means that if the hull is punctured, oil or other cargo is likely to spill into the ocean. A ship with a double hull has two layers of watertight structure, with empty space between them. This design reduces the risk of marine pollution if the ship is damaged.

F. Life Expectancy Estimates from Cox Regression

In the main specification, life expectancy is calculated separately for the arrested and the non-arrested group, based on the distribution of vessels' age at death, regardless of their characteristics. We can also calculate the ship-specific life expectancy after using Cox regression. Cox relative hazard regression yields estimation for coefficients ($\hat{\beta}$) on ship characteristics (X) and baseline hazard rate ($h_0(t)$). Therefore, $h_0(t) \times e^{\hat{\beta}' X}$ gives the predicted hazard rate for each ship, taken into effects of ship-specific characteristics. We can further calculate ship-specific life expectancy based on the post-Cox predicted hazard rate. Concerned about the fact that there may be too much noise in the above predicted hazard rate and hence the new ship-specific life expectancy measure, we group vessels according to their vessel type (bulk carrier, fully cellular container, reefer, general cargo tramp, etc). Because of this grouping procedure, we state in the paper that we "partially" control for the characteristics of ships. We use several methods to group the vessels in order to reduce the noise in the estimation, and the main findings are robust to those different specifications.

G. Identifying Distressed Firms using Downsizing Filter

A potential issue with collecting data on distressed firms is that some firms through amicable renegotiation might not only avoid arrests of their ships but avoid significant publicity surrounding any debt renegotiation. We address this issue of unidentified distressed companies, by combining two sets of data: distressed events for companies recorded in shipping news and companies which involve large scale sales of ships concentrated in narrow windows, and which we refer to as "downsizing events." We have included the latter filter because we recognize that some distressed firms may reorganize amicably with their creditors without advertising any debt renegotiation.

To identify downsizing events we fit a logistic function to the variation in each owner's fleet size over a 10 year rolling window.[47] We use a non-linear model to fit the following functional form:

$$S_{t-t_0} = S_1 + \Delta S \left(\frac{1}{1 + e^{\rho(t-t_0)}} \right) \tag{A-1}$$

where, S_t is the stock of vessels of an operator at time t, S_1 is a constant that shifts the entire logistic function vertically (similar to an intercept), and ΔS is the vertical range within which the logistic function changes over time. ρ measures the steepness of the downsizing, and t_0 is the mid-point of the downsizing event window. We estimate a set of parameters of the function, $(S_1, \Delta S, \rho, t_0)$ using non-linear regression procedure. Using these parameters for each operator over a 10 year rolling window we calculate the slope of the downsizing event at the midpoint of the event window (t_0), and the duration of the downsizing period. We also use the R^2 of the non-linear regression to measure the goodness of fit of the logistic function.

To implement the downsizing filter we restrict our sample to owners with at least 10 vessels at the start of the event window. We then apply the following criteria to identify distress events: (i) the slope of

[47] We have the following six rolling windows during our sample period: 1995 – 2000, 1995 – 2005, 2000 – 2010, 2005 – 2015, 2010 – 2020, 2015 – 2020.

the curve at the mid point is negative, (ii) $R^2 > 60\%$, and (iii) magnitude of downsizing as a proportion of initial fleet size must be at least 0.35. These criteria are consistent with the downsizing episodes of the bankrupt and financially distressed firms identified using Lloyds News. To remove mergers and acquisitions from the sample of firms with downsizing events, we do not include operators that sold more than 85% of their fleet to the same buyer. Applying these criteria we identify 660 distress events. In 265 of these distress episodes the operators sold more than 90% of their initial fleet.

Here we provide a brief description of the downsizing events. While the unconditional probability of arrest in the full sample is only 0.14%, it increases to 0.53% during downsizing events. The probability of arrest further increases to 1.4% during downsizing events in which the operator sells more than 90% of its initial fleet. These comparative statistics confirm the effectiveness of our proxies for identifying distress. While the probability of arrest significantly increases with distress, it still remains economically low even in extreme downsizing events. The average duration of distress episodes identified by our downsizing filter is 5.6 years, during which on average 77% of the initial fleet is sold and 5.6% of the fleet is arrested. We find that the median arrest rate is 0 in our sample of downsizing firms. 80% of these firms had no arrests. In fact, the median arrest rate is 0 even in extreme distress events when the owner is liquidating (and sells more than 90% of its initial fleet). The average arrest rate in the downsizing sample is 5.6%, and at the 95th percentile the arrest rate is 31%. This suggests that coordination failures akin to Adriatic Tankers are relatively rare in our sample. In fact, less than 2% of our downsizing sample has an arrest rate above 80%.

In Table A.5 we formally test whether downsizing events are correlated with arrests. In columns (1) – (3), we report that the probability of arrest increases by 0.39% during downsizing events. Thus, downsizing roughly triples the unconditional probability of arrest of 0.14%. In columns (4) – (6), the independent variable, *Downsizing (>90% fleet)* is one if the operator sells more than 90% of its initial fleet during downsizing events and is zero otherwise. During these extreme distress episodes we find that the probability of an arrest increases by 1.2%.

Figure A.1: Charter Rates and Vessel Price Indexes

In this figure, we show the charter rates in the tanker and bulk rate businesses and the price indexes of vessels from 1995 to 2011. $P_{2005} = 100$.

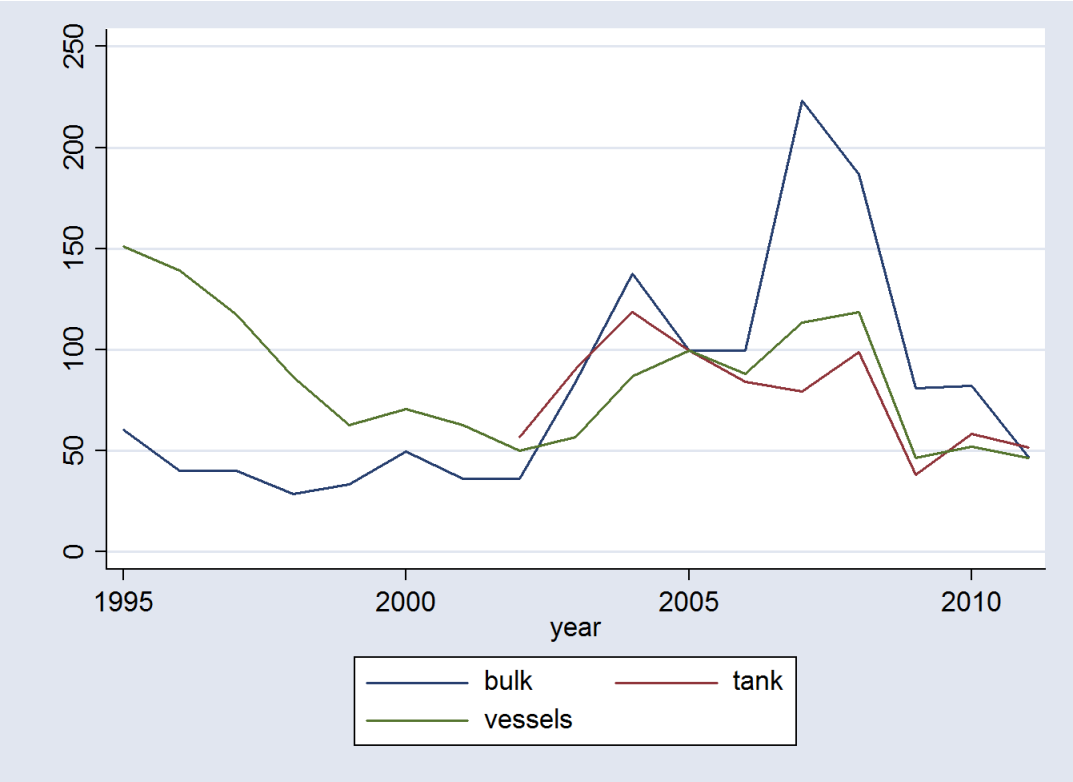


Table A.1: Funding data for twenty seven vessels

This table reports capital structure information at vessel level from the accounts of 27 subsidiaries of 7 shipping firms registered in several jurisdictions. Statistics on five variables are reported, as listed in column 1. Source: Data supplied by a shipping consultancy firm.

	mean	median	min	max
maturity of loans (years)	7	6	4	12
loan amount ($, million)	43.5	51.3	14.7	70
loan/value (%)	64.8	70.1	44	76
balloon payments (n=25, $ million)	18.3	14.4	0	48.1
spread over LIBOR (%)	2.35	2.75	1.4	2.75

Table A.2: Comparison of Leverage in Shipping versus other Transportation Industries

This table compares the leverage ratio and interest rates on shipping loans versus other transportation loans. In columns (1) and (2), the dependent variable is the book leverage ratio (Total Debt/Total Assets). In columns (3) and (4), the leverage ratio includes capital and operational lease obligations. In columns (5) and (6), the dependent variable is the Interest Rate. The leverage ratio and interest rate are regressed on an indicator variable for whether the firm belongs to the shipping industry, and firm level controls such as asset tangibility and profitability. *Shipping Firm* is the indicator variable that takes value 1 if the firm is a shipping firm. The variable *Tangibility* equals Tangible Assets/Total Assets. *Profitability* is defined as operating income after depreciation scaled by (lagged) total assets. Country and year fixed effects are included. Source: Data is from COMPUSTAT (North America and Global)

	(1) Leverage Ratio (W/O Leasing)	(2) Leverage Ratio (W/O Leasing)	(3) Leverage Ratio (With Leasing)	(4) Leverage Ratio (With Leasing)	(5) Interest Rate	(6) Interest Rate
Shipping Firm	0.046***	0.026***	0.047***	0.047**	-0.005***	-0.002**
	(0.002)	(0.002)	(0.017)	(0.020)	(0.001)	(0.001)
Tangibility		0.229***		-0.225***		-0.047***
		(0.008)		(0.036)		(0.002)
Profitability		-0.354***		-1.047***		-0.044***
		(0.017)		(0.121)		(0.006)
Year FE	YES	YES	YES	YES	YES	YES
Country FE	YES	YES	YES	YES	YES	YES
Observations	22,203	20,070	5,393	4,538	22,203	20,070
Adjusted R^2	0.103	0.185	0.020	0.276	0.103	0.179

Table A.3: Direct costs of arrests

This table reports the direct costs of arrests for 22 vessel arrests in England over the period 1995-2010. Column 2 shows the number of immobilization days, column 3 shows the sales price and column 4 shows the total cost as a percentage of sales price.

	Immobilization (days)	Sales price (USD, millions)	Total costs as % of sales price
mean	111	3.25	18%
median	71	1.09	8%
st.dev	165	8.16	30%
min	19	0.04	2%
max	835	38.65	105%
Observations	22	22	21

Table A.4: Auction data from UK ports

This table describes the number of bidders for vessels arrested and sold in UK ports. Column 2 reports the number of bidders, column 3 reports the spread between the top 2 bidders as a percentage of the sales price, and column 4 reports the spread between the top 3 bidders as a percentage of the sales price.

	No. of bids	Spread between Top 2	Spread between Top 3
mean	8.5	24%	30%
median	8	22%	31%
st. dev	4.9	20%	10%
min	1	1%	10%
max	23	79%	60%

Table A.5: Probability of Arrests during Downsizing Events

This table reports the probability of arrests during distress episodes. The dependent variable, *Arrests* equals 1 if the ship is arrested and equals 0 otherwise. *Downsizing* equals 1 for the operator during its downsizing event and equals 0 otherwise. *Downsizing (> 90% fleet)* equals 1 for the operator that sells more than 90% of its fleet during its downsizing event and equals 0 otherwise. *Hedonic Price ($ million)* of a vessel estimates the market price of the ship in a given year quarter. *Salvage Value* measures the depreciation of a vessel, and is estimated by the proportion of vessel's current market value as a fraction of its replacement value (i.e. the current market price of an identical new vessel). The regressions include ship type (and size category) and year quarter fixed effects. The unit of observation is vessel-quarter. Standard errors clustered by ship type are reported in parentheses. *** denotes significance at 1%, ** at 5%, and * at 10%.

	Arrests					
	(1)	(2)	(3)	(4)	(5)	(6)
Downsizing	0.00394***	0.00388***	0.00387***	0.00062	0.00069*	0.00066*
	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)
Downsizing (> 90% fleet)				0.0121***	0.0117***	0.0117***
				(0.003)	(0.003)	(0.003)
Hedonic Price			-0.00001*			-0.00001
			(0.000)			(0.000)
Salvage Value			-0.00133**			-0.00139**
			(0.001)			(0.001)
Constant	0.00133***	0.00133***	0.00203***	0.00133***	0.00133***	0.00203***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Year Quarter FE	NO	YES	YES	NO	YES	YES
Ship Type (and Size) FE	NO	YES	YES	NO	YES	YES
Observations	3,735,752	3,735,752	3,635,240	3,735,752	3,735,752	3,635,240
Adjusted R^2	0.001	0.002	0.003	0.002	0.003	0.003

Table A.6: Probability of Spills during Downsizing Events

This table reports the probability of an oil spill (and pollution incident) during distress episodes. The dependent variable, *Pollution Incidents* equals 1 if the ship is involved in a pollution incident and equals 0 otherwise. *Downsizing* equals 1 for the operator during its downsizing event and equals 0 otherwise. *Downsizing (> 90% fleet)* equals 1 for the operator that sells more than 90% of its fleet during its downsizing event and equals 0 otherwise. *Hedonic Price ($ million)* of a vessel estimates the market price of the ship in a given year quarter. *Salvage Value* measures the depreciation of a vessel, and is estimated by the proportion of vessel's current market value as a fraction of its replacement value (i.e. the current market price of an identical new vessel). The regressions include ship type (and size category) and year quarter fixed effects. The unit of observation is vessel-quarter. Standard errors clustered by ship type are reported in parentheses. *** denotes significance at 1%, ** at 5%, and * at 10%.

	Pollution Incident					
	(1)	(2)	(3)	(4)	(5)	(6)
Downsizing	0.00089***	0.00061**	0.00053**	0.00035	0.00016	0.00008
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Downsizing (> 90% fleet)				0.00197***	0.00164***	0.00163***
				(0.001)	(0.000)	(0.000)
Hedonic Price			-0.00002**			-0.00002**
			(0.000)			(0.000)
Salvage Value			-0.00106			-0.00107
			(0.001)			(0.001)
Constant	0.00594***	0.00595***	0.00677***	0.00594***	0.00595***	0.00677***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Year Quarter FE	NO	YES	YES	NO	YES	YES
Ship Type (and Size) FE	NO	YES	YES	NO	YES	YES
Observations	3,735,752	3,735,752	3,635,240	3,735,752	3,735,752	3,635,240
Adjusted R^2	0.000	0.001	0.001	0.000	0.001	0.001

Table A.7: Probability of Abandonment during Downsizing Events

This table reports the probability of vessel and crew abandonment during distress episodes. The dependent variable, *Abandonment Incident* equals 1 if the ship or crew are abandoned by the operator and equals 0 otherwise. *Downsizing* equals 1 for the operator during its downsizing event and equals 0 otherwise. *Downsizing (> 90% fleet)* equals 1 for the operator that sells more than 90% of its fleet during its downsizing event and equals 0 otherwise. *Hedonic Price ($ million)* of a vessel estimates the market price of the ship in a given year quarter. *Salvage Value* measures the depreciation of a vessel, and is estimated by the proportion of vessel's current market value as a fraction of its replacement value (i.e. the current market price of an identical new vessel). The regressions include ship type (and size category) and year quarter fixed effects. The unit of observation is vessel-quarter. Standard errors clustered by ship type are reported in parentheses. *** denotes significance at 1%, ** at 5%, and * at 10%.

	Abandonment Incident					
	(1)	(2)	(3)	(4)	(5)	(6)
Downsizing	0.00057***	0.00057***	0.00057***	0.00006	0.00008	0.00008
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Downsizing (> 90% fleet)				0.00184***	0.00178***	0.00179***
				(0.000)	(0.000)	(0.000)
Hedonic Price			-0.0000001			0.0000002
			(0.000)			(0.000)
Salvage Value			-0.00031***			-0.00032***
			(0.000)			(0.000)
Constant	0.00020***	0.00020***	0.00033***	0.00020***	0.00020***	0.00033***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Year Quarter FE	NO	YES	YES	NO	YES	YES
Ship Type (and Size) FE	NO	YES	YES	NO	YES	YES
Observations	3,735,752	3,735,752	3,635,240	3,735,752	3,735,752	3,635,240
Adjusted R^2	0.000	0.001	0.001	0.000	0.001	0.001

Table A.8: Comparison of Fire Sale Discount across Asset Classes

This table lists the fire sale discounts reported by several papers across different asset classes in real assets and financial assets. The table also reports the quality-adjusted fire sale discounts for real assets.

Panel A			**Real Assets**		
Asset Class	Reason for Fire Sale	Raw Fire Sale Discount	Paper	Quality-Adjusted Fire Sale Discount	Paper
Ships	Arrested Sales	24%	This Paper	12%	This Paper
Houses	Foreclosures or Forced Sales	27%	Campbell et al. (2011)*	9%	Andersen and Nielsen (2017)
Aircraft	Distressed Sales	15%	Pulvino (1998)	8%	Franks et al. (2024)
Aircraft	Sales in Chapter 11 Bankruptcy	20%	Pulvino (1999)	9%	Franks et al. (2024)
Aircraft	Sales in Chapter 7 Bankruptcy	30%	Pulvino (1999)	12%	Franks et al. (2024)

Panel B	**Financial Assets**		
Asset Class	Reason for Fire Sale	Fire Sale Discount	Paper
Equity	Forced stock sales by distressed Mutual Funds	8-10%	Coval and Stafford (2007)
Bonds	Downgraded corporate bond sales by constrained Insurance Firms	6-7%	Ellul et al. (2011)
Debentures	Hedge Fund deleveraging during 2008 crisis	10-15%	Mitchell and Pulvino (2012)

*Campbell et al. (2011) extensively document that the discount on foreclosed homes could be due to vandalism and/or poor maintenance. In a separate set of non-foreclosed houses sold by old homeowners they document an 8-9% discount, which is interpreted as an under-maintenance discount as old people have lower incentives to maintain their homes.

Table A.9: Arrests, by trigger and resolution

This table reports the number of arrests triggered by various creditors, and how the arrest event was subsequently resolved. The classification is made on the basis of LLI narratives in conjunction with other information including data on transfer of ownership and, break-up of vessels.

		Party Triggering Arrest					
		crew	mortgage	other	unknown	unsecured	total
Resolution	auction	11	131	10	50	32	234
	break-up	11	59	39	38	21	168
	sale	20	123	57	126	42	368
	same owner	35	83	428	402	283	1231
	unknown	1		4	187	2	194
	total	78	396	538	803	380	2,195