Lower margins are tied to companies’ ESG rating rather than to low-carbon assets

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Abstract

Lenders are likely to face significant transition risk associated with stranded shipping assets, but whether and how such risks are incorporated in their lending practices is still an open question. The extent of this risk depends on whether banks are able to incorporate such risks in their lending activity. Our results show that lower margins are tied to shipowners’ ESG rating rather than to low-carbon ships. Banks penalized carbon efficient ships before the Paris Agreement, but they no longer do while they have started rewarding shipowners with better ESG performance since then. Signing the sectoral voluntary disclosure initiative (Poseidon Principles), leads lenders to request margins 2.4 percentage points lower for companies with high ESG ratings, compared to those with the low scores. However, the Poseidon Principles does not impact the pricing of ships’ carbon intensity, casting doubts on the capacity of disclosure initiatives to change investment outlays.

Introduction

In his speech the “Tragedy of the horizons”, the Governor of the Bank of England pointed out how financial companies could see their performance affected by climate change \(^1\). Climate-related risks might materialize as a consequence of climate-led extreme events (physical risks), and as asset stranding, when a disorderly introduction of climate policies lead to a sudden and unexpected devaluation of some assets (transition risks) \(^2,3\). The latter is particularly relevant for shipping assets holders as ships are long-lived assets (around 20 years) largely financed by debt, and potential assets devaluation could strongly impact lenders’ financing portfolios. Recent evidence shows that a large range of the shipping existing capacity is at risk of being stranded, since committed emissions reduction from the industry exceed by 30–40% the allocated shipping carbon budget \(^4,5\).

Despite its historical inertia, the shipping sector is under growing pressure from governments, climate-conscious investors and broader public opinion to decarbonize \(^6\). Initial efforts include the International Maritime Organization (IMO) adopting in 2018 an Initial Strategy to reduce shipping absolute emissions by 50% compared to 2008 levels by 2050, and discussion is ongoing to further tighten this target \(^7\). More recently, the EU has agreed to include shipping into the EU carbon market between 2024 and 2026. Shipping customer pressure is also increasing, as demonstrated by initiatives including the Sea Cargo Charter, where signatory charterers commit to report their shipping emissions compared to a decarbonization trajectory, or the Cargo Owners for Zero Emission Vessels, where container customers such Amazon or IKEA are committing to using zero-emission shipping from 2025 onward \(^8\). Such climate initiatives call for greater transparency and climate-related disclosure, the setting of emissions reduction targets and more climate-aligned strategies.

Despite this increased engagement, whether lenders are accounting for and internalising climate-related risks in their decision process is still an open question. The literature has found contradictory evidence on whether transition risks affect the prices of financial instruments, and in particular the cost of debt. While some studies find that transition risks have no effect on the bond yields \(^9,10\), others suggest that some
financial actors have started to incorporate them into bond and loan margins, although insufficiently\textsuperscript{11–14}. In particular, the Paris Agreement might have increased the awareness of lenders on the bond and loan markets as debt pricing have started to reflect borrowers’ environmental performance and owned fossil fuel reserves afterwards\textsuperscript{11,15}. Most of current evidence has looked at how margins vary depending on borrowers’ characteristics such as the companies’ participation to the Carbon Disclosure Project\textsuperscript{13,14}, ownership of fossil fuel reserves by the borrowers\textsuperscript{15} and reported corporate emissions\textsuperscript{11} rather than tie them to the type of assets financed as lower margins should be demanded for low-carbon assets, and vice versa. This might be because of the lack of sufficiently granular data on physical assets and their links to financiers\textsuperscript{16}. Looking at asset and not only corporate level when studying climate-related risks, is crucial for a more realistic assessment of how such considerations translate into investment decision and stranding effects. Indeed, companies with high past ESG rating might not necessarily invest in low-carbon assets and anecdotal evidence suggests that companies with high ESG ratings are not more likely to emit green bonds than less environmentally-friendly companies\textsuperscript{17}.

The shipping lending market offer a unique opportunity to investigate the pricing of the transition risk at both asset and corporate level as ships are often financed by loans using the ship asset as collateral\textsuperscript{18}. In technical terms, ‘collateral’ refers to a lender’s right to possess the asset used as security on a borrower’s potential default or bankruptcy (e.g., the lender reserves the option to liquidate the asset), hence allowing for an exclusive identification between the loan and the underlying asset. Potential transition risks carried by ship assets may impact shipping lenders in two ways. First, like in any other industry, the deterioration of the profitability of the companies affected by transition risks may have cascade effects on their lenders by increasing their default rate, which might be amplified by lenders’ interlinkages\textsuperscript{19–21}. This channel has proved to have substantial impact on shipping lenders in the past. For example, the oversupply of ship capacity and low shipping earnings following the 2008 economic crisis resulted in a non-performing loans ratio of 40\% on German banks’ shipping book, which led to their partial retrieval from the shipping market and large impairment on shipping loans\textsuperscript{22}. Second, transition risk might lead to an unexpected devaluation of the ship assets due to changes in regulation, technology or consumer demand. This would impact the lender in case of the borrower’s bankruptcy, because the value of the ship might be the only way to recover the initial amount provided, although ship arrests are in practice only used as a last recourse\textsuperscript{23,24}.

Here we investigate whether transition risks are reflected into lenders’ lending activity. In particular, we explore whether lenders price environmental performance at the corporate and/or asset level, and whether lenders’ commitment to report on emissions have an impact on investment decisions. The underlying assumption is that if lenders are aware of transition risks on the assets and companies financed, they would incorporate such risks into a higher cost of debt. Additionally, we look at whether sectoral disclosure initiatives, namely the Poseidon Principles (launched in 2019) has impacted signatory lenders’ activity. Indeed, by signing into this framework, 28 lenders covering more than 50\% of the global ship finance portfolio\textsuperscript{25} have committed to assess and report on the carbon intensity of their shipping
portfolio. We used an explanatory mixed methods approach so that we validate and explore the drivers of the quantitative results with insights from 9 semi-structured interviews with major shipping debt-providers, representing together 24% of the shipping debt portfolio.

Results

Development of the shipowners’ financing costs

A large range of tools and metrics are available to measure environmental performances at company (e.g. ESG rating of a borrower) and asset level (e.g. the carbon intensity of a ship). The Carbon Disclosure Project (CDP) offers one of the most comprehensive public database of companies’ ESG rating, containing ratings for more than 13,000 of companies based on their self-reported carbon emissions data and other factors such as governance and engagement. It is thus used as proxy for the perceived transition risk at the corporate level. On the asset side, shipowners have to measure the Annual Efficient Ratio (AER) of the ship above 5,000 gross tonnage to comply with the Data Collection System (DCS) introduced by the International Maritime Organisation (IMO). This indicator measures the CO2 emissions of a ship divided by its capacity and the distance sailed per year, thus capturing transition risks at asset (ship) level. Because of its availability (FUSE database), and after the introduction of the Poseidon Principles, the AER of the ships are widely collected and scrutinized by shipping lenders, as acknowledged by the interviewees.

To investigate whether transition risks impact the margins of the loans, we conduct an econometric analysis on a new dataset obtained by matching a data on syndicated loans from 2010 to 2021 (Dealscan dataset) with related shipowners and ships (Clarkson’s World Fleet Register (WFR)). The Dealscan database contains financial information on underwritten loans, including the margins of loans, defined as basis points over the London Interbank Offered Rate and various loans’ characteristics. Due to confidentiality issues, as lenders are not willing to publicly disclose which ships they have financed and related financial terms, the link between the two databases is created through an algorithm matching each loan to individual ships based on ship’s build date and loan issuance date. In particular, we used the average delay between the date of the loan was underwritten and the date when the ship was delivered to estimate which ships was financed by each loan. This approach allows us to build a new dataset of loans-financed ship assets which did not exist before. As robustness check, the data matching process was validated by one key lender on a sample of transactions representing $7.5bn or 2% of the total underwritten shipping loans (calculated based on the 2021 top 62 shipping banks’ portfolio). This lender confirmed that the algorithm uniquely matched most transactions with the respective ships (90%) proving the validity of the approach. The details of the loans-ships matching algorithm are presented in the methods sections.

The margin of loans mainly depends on loan-, lender-, borrower- and time-, country- specific. The conditions on the loan and the financial characteristics of the borrower impact the pricing of the loan as
they are usually considered proxies for the potential risk that the borrower defaults. We therefore included financial information on the borrower from Refinitiv-eikon. Time and country dummy variables further control for unobserved variables, e.g. the health of the market, which might also affect the riskiness of the loan. Because it is not clear from the literature what are the main drivers of loans dedicated to financing ship assets, we used the WALS tool on an original large list of variables to select a subset of controls. The weighted-average least-squares estimator (WALS) method is used to determine the best model specification in the absence of theoretical model. The initial list was compiled by included traditional drivers of margin identified in the literature and additional variables which were suggested by interviewed lenders (ship second-hand price, number of ships owned by the parent shipowner).

**Pricing of the companies’ and ship assets’ transition risks**

The Paris Agreement has signalled an increased ambition of the international finance community to align financial flows with climate priorities. This has led to an increased pricing of environmental performance into the cost of debt by lenders both at the corporate and at the asset level (Fig. 1).

On the whole period, companies with high ESG rating have attracted lower margin (Fig. 1 model (1)). However, there is a clear increase in pricing after the Paris Agreement and negligible pricing before then, which indicates that lenders have started to price companies’ ESG rating into the cost of debt (Fig. 1 model (2)). We observe this shift by including in the model (2) an interaction term between the companies ESG rating and a post 2015 dummy to capture the shift in pricing of operational carbon intensity after the Paris Agreement.

On the other hand, carbon intensive ships have attracted lower cost of debt than their counterparts over the whole period (Fig. 1 model (3)). Carbon intensive ships attracted significantly lower margins, but only before the Paris Agreement. This effect is particularly counter-intuitive and suggests that not only were lenders unaware of transition risks before then, but they would see carbon efficiency as an unnecessary cost and source of risk. The perceived source of risk might be the incapacity to recoup the additional capital invested for improved energy efficiency through increased revenue, because the ship hiring market only imperfectly reward energy efficiency. The evolution of the pricing over the period suggests that there is an increased awareness of transition risk after 2016 (Fig. 1 model (4)), which is insufficient though since it does not lead to an increased margin for carbon intensive ships. As a result, carbon efficient ships would be priced similarly to carbon-intensive ones after 2015.

The effects of the control variables are in line with previous findings from the literature. Increased maturity is associated with higher margin, indicating an increased risks on the loan. High risk companies which need to provide collateral for their loans have, on average, a cost of debt 1.7 percentage points higher (Fig. 1 models (1) and (2)), but this effect vanishes when looking at only ship finance transactions (Fig. 1 models (3) and (4)). More profitable, less leveraged and bigger companies also attract lower costs of debt. For ship financing, larger amount and lower number of lenders attract higher interest rates (Fig. 1 models (1) and (2)), but those do not seem to have a large impact on the cost of debt of other purposes.
(Fig. 1 models (1) and (2)). Surprisingly, a bullish second-hand ship market increases the lenders’ perceived risk (Fig. 1 model (3) and (4)). Given the cyclical nature of the shipping industry, this suggests that lenders expect grim future economic conditions when the market is high, and inversely.

Interviewed shipping lenders highlighted that margins are not driven by the carbon intensity of the ships they financed neither by climate-related credit risk analysis, but mainly by lenders competition for few top-tier shipowners. Indeed, the margin over LIBOR is set at a minimum above the lender’s cost of capital and the loan credit risk, whose calculation excludes any asset-related transition risks. This credit risk, which has not significantly evolved over the last decade, mostly uses backward-looking variables, such as the company’s leverage and profitability, and expected earnings (which does not include carbon costs) based on historically performance of the shipping segment of the asset. Even when commercial banks mentioned using forward-looking scenarios, none of them included a shipping decarbonization scenario.

Interviewed lenders confirmed that the use of this credit risk methodology is a barrier to pricing transition risks reinforcing inertia to change it: “The capital requirements to our banks is based on our internal risk rating model. We are a so-called IRB Bank internal rating based model approved by the financial regulator (…). We cannot just change that model all the time. (…) But the full effect of ESG and climate is not yet included in that model” (interview 9). However, most of the interviewed lenders have developed tools to measure companies’ ESG rating and environmental strategy over the last decade. Such company score is included by some shipping lenders into the credit risk analysis, which might explain the positive pricing of company’s ESG rating after 2015: “The pricing is still completely risk return driven. So there is no climate risk things. What you see now is that you have ESG, but we see it more on the corporate facility basis.” (Interview 5).

**Effect of lenders’ reporting commitments on margins**

Whether lenders price in the corporate and/or the asset environmental performance into the loans margins might reflect emissions disclosure efforts. The Poseidon Principles allow us to investigate the impact of lenders’ voluntary disclosure initiatives on the pricing of transition risk, since it is the first global sector-wide alignment disclosure agreement.

The Poseidon Principles has a positive effect on the pricing of company’s ESG rating (Fig. 4). The scale of this effect is economically significant showing lowest performing companies face a cost of debt 2.4 percentage point higher than the highest performing companies. However, the Poseidon Principles have a negligible effect on the pricing of the ship asset carbon intensity. This suggests that the voluntary commitment of disclosing its financed carbon emissions can have a concrete impact on investment decisions, but it is not ultimately reflected into the assets financed.

The results suggest that lenders’ climate commitments have translated into an increased pricing of the company’s ESG rating, but not of the asset transition risk. Awareness of transition risks and the necessity of the transition to low-carbon shipping had a concrete impact on the lenders’ behaviour as they provided preferable conditions to shipowners with higher ESG rating. This is a clear incentive for borrowers to
improve their ESG ratings and to be perceived as a more sustainable company. However, the results also suggest that even climate proactive lenders are not aware of the cascade effects of transition risks from the assets to their profitability, as their do not factor the transition risks of their assets into the pricing of the loans they provide.

All interviewed signatories highlighted that the Poseidon Principles had induced a large change in the lenders’ activities, so that data related to the ships’ AER was systematically collected and scrutinized in the investment decision process. Some emphasised that they would take ships’ environmental performance into account to engage with the client, but the impact on actual decisions and even more on pricing are so far limited: “We use the Poseidon Principles to have a dialogue with their clients. So it’s not that we won’t finance a ship which is above the pathway, but we want to (...) understand from the owner what they [and] what their decarbonization strategy is” (interview 4). How this metrics impacts the decision was not clear and seemed to be an add-on on the loan assessment process, while having no effect on calculated credit risk and therefore the pricing: “I wouldn’t say that banks are pricing ships lower if they’ve got a good AER, and worse if it's got a bad AER. I don't think we've reached that basic situation yet” (Interview 2).

Discussion

Shipping lenders when lending to shipowners were particularly misaligned with the decarbonisation of shipping before the Paris Agreement. This paper shows that they were either not aware of, or prioritising, transition risk, as they provided preferable margin to carbon intensive ships while penalizing those with more efficient designs. This might first be explained by the fact that shipping was sheltered for a long time from regulatory pressure to decarbonize while other sectors (mobility, electricity generation for example) had already started their transition. Cargo shipping, which represents most of the sector’s capacity, is also fairly remote from consumer demand making it hard to provide a decarbonisation-aligned business case prior to regulation – for example it might be difficult for end consumers to connect their actions to climate friendly choices related to how their goods are moved at sea. In this context, lenders were pricing in margins they provided to carbon efficient ships and were therefore hindering the uptake of energy efficient ships.

However, the awareness of lenders has increased after the Paris Agreement, and there are signs that this positively impacted the pricing of shipowners’ ESG rating and ship assets’ environmental performance to compensate for the additional risk of the energy efficient technologies. This increased awareness is not sufficient though, as it fails to lead to a differentiated margin based on the carbon intensity of the ship. So, although lenders are supporting ESG rating at a corporate level and they are not favouring carbon intensive ships anymore, they are not yet directly supporting lower-emission ships. This is likely to be because asset-level transition risks are not formally included in the credit risk assessments conducted by major shipping lenders, and related margins are determined by competition between lenders and backward-looking metrics on shipowners and shipping segment past performance. Such methodology is
ill-suited to capture transition risks which have not materialized in the past, which instead would require forward-looking risk assessments\textsuperscript{37,38}.

This is a critical issue for two main reasons. First, given the lifespan of a ship (20 years) and the average tenor of the observed loans (7 years in our sample), the viability of the shipping loans on lenders’ portfolio might likely come at risk in the coming years if transition risks materialize. Second, in practice lenders are not yet incentivizing the uptake of carbon-emission ships by lowering the cost of debt – in fact, before 2015, they were disincentivizing it.

This has important implications for policy makers of the shipping and the lending sectors. Firstly, this paper’s evidence makes a case for strong regulation and enforcement action. It is clear that not only is the negative externality of shipping’s climate impact not internalised (e.g. there is no cost to the sector’s GHG emissions taken by the sector), but market forces that might have been assumed by regulators to drive efficiency improvement in time (e.g. as a means to reduce operating costs), are not evidenced in practice. Using effective policy measures that are clearly aligned to a Paris Agreement temperature goal is needed. Examples include a carbon tax, requirements for newbuilds and/or existing ships, subsidies to alternative fuels production, bunkering and ships.

The evidence that improvements to the way market forces incentivised an improvement in conditions for more energy efficient designs provides a justification that whilst waiting for entry into force of the policy solutions, there is a benefit to having clear signals of intent to decarbonise international shipping in line with the Paris Agreement temperature goals, from organisations such as the IMO. Even if no policy is implemented right away, as expectations of lenders influence investment decisions, a pre-commitment of policy makers would foster private investors towards low-carbon technologies\textsuperscript{2}.

Our analysis further contributes to the nascent evidence on the limited effectiveness of disclosure initiatives in changing investment outlays\textsuperscript{39}. The Poseidon Principles have failed to incentive direct benefits from investing in low-carbon assets so far – which might be linked to the fact that its implementation is recent and the shipping markets have been affected by the consequences of the Covid-19 pandemic - but they have still induced a preference towards companies with higher ESG rating. The fact that lenders price in the ESG rating of the borrower means that they might be indirectly promoting low-carbon ships if shipowners with higher ESG rating were financing more carbon-efficient ships.

However, there is no guarantee that this is happening. Our analysis therefore further strengthens the case for a strengthening of disclosure initiatives and the effort taken to monitor them, or more interventionist policies to regulate the financial sector, not only on the emitters side. Several policy options are available to regulators: requiring lenders to measure and report on emissions financed using industry standards and taxing financial actors based on the emission intensity of their portfolio, or reducing (respectively increasing) the capital adequacy requirements to carbon efficient (intensive) portfolios (green supporting factor) or green monetary easing policies\textsuperscript{16,40,41}. When possible, for example in project finance or with the use of a collateral, such regulations should concern not only the companies’ emissions but also the asset financed. This would allow to link the cost of debt to the environmental performance of the
borrower and of the asset directly, and hence drive the financial system to contribute to the transition to a low-carbon economy.

**Methods**

**Loans-ships matching algorithm**

Because it is not publicly known which ships are financed by each loan, the construction of the dependent variables representing the transition risk requires the development of an algorithm to match individual ships to the loans. This algorithm is further detailed in the next subsection.

Data on existing and ordered ships was collected on Clarkson World Fleet Register, and data on loans were taken from Dealscan dataset. There is no direct correspondence however between ships listed in Clarkson database and the loans listed in Dealscan. We developed an algorithm to provide a "best guess" of which ships were financed by specific loans. This algorithm can be broken down in three steps:

1. First, the average time lag between the active date of the loan on the one hand side, and the ship build date of the ship, on the second hand side, was calculated. This lag is called deal-to-built lag in the rest of the article.

2. In parallel, the correspondence between the list of borrower companies from Dealscan, and shipowners from Clarkson, was built.

3. Finally, the ships were attached to single loans by matching shipowners/borrowers and build dates/loan active dates.

**Statistics on the loans-to-built lag**

For 13 loans identified, a special vehicle was created to act as a borrower for one specific ship. Those loans have been identified because the name of the borrower is the same as the name of the ship or the hull, and the loan purpose is either "ship finance" or "ship or aircraft finance". Although this subset of loans is quite small, it was very useful to identify some characteristics lag between the date at which the loan was active and the date at which the ship was built, which were used in step 3. Average and standard deviation of this lag could be computed, as well as a tolerance threshold (tolerance in the following) for search which is computed as:

\[
\text{tol} = \max (\text{date}_{\text{build}} - (\text{date}_{\text{loan}} + \text{lag}_{\text{mean}}))
\]

With \(\text{date}_{\text{built}}\) being the date in Clarkson database when the ship was delivered, \(\text{date}_{\text{loan}}\) the date a loan became active in Dealscan database, and the \(\text{lag}_{\text{mean}}\) the average of the lags between the loan active date and the build date of the 13 identified loans.
Matching borrowers to shipowners

Apart from those 13 loans clearly identified and for the large majority of loans, it was not possible to find a direct correspondence between the ships and a loan. For those, step 2 identifies the correspondence between:

- Borrowers in Dealscan, identified by the website provided (when available), the stock exchange name (when listed and provided) or their name; and

- Ship owners and ship owner groups in Clarkson, identified by the website provided (when available), the stock exchange ticker (when listed and provided) or their name.

When an exact correspondence was found between either website, stock exchange name or names (in this specific order), those were automatically matched. For the others, an algorithm was run on the list of names to find the closest possible names, and the results were manually checked to find the correspondences between borrowers/shipowners or borrowers/ship owner groups. Note that this step probably missed some correspondences, when the company had changed names for example, but there is confidence that the correspondences found were properly matched. When the borrower was found to have been acquired by another company or has disappeared and the ships are named with a pattern (e.g. Hanjin Shipping named all its vessel "Hanjin X"), the shipowner was not matched but a subset ships whose names correspond to this pattern was matched. The step was very time-consuming and a total of 281 borrowers/shipowners correspondences (with ships, owners, owner groups or former owner) corresponding to 669 deals categorized as "ship finance" or “ship and aircraft finance” were identified.

Matching ships to loans

Of those 669 loans, ships were matched to each of the loans where the ship build date was found to be close enough to the expected build date from the loan data. The date was considered "close enough" when they met one of the following three criteria:

Criterion 1: select all ships of the shipowner where the below two conditions were met:

\[
\begin{align*}
    \text{date}_{\text{built}} - \text{date}_{\text{loan}} &\leq \text{lag}_{\text{mean}} + \text{lag}_{\text{stdev}} \\
    \text{date}_{\text{built}} - \text{date}_{\text{loan}} &> \text{lag}_{\text{mean}} - \text{lag}_{\text{stdev}}
\end{align*}
\]

2

With \( \text{lag}_{\text{stdev}} \) the standard deviation of the lags of the 13 identified loans.

Criterion 2: select all ships of the shipowner where the debt deal is reached between the date at which the ship is contracted to the shipyard, and the date the ship is built:

\[
\text{date}_{\text{contract}} > \text{date}_{\text{loan}} > \text{date}_{\text{built}}
\]

2
With \(date_{contract}\) the date at which the ship is contracted to the shipyard, from Clarksons WFR.

Criterion 2: if no ship met criterion 1 nor 2, find the ship which meets the two conditions below:

\[
\begin{align*}
\min & \quad (date_{built} - (date_{loan} + \text{lag}_{mean})) \\
\text{abs} & \quad (date_{built} - (date_{loan} + \text{lag}_{mean})) < tol
\end{align*}
\]

With \(tol\) from Eq. (1). 308 loan-ships matches were found using method 1, with an additional 307 loan-ships matches found using method 2. One unique loan (defined by a unique date-borrower combination) provides several loan spreads data points because for the same deal, one could have several lenders and borrowing conditions. As a result, a total of 457 unique loan-ships matches were found. We further exclude all loans whose purpose is not “ship finance” or “ship and aircraft finance” from the sample, as those might not have been used to finance a ship. This leads to a dataset of 1053 observations.

The matching results have been validated with one shipping lender, who confirmed that the matching was correct for 89% of the ships identified and classified as “ship finance”. However, the sample of loans reported in Dealscan covers only a small part of the total loan activity (roughly 10% according to the person validating the sample), and is especially scarce on the data after 2019.

**Quantitative data collection**

The transition risk of each ship is proxied by its carbon intensity. Specifically, the Annual Efficiency Ratio (AER) is used as the standard measure of the ship’s carbon intensity. Data for the AER were taken from the UMAS Fuel Use and Emissions (FUSE) model. The AER is expressed in gCO2/dwt-nautical mile and is calculated using the estimated fuel consumption and the travelled distance for the year, so it is dependent on operations during the previous year but not of the share of deadweight utilised.

The efficiency of the fleet has increased over time as a result of high fuel prices rather than regulation\textsuperscript{42}. In addition, larger ships have on average a lower carbon intensity than smaller ships, the ship type has a large impact on the carbon intensity. As a result, the carbon emissions of the ship per deadweight are highly dependent on the type of the ship – i.e. whether it transports passengers or commodities, and in the latter case which cargo is transported – and on the size of the ship, so using directly carbon intensity might bias the results. To control for those variations, the difference in carbon intensity for each ship relative to its cohort was used as a proxy of the ship’s transition risk, rather than its absolute carbon intensity, as follow:

\[
CI_i = (AER_i - AER_{cst})/AER_{cst}
\]

with \(CI_i\) the carbon intensity of the ship which is part of the peer group defined by ship type \(c\), size bin \(s\) and built in year \(t\). Finally, since more than one ship could be attached to a loan, the transition risk of a loan is computed as the average carbon intensity of its attached ships.
Several control variables on loans characteristics and borrowers' characteristics have been included in the regression, based on the suggested independent variables proposed by \textsuperscript{15,30,31}. Loans characteristics is taken from Dealscan directly; companies-related data is taken from Refinitiv-Eikon. Shipowner sizes are taken from Clarksons WFR and second-hand ship price index from Clarksons Ship Intelligence Network (SIN). In addition, fixed effects for years and borrower countries are controlled for.

**Regression model**

The dependent variable regressed is the all-in-spread down ($AISD$) of the loan, i.e. the basis points (bps) over the LIBOR. Note that one unique loan transaction (defined by a unique date-borrower combination) can correspond to several data points if more than one lender is lending, and/or various loans characteristics ($L_t$) are applied. Typically, one loan can be made by two tranches with two different AISD and tenors; each tranche is usually financed by more than one lender. The empirical model used is described by Eq. (5) below:

$$AISD_{lbft} = \alpha_0 + \alpha_1 CI_l + \alpha_2 CI_l \times Post2015 + \alpha_4 L_{bft} + \alpha_5 F_{ft} + \epsilon_{lbft}$$

with $l$ subscripts indicate a unique loan deal, $b$ the lender, $f$ the borrowing company and $t$ the time. $CI_l$ stands for the carbon intensity attached to the loan, which is a function of the carbon intensities of the ships financed. $Post2015$ is a dummy variable which takes the value 1 after 2015 (date of the Paris Agreement), 0 otherwise. $L_{bft}$ and $F_{ft}$ are vector of loan and lender characteristics that might affect the cost of the loan spread. $\alpha_0$ is a vector of fixed effects (year, lender and constant). $\epsilon_{lbft}$ is the remaining variation. The coefficients of the model are computed using an OLS regression with robust standard errors clustered by borrower company.

There is already an extensive literature on the drivers of the loans margins, the loans' and borrowers’ characteristics included were directly informed from those articles. Those include in particular the loan amount, number of lenders, collateral, repayment type, maturity and loan purpose for the loans’ characteristics; and company size, leverage, profitability for the borrowers’ characteristics. However, there is no econometric literature to the knowledge of the authors on the drivers of ship finance. We used the Weighted-Average Least Square (WALS) procedure proposed by \textsuperscript{33} on an original large list of variables to select a subset of controls. The initial list was compiled by included traditional drivers of margin identified in the literature (those used in the first regression model and tranche amount, short maturity and borrower’s capitalization) and additional variables which were suggested by interviewed financiers (ship second-hand price, number of ships owned by the parent shipowner).

A summary of the regression variables included in the model is provided in Table 4 – 1 and the summary statistics in Table 4 – 2.
**Table 4-1**  
Summary of regression variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDP score</td>
<td>The CDP scores were coded from 0 to 4 with 0 being the lowest ESG score possible (E) and 4 the highest (A).</td>
<td>Carbon Disclosure Project</td>
</tr>
<tr>
<td>AER</td>
<td>Ship’s Annual Efficiency Ratio relative to its cohort average AER</td>
<td>FUSE</td>
</tr>
<tr>
<td>Loan amount</td>
<td></td>
<td>Dealscan</td>
</tr>
<tr>
<td>Tranche amount</td>
<td></td>
<td>Dealscan</td>
</tr>
<tr>
<td>Number of lenders</td>
<td></td>
<td>Dealscan</td>
</tr>
<tr>
<td>Collateral</td>
<td>Dummy equal to 1 if the loan is secured by a collateral</td>
<td>Dealscan</td>
</tr>
<tr>
<td>Repayment type</td>
<td>Series of dummy variables corresponding to the type of repayment</td>
<td>Dealscan</td>
</tr>
<tr>
<td>Loan purpose</td>
<td>Series of dummy variables corresponding to the purpose of the loan</td>
<td>Dealscan</td>
</tr>
<tr>
<td>Maturity</td>
<td>Loan tenor, in months</td>
<td>Dealscan</td>
</tr>
<tr>
<td>Short maturity</td>
<td>Dummy equal to 1 if the tenor of the loan &lt; 5 years</td>
<td>Dealscan</td>
</tr>
<tr>
<td>Company size</td>
<td>Logarithm of the borrowers’ total assets</td>
<td>Eikon</td>
</tr>
<tr>
<td>Leverage</td>
<td>Borrowers’ total debt/total assets</td>
<td>Eikon</td>
</tr>
<tr>
<td>Profitability</td>
<td>Borrowers’ net income/equity</td>
<td>Eikon</td>
</tr>
<tr>
<td>Second-hand price</td>
<td>5-year old Clarkprice index</td>
<td>Clarksons’ Shipping Intelligence Network</td>
</tr>
<tr>
<td>Shipowner size</td>
<td>Number of ships owned by the shipowner borrowing</td>
<td>Clarksons WFR</td>
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</tbody>
</table>
Table 4-2
Summary statistics of regression variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
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<tr>
<td>AISD</td>
<td>16262</td>
<td>158.29</td>
<td>102.24</td>
<td>1</td>
<td>1250</td>
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<td>CDP score</td>
<td>4422</td>
<td>2.37</td>
<td>0.86</td>
<td>0</td>
<td>4</td>
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<td>Poseidon Principles signatory</td>
<td>16470</td>
<td>0.02</td>
<td>0.14</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Second-hand price index</td>
<td>16470</td>
<td>21.69</td>
<td>3.99</td>
<td>14.49</td>
<td>33.04</td>
</tr>
<tr>
<td>Loan Amount</td>
<td>16470</td>
<td>7.37</td>
<td>1.31</td>
<td>2.3</td>
<td>10.71</td>
</tr>
<tr>
<td>Tranche amount</td>
<td>16470</td>
<td>6.52</td>
<td>1.36</td>
<td>0.69</td>
<td>10.13</td>
</tr>
<tr>
<td>Number of Lenders</td>
<td>16468</td>
<td>27.4</td>
<td>22.33</td>
<td>1</td>
<td>94</td>
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<tr>
<td>Collateral</td>
<td>16470</td>
<td>0.21</td>
<td>0.41</td>
<td>0</td>
<td>1</td>
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<tr>
<td>Short Maturity</td>
<td>16470</td>
<td>0.59</td>
<td>0.49</td>
<td>0</td>
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<tr>
<td>Maturity</td>
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<td>43.7</td>
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<td>722</td>
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<td>Repayment Type</td>
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<td>2.18</td>
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<td>7</td>
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<tr>
<td>Firm Size</td>
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<td>24.79</td>
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<td>15.38</td>
<td>31.29</td>
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<tr>
<td>Leverage</td>
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<td>0.36</td>
<td>0.15</td>
<td>0</td>
<td>1.21</td>
</tr>
<tr>
<td>Profitability</td>
<td>12086</td>
<td>0.11</td>
<td>0.29</td>
<td>-1.65</td>
<td>4.27</td>
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<tr>
<td>Shipowner size</td>
<td>9960</td>
<td>65.38</td>
<td>80.68</td>
<td>1</td>
<td>968</td>
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<td>AER</td>
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<td>24.11</td>
<td>54.61</td>
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<td>438.19</td>
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<td>Relative AER</td>
<td>998</td>
<td>0.08</td>
<td>1.67</td>
<td>-1</td>
<td>27.71</td>
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</tbody>
</table>

Interview data collection

This article draws on data from 9 in-depth interviews with financiers covering around 27% of the shipping debt, conducted between May and November 2022 to validate the quantitative results and investigate their drivers. 8 interviews have been conducted with commercial banks active in shipping and 1 with an alternative lender specialized on the shipping decarbonization. All were mostly providing shipping debt to the industry, although some would also provide a range of products in addition to debt. All interviews were conducted with senior managers of financial companies involved in the shipping segment. One interview was conducted face-to-face and the others virtually. Interviews typically lasted an hour. All interviews were recorded. Interviews were guided along a general interview guide but were left semi-structured.
Table 4-2
List of interviews

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Location</th>
<th>Poseidon Principles</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interview 1</td>
<td>Commercial bank</td>
<td>North America</td>
<td>Yes</td>
<td>$5-10bn</td>
</tr>
<tr>
<td>Interview 2</td>
<td>Commercial bank</td>
<td>Western Europe</td>
<td>Yes</td>
<td>&gt;$10bn</td>
</tr>
<tr>
<td>Interview 3</td>
<td>Alternative lender</td>
<td>Western Europe</td>
<td>No</td>
<td>$0-5bn</td>
</tr>
<tr>
<td>Interview 4</td>
<td>Commercial bank</td>
<td>Western Europe</td>
<td>Yes</td>
<td>&gt;$10bn</td>
</tr>
<tr>
<td>Interview 5</td>
<td>Commercial bank</td>
<td>Western Europe</td>
<td>Yes</td>
<td>&gt;$10bn</td>
</tr>
<tr>
<td>Interview 7</td>
<td>Commercial bank</td>
<td>Asia</td>
<td>Yes</td>
<td>&gt;$10bn</td>
</tr>
<tr>
<td>Interview 9</td>
<td>Commercial bank</td>
<td>Western Europe</td>
<td>Yes</td>
<td>$5-10bn</td>
</tr>
<tr>
<td>Interview 11</td>
<td>Commercial bank</td>
<td>Asian branch of a North American bank</td>
<td>Yes</td>
<td>$5-10bn</td>
</tr>
<tr>
<td>Interview 13</td>
<td>Commercial bank</td>
<td>Western Europe</td>
<td>Yes</td>
<td>$5-10bn</td>
</tr>
</tbody>
</table>

Declarations

Data availability

Restrictions to the availability of the data used in the econometric analysis (FUSE, Refinitiv-Eikon, Dealscan, Clarksons WFR) apply as they are under license for the current study and so are not publicly available. The CDP scores are publicly available and can be consulted at https://www.cdp.net/en/companies/companies-scores.

Acknowledgements

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Authors contributions

MF, NA and TS designed and conceptualized the research. MF collected and analysed the data. MF and NA wrote the manuscript.
Competing interests

The authors declare no competing interests.

References


**Figures**

![Corporate credit rating and Asset carbon intensity](image)

**Figure 1**

Corporate and asset transition risks, and cost of debt
The dependent variable is the loan margin. The regression coefficients plotted are estimated using the Ordinary Least Squares (OLS). Further controls of loan purpose, repayment type, borrower country and year fixed effects are included in the models (see details results in the methods). Estimates with robust standard errors clustered at company level. *P < 0.1, **P < 0.05, ***P < 0.01.

Figure 2

Company’s ESG score, Paris Agreement and the cost of debt

Effect of the dependent variable CDP score on the cost of debt before and after 2015, estimated using model (2) in fig. 1 with 95% confidence intervals. The CDP scores were coded from 0 to 4 with 0 being the lowest ESG score possible (E) and 4 the highest (A). Predicted costs of debt were corrected by the period average cost of debt for readability.
Figure 3

Financed ship assets carbon intensity, Paris Agreement and the cost of debt

Effect of the dependent variable ship carbon intensity on the cost of debt before and after 2015, estimated using model (4) in with 95% confidence intervals. Relative carbon intensity is the financed ships’ AER compared to their year cohort’s average AER. The predictions of the costs of debt were estimated for different percentiles of the relative AER. Predicted costs of debt were corrected by the period average cost of debt for readability.
Figure 4

The role of lenders’ commitments on the pricing of transition risks

The dependent variable is the loan margin. The regression coefficients plotted are estimated using the Ordinary Least Squares (OLS). Further controls of loan purpose, repayment type, borrower country and year fixed effects are included in the models (see details results in the methods). Estimates with robust standard errors clustered at the companies level. *P < 0.1, **P < 0.05, ***P < 0.01.
**Figure 5**

Lenders' carbon reporting commitment, company's ESG score and cost of debt

Effect of the dependent variable CDP score on the cost of debt estimated when lenders are Poseidon Principles signatories (red) and non-signatories (blue). Margins were estimated using model (5) with 95% confidence intervals.
Figure 6

Lenders’ carbon reporting commitment, financed ship assets’ carbon intensity and cost of debt

Effect of the dependent variable ship carbon intensity on the cost of debt estimated when lenders are Poseidon Principles signatories (red) and non-signatories (blue). Margins were estimated using model (6) with 95% confidence intervals. The predictions of the costs of debt were estimated for different percentiles of the relative AER.