1 Financial Management in Shipping

Financial management in shipping is a high-risk activity due to the substantial amount of invested capital, the cyclical nature of the industry, and the reputational risks involved—for example, as a result of adverse news related to sanction breaches, code of conducts, and environmental disasters. The complexity around sourcing, validating, and reporting relevant information and dealing with documentation based on archaic and paper-based commercial and legal frameworks adds to the risk. Almost a century ago, Fayle (1933, p. 276) noted that: “The
extreme elasticity of tramp shipping, the ease with which new-comers can establish themselves, and the very wide fluctuations of demand, make ownership of tramp steamers one of the most speculative of all forms of legitimate business”.

As a result, if we consider a ship as a legal entity operating in a maritime network of agents, brokers, banks, and suppliers (hereafter “the actors”), we will understand that the costs and risks associated with a maritime voyage are highly distributed, scattered, and often hidden among the multitude of parties. This is also due to the highly secretive nature of the global shipping industry. There is a certain mismatch between what bankers and investors like and what shipping can offer as an industry. To limit risk, bankers like well-defined corporate structures, transparency, and predictable earnings and investors prefer high yields and steady growth. Shipping offers highly volatile asset values and revenues, internationally mobile assets, activities, and corporate structures, and the latter are often less formal with many family owned rather than stock-listed firms. In all this is an interesting business for ship owners, but it easily turns into a nightmare for bankers and investors. In such a setting it becomes clear that the network’s attractiveness, resiliency, compliance, and sustainability over time will benefit greatly by promoting transparency and cost visibility.

In an era of maritime informatics, there are substantial gains in achieving higher degrees of transparency associated with planned and conducted operations in the maritime transport chain.

1.1 A Myriad of Actors Defining a Maritime Transport Chain

The maritime transport sector is a connected network of actors forming a complex and complicated value chain (Haraldson et al., 2020). Whereof complicated refers to the myriad of actors, as illustrated in Fig. 1, ensuring that cargos reach their destinations on time. Complexity refers to the opacity around the network in terms of available, accessible, and accurate data and information.

In theory, the most valuable value chain is the one where its network is clearly mapped and roles and responsibilities clearly defined and where monies, goods, and service levels can be tracked, managed, reported, and eventually improved. The value of such a chain is in its transparency and its predictability.

In practice, however, despite an increasing focus and requirements of financiers\(^1\) to perform increasingly due diligences on the value chain, consistent transparency can be achieved only by sharing data and information throughout the value chain or by enforcement actions from lawmakers, regulators, and financiers embracing frameworks to mitigate the risks related to environmental, social, and governance

\(^1\)Financiers refer to banks, investors, and any other legal entities providing funding and capital to the maritime sector.
(ESG) in their credit exposures. One example is the Poseidon Principles (2019), which will be covered later in this chapter.

1.2 The Spread of Costs and Risks Throughout the Value Chain

Based on the myriad of actors and the complexity of the maritime network, a discussion on how to fairly and consistently spread the costs and risks of a voyage throughout the value chain in terms of resiliency, compliance, and sustainability becomes highly relevant. We use the following operational definitions:

- **Resiliency** is the ability to withstand events that could affect the cash flow of a ship by taking into account the different charter arrangements (see Sect. 2.1) and its legal validity, hence impact on liquidity in stressed situations. Charter fees are the principal source of repayment in connection with ship financing, impacting liquidity and profitability ratios that financiers use to monitor the performance of a shipping loan.
- **Compliance** is the licence to operate a business in respect to and within a given set of rules and regulations, such as trade sanctions and anti-money laundering.
Compliance can have a significant impact on liquidity and thereby a borrower’s repayment capability and hence covenants.²  
• **Sustainability** is defined as the investment required to decarbonise and operate with respect to environmental, social, and governance requirements and a ship owner’s personal criteria. Sustainability can have a potential impact on cash flows and the collateral value of a ship and therefore the value to loan ratio.³

For financial management and decision-making, costs are often classified as a capital expense (CapEx) or an operational expense (OpEx). CapEx are “funds used to acquire, upgrade, and maintain physical assets such as property, buildings, an industrial plant, technology, or equipment” (Kenton, 2019). “Capital expenditure should not be confused with OpEx, which are shorter-term expenses required to meet the ongoing operational costs of running a business. Unlike capital expenditures, operating expenses can be fully deducted on the company’s taxes in the same year in which the expenses occur” (ibid.).

Maritime informatics can provide substantial opportunities to cost control and risk mitigation associated with both CapEx and OpEx. We also acknowledge that different shipping segments have different business logics and may differ in terms of the impact of CapEx and OpEx.

In terms of risks, there is mounting pressure from financiers to request and perform enhanced due diligences by measuring, mitigating, and reporting financial and non-financial risks, for example, in terms of trade sanctions, environmental and climate performance, and unknown liens tied to the ship.

Increasingly, the maritime network will benefit by promoting connectivity solutions among the actors to secure and share relevant data and information to help mitigate risks and reduce costs throughout the value chain. The industry is familiar with collaboration and sharing. Collaborative arrangements between owners with regard to their tonnage have existed for many years and are referred to as a “pool”. The principle is simple; two or more ship owners merge their commercial operations to form a larger offering to their clients. This means that these ships work collectively, enabling the owners to offer more contracts and tonnage options and also share expenses. By sharing costs, and also profits and losses, the pool enhances its ability to secure funding from sources beyond traditional shipping financiers.

The mechanism of ship mortgage and pledge over present and future earnings will likely remain distinctive for the industry. Equally so, the right to enforce financial obligations will remain essentially in their current form, such as repossession, sale, and arrest (eventually followed by sale) of the ship (Girvin, 2019). Events like the COVID-19 pandemic represent triggers for performing material impairment tests of the securities pledged the favour financiers. Depending how well those

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²Provisions required by financiers to ensure adequate mechanism to monitor the performance of a financial transaction.
³The value to loan ratio is a covenant ensuring that the value of the mortgaged ship does not fall below a certain percentage (e.g. 110%) of the loan debt provided by the financiers.
events are described in the deed of covenants (ibid.), they can and will be considered as an event of default to be enforced.

The assessments of the performance of a specific financial structure are based on past and present information—mainly financial data around past earnings—supporting the evaluation of present “state of things” as a starting point wherefrom to predict and forecast future market conditions, for example, in terms of stress testing.

The preceding approach is rather “subjective” in terms of assessment models, outlooks and risk statements, and appetite for ship owners, banks, and other relevant actors in the different segments of maritime transport. It relies on scattered data points at best. At worst, those data points are immaterial, inaccurate, or inaccessible. Therefore, they are misleading in terms of financial management and decision-making. Maritime informatics can contribute to achieving control, mitigating risks, and reducing the subjectivity of the assessments and thereby the costs associated with financial assessments.

In order to understand the role that informatics could play, we briefly look at traditional ship financing and characteristics. Traditional ship owning and building were heavily dominated by seafaring nationals and families throughout the 1900s, in particular by Greeks, Germans, Danes, and Norwegians. Traditionally shipping routes were localised, and there was no need for large fleets. Finance was dominated by local banking structures (half equity, half finance) backed by very low interest rates.

As tonne miles increased with the prominence of Chinese industrialisation from the 1950s onwards, so too did financial options. Traditional financing was replaced with modern twenty-first century finance; bonds, debt sharing, and initial public offering (IPOs) began to influence who had the ability to raise funds, and competition was introduced into every element of the shipping chain, from ship construction to ship owning. Today, we are accustomed to large oil majors with A+ grade bonds; however, ship owners are often within the junk bond section. This is a segment in which more transparency could enhance an owner’s potential to raise cheaper funds, as we will explore in the next section.

2 The Financing of Maritime Transport Services

Shipping is a transnational, cross-jurisdictional, and cyclical industry with highly leveraged assets. Thus, the ability of a ship owner to understand and time this complex market is a critical dimension for investment decisions, impacting the capability to finance investments throughout the lifetime or possession of a ship. Understanding the market requires insights and investments, and there are high levels of uncertainty and sheer luck. Therefore, it is vital that potential investors, banks, and all lenders have up-to-date and accurate information pertaining industry metrics and not be reliant on rules of thumb or simplistic drivers such as oil prices.
Typically, financers translate uncertainties into risks, which result in a premium to be paid in terms of higher capital costs, mainly interest related. Markets will usually translate uncertainties and luck into higher or lower operational costs. For capital as well as operating costs, the translation can differ widely between shipping segments.

The shipping industry is operated through different types of chartering. This means that the ship may or may not be owned by the shipping company that provides services to its clients. A ship can be chartered at several layers, and operational costs, manning, and technical or nautical management could be outsourced. Chartering contracts (Gorton, Hillenius, Ihre, & Sandevärn, 2009; Tallack, 1996) are divided into three types: voyage charter, time charter, and bareboat charter.

**Voyage charter**, is an agreement for the transport of goods at sea where the ship is doing for the charterer one or consecutive voyages. Freight is determined depending of area, cargo, distance, passages risk, and overall freight market level. A voyage charter is a contractual agreement between the owner and charterer whereby the owner loads the cargo, undertakes the voyage including all costs and responsibilities, and delivers the cargo to the charterer or its customer. It resembles taking a taxi between two points. The consecutive version of a voyage charter is agreed with a single shipper; freight is usually then calculated in the same way as for a traditional voyage charter. Such trade is usually called tramp shipping. The owner of the ship covers capital, operating, and voyage costs. In certain types of voyage charters, sling for loading and discharging sawn timber in a general cargo open hatch ship is not included. Under a voyage charter, the owner has a larger share of contractual obligations and responsibility, and the masters follow instructions from the ship owner.

**Time charter** enables the charterer to “rent” a ship for a period of time, or for a specific voyage. Freight is prepaid and covers a certain time, such as 30 days. It is similar to hiring a bus with driver for a vacation or excursion. The charterer is liable for all costs including bunkers, fairway dues, canals, and port fees, but the owner remains responsible for the cost of the crew and the financing of the ship. These types of charters are often paid by the day, 30 days in advance, and are often tied by contractual constraints, such as trading and cargo exclusions, enabling the charterer to only use the ship for its core business and not “to play the market”. Under a time charter contract, the owner has less contractual responsibilities than it would have under a voyage charter. The owner covers capital and operating costs, but voyage costs are covered by charterer. The master is instructed by the ship owner regarding the ship and the charterer regarding the cargo.

**Bareboat charter** is uncommon in the “spot” market and is usually reserved for very long-term charters between an owner and a charterer with a long-standing relationship. Under this agreement, the owner builds a ship, and the charterer is responsible for all cost, including the crewing and management of the ship. It resembles leasing or renting a car. These types of contracts are common between refineries, or state-controlled entities that need control of tonnage, yet do not want the capital expenditure of building the ship appearing in their balance sheet. It is
common that the ship is additionally re-chartered for as a time or voyage charter. The master is both appointed and instructed by the charterer.

These different types of chartering procedures are summarised in Table 1. The ESG costs will always be carried by the ship owner, who owns the asset. The type of charter determines the data to correctly allocate costs and hence contribute to enhance the predictability of present and future cash flows.

In shipping, strategic plans are developed based on a company’s vision and goals, bearing in mind competitive advantage and challenges. A practical plan is to establish key performance indicators (KPI) and targets. For example, a KPI from a customer’s perspective with direct impact on financial objectives is average running cost per day per ship. Achieving this KPI requires a set of performance measures from each ship, such as the number of overdue planned maintenance tasks. Increasingly, financiers include ESG-related KPIs mainly around decarbonisation in terms of reduction of CO₂ emissions measured as “carbon intensity” (see Sect. 3.4).

Data analysis assists in developing a minimum cost scenario highlighting the potential savings and how they can be realised. This also allows integration of risk management with such scenario developments. Different types of shipping are also used in exemplifying maritime informatics opportunities. For the elaboration of the characteristics on different types of shipping, see Lind et al. (2020).

### 3 The Different Maritime Transport Costs

Building upon “general cost classification” (Stopford, 2008), OpEx can be distributed over operating cost for operating a ship and voyage costs associated with the actual voyage. The price of a transport needs thus to reflect CapEx, OpEx, voyage costs, and increasingly ESG costs, mainly in terms of preventive measures, both CapEx and OpEx, to mitigate climate and social risks.

Understanding the diversity and nature of operating costs is extremely important. Most business models utilise cost-efficiency to increase shareholder value; however, most costs within the shipping industry are considered as “sunk”. They are paid operating and running costs and include:

- Dry-dock (maintenance costs)
- Crewing/management fees

| Charter type       | Duration             | Capital costs | Operating costs | Voyage costs | ESG costs |
|--------------------|----------------------|---------------|-----------------|--------------|-----------|
| Voyage charter     | Single voyage days to weeks | Ship owner    | Ship owner      | Ship owner   | Ship owner|
| Time charter       | Days to years        | Ship owner    | Ship owner      | Charterer    | Ship owner|
| Bareboat charter   | Months to several years | Ship owner    | Charterer       | Charterer    | Ship owner|
Dry-docking is an inescapable part of ship ownership and a requirement of the regulations set by the International Maritime Organization (IMO, 2017). Appropriate crewing of a ship is also a core part of a ship’s regulatory compliance and operational requirements. A crew often includes a mix of seafarers with a variety of nationality, experience in years, and rank required for specific voyages.

The costs associated with operating ships are diverse, non-standard, and involve high levels of complexity. At the macro level, costs can be categorised (Lind, Lillelund Forcellati, et al., 2018a; Stopford, 2008; Wijnolst & Wergeland, 1996), as below and detailed later in Table 2:

- Voyage cost (OpEx)
- Operating cost (OpEx)
- Capital cost (CapEx)
- ESG cost

### 3.1 Voyage Costs and the Role of Maritime Informatics

A voyage requires many services, each of which generates expenses that need to be tracked, validated, and classified to create a system of record. Subsequently, these data can be analysed to determine, for example, the profitability for each voyage and identify actions for improving performance (Lind et al., 2018b).

Voyage costs vary by locations and jurisdictions and are potentially impacted by the opacity of the value chain because of different rules, regulations, cultures, and codes of conduct throughout the value chain.

Furthermore, the services and goods related to a specific voyage can be difficult to predict due to unplanned and unscheduled events. When a service is required by a ship, usually the service provider cannot provide much transparency if the process remains largely manual, unstructured in its communication, and difficult to reconcile due to language, geographies, and cultures. Digital records can support cost calculation and verification, such as the “Pay-As-You-Sail” (PAYS) licencing model for electronic charts. Another example, very helpful during the Covid-19 pandemic, is the digital loss prevention tool (TELP) introduced by the Swedish Club (TradeWinds, 2020).

### 3.2 Operational Costs and the Role of Maritime Informatics

Maintenance is an important contributor to achieve the intended lifetime of technical capital assets, such as ships. Maintenance regards all technical and management actions intended to retain an item in, or restore it to, a state in which it can perform as required (ISO, 2016). This captures combinations of all the technical and associated administrative activities required to keep equipment, installations,
Table 2 Different costs associated to maritime transports (building upon Stopford, 2008; Wijnolst & Wergeland, 1996) and digital data streams driving financiers’ costs and risks

| Costs                      | Digital data streams driving financiers’ costs and risks |
|----------------------------|---------------------------------------------------------|
| Type          | Category                    | Definition                                                                 | Resiliency                                      | Compliance                                      | Sustainability                                    |
| Voyage cost (OpEx) | Canal costs                  | Costs associated to the passage of canals                              | Canal fees and accumulated fees throughout the voyage | Sharing of time slots for passage in standardised formats | Present and future trade patterns                |
| Port fees                  | Costs associated with cargo handling at a port (often includes agency fees as well) | Open, national, international, and offshore and dual flags registers capturing fees Accumulated fees throughout the voyage | Port congestion and regulation (code of conduct) |                                                |                                                 |
| Agency fees                | Costs associated with calling a port for cargo handling |                                                | Sharing of plans and progress by involved actors |                                                |                                                 |
| Bunker                     | Costs for ships fuel. Determined by ship machine, size, speed, hull, weather, draft, etc. |                                                |                                                | Fuel efficiency/smart metres | Country-specific regulations | Possible introduction of green tax regulation Data on used type of bunker |
| Operating cost (OpEx)      | Crew costs/management fees   | Costs associated to the crewing of the ship and the technical management in some cases | Operating as a pool, stand-alone, in-house, or outsourced ship management | Own vs. third parties’ services meeting standardised and agreed requirements | Contingency plans for crew Insurance coverage |

(continued)
| Costs Type | Category | Definition | Resiliency | Compliance | Sustainability |
|------------|----------|------------|------------|------------|----------------|
| Repairs and maintenance | Costs for repairs when damage occurs, maintenance of ship equipment (hull, cargo handling equipment, engine, auxiliary, superstructure, etc.). This includes costs for spares kept onboard and minor repairs | Employability | Frequency of expected and conducted repairs | Regular inspections and certifications |
| P&I, Kasko | Insurance costs for cargo (third party), machinery, and hull | Laws of a specific flag | Sanction regimes | Standing and reputation |
| Dry-dock | Costs for periodic dry-dock when larger maintenance and repairs are carried out. The maximum interval between any two dry-dock inspections should not exceed 60 months; however, this interval is reduced to 36 months for ships over 10 years old | Transhipment | Black-listed | |
| Management fee | Costs for commercial and operational activities like technical, nautical, and crew management and administrative tasks like equipment purchase and arranging insurance and claims. Usually called administration cost or overhead. Varies with the size and trading area of a ship and dependent on the business model of the owner but usually sensitive to economics of scale | Size of cargo | Benchmarking with similar companies in the industry | Contractual framework and standards |
| Capital cost (CapEx) | Interest (own cap) | Expectations or requirements from equity owners usually defined as a discount rate of invested capital. Often referred to as the yield | Ownership (e.g. special purpose vehicle) and injected own funds | |
| Support for Financial Decision-Making | 265 |
|-------------------------------------|-----|

**Interest (loan)**
Interest payments to a financial institution
Costs for depreciation over a ship’s economic life and is largely set by its new (or second-hand market) price. Depending of segment, this cost could vary widely. Lifespan in wet bulk and product tankers is 15 years; passenger ships could have an economic lifespan of 30 years or more. Calculations also must consider residual value as ships could trade in another geographical areas to prolong their economic life. Finally, a ship’s rest value is set by its weight and internals as scrap.

**Depreciation**
Interest payments to a financial institution
Costs for depreciation over a ship’s economic life and is largely set by its new (or second-hand market) price. Depending of segment, this cost could vary widely. Lifespan in wet bulk and product tankers is 15 years; passenger ships could have an economic lifespan of 30 years or more. Calculations also must consider residual value as ships could trade in another geographical areas to prolong their economic life. Finally, a ship’s rest value is set by its weight and internals as scrap.

**ESG cost**
**Taxes**
Future carbon taxes on bunker fuel impacting the OpEx

**Compliance**
Disclosure and reporting requirements to banks, regulators, agencies, etc.

**Depreciation**
Scrubbers, retrofit, and new propulsions impacting the CapEx

| Financial ratios impacted by freight rates, interest and currency exchange rates fluctuations (Future) earnings capacity |
| Corporate incorporation (state owned, public or privately listed, etc.) and quality of security package and jurisdictions |
| Reputation and shareholders Creditworthiness of the charterer or shipper Managerial capacity and integrity |

| Ship values impacted by demand and supply of ships in different segments |
| Level of governmental subsidies; e.g. tax incentives for investing in greener technology |

| Conducted trade/activity (e.g. oil, bulk, passengers) |
| Additional security in the form of parent guarantee |

| Full disclosure of ownership Due diligence of the supply chain (e.g. know your customer’s customer) Carbon intensity |
Fig. 2 Ship operating cost index (annual change in percent) (Drewry, 2019)

and other physical assets in the desired operating condition or to restore them to this condition. Maintenance cost is a significant portion of the operational cost, and breakdowns and downtime have an impact on a ship’s performance, higher repair costs, and health, safety, and the environment. The cost categories such as spares, stores, lubricants, maintenance, and repair are the expenses that support a ship manager’s decisions in terms of effective and efficient technical management. These costs are rapidly increasing, especially with a ship’s age. It can be up to 20–30% of total operating expenses. The latest Ship Operating Costs Annual Review and Forecast 2019/2020 by Drewry (2019) (Fig. 2), which includes ships in the container, chemical, dry bulk, oil tanker, LNG, LPG, general cargo, reefer, roro and car carriers sectors, presents an increase in costs on broad-basis across all the main cargo carrying sectors. According to Drewry’s estimates, the average daily operating costs on 46 different types of ships and sizes increased by 2.2% in 2019, in comparison to underlying increases of 1.1% and 0.7%, respectively, in the previous 2 years. Costs on stores, spares, and lubricants increased for a third year. Expenses on repair and maintenance and dry-docking fastened to 3.1% in 2019.

Maintenance optimisation models indicate the best decision given a certain problem and available information. The traditional OpEx optimisation approach links to the income and are usually run through cost-cutting programmes in order to meet the income and market challenges. However, smart OpEx management can provide solutions for cost savings in the range of 14–45% (Brattekaas, 2019). The traditional approach lacks investment in digital solutions and optimisation via innovation. Even the Best Practice Ship Management Study (Fraunhofer and Germanischer Lloyd, 2013), which compared snapshots of 200 shipping companies at an interval of 2 years in 2010 and 2012, for each USD1000 CapEx, only USD7 were invested in software technologies. As a comparison, the oil and gas industry invests USD35 in new assets for every USD1000 in CapEx. Nevertheless,
the ongoing change and next management generation has lowered the barriers to more widespread use of information systems in all departments. There is scope for maintenance optimisation due to the technological push and economic necessity, which is today possible via digital solutions, data integration, and analysis at a very nominal cost to optimise business processes.

The growing trend towards business intelligence applications is to integrate data and automate reporting. The wide range of compatible modules combined with reliable communication and data management can simplify operations, optimise performance, and save costs. In recent years, companies across multiple industrial sectors have invested in improving their understanding of both historical and real-time data that they possess. The source of the data is specific to the processes, but the objective for all remains the same: to use data analytics techniques to develop a toolset facilitating prediction of performance based on real-time and historical data.

Condition monitoring (CM) has gained traction in recent years, as scheduled overhauls are significantly more cost-effective than unscheduled repairs. In maritime applications, maintenance strategy has evolved from a planned to a predictive maintenance model mainly on the back of CM developments in the sector.

Condition-based maintenance constantly checks the performance of equipment, providing alerts or alarms in advance of potential equipment failures and collects data for evaluation. The data analysis offers a machinery health management system capable of supporting appropriate decisions about maintenance actions based on diagnostics or prognostics information, available resources, and operational demand. An online system connected to a ship’s communication network enables exchange of process parameters, such as output, speed, temperature, and start and stop variables. Based on process parameters, online CM systems can independently relate data to operating status and use variable alarm thresholds. Data synchronisation with online monitoring systems uses the variables received to decide whether there has been a significant change (trigger alarm value/initiate event) or additional measurements initiated (smart data) or the data should be saved/discarded.

A combined implementation of offline and online systems offers the most economical approach to reliable CM. Using this combined approach, critical machines can be monitored around the clock using online systems whereas less critical machinery is monitored at suitable frequency, such as with planned maintenance system (PMS), using offline measurements. The result is a reliable and cost-efficient CM programme and a general reduction of the workload for the onboard crew. Any retrofit or addition of equipment arising from the need of regulatory compliance adds to the maintenance cost will result in certain increases to operating costs. These additional costs cannot be ignored, and ship owners and operators must find new and innovative ways to reduce their OpEx.

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4PMS is a software system that allows maintenance teams and operators to plan maintenance tasks. It allows to request and schedule tasks at set intervals based on maker or class requirements.
Adopting maritime informatics principles may be intimidating and be perceived to be a costly add-on without real benefit; however, the best justification of enabling digitalisation is in the data itself. Without measurement, new learning is not possible. Investments are required for onboard sensors, data transmission, and analytics. Data can support investment in a machinery health management system where benefits can far outweigh the risk (See Fig. 3). Maritime informatics for every shipping business will soon be a necessity for continued commercial buoyancy. To achieve financial efficiency in OpEx, ship owners need to monitor and analyse performance more frequently than the traditional use of daily noon reports or weekly maintenance reports.

### 3.3 Capital Costs and the Role of Maritime Informatics

The decisions on where to incorporate which law to follow and how to operate and manage a ship have an impact on the capital costs. Broadly speaking, capital costs are a function of the profile of the borrower (incorporation, management structure), its ownership, commitment (invested capital, additional securities pledged in favour of financiers, recourse vs. non-recourse), the operating risks (present and future cash flow), its financial standings (earnings ability), and the quality of collaterals to offer. The prior decisions are influenced by:
Support for Financial Decision-Making

- The economic cycles and the volatility in demand impacting freight rates and ship values for the different segments of maritime transports
- Laws and regulatory requirements
- Risk profile and ownership requirements

It appears clear that the decision-making can be severely weakened when flows of critical data are potentially withheld by vested interests within the value chain. Unclear decision-making is detrimental to the network, and increased capital costs and opaqueness spreads throughout the value chain.

Timely disclosures of relevant and accurate information promote resiliency, compliance, and sustainability resulting in predictability. Trust and confidence are built when assessing, managing, and reporting the present and future costs of capital. In this regard, several indicators can assess the predictability of capital costs:

1. Macro outlook especially in terms of low economic growth
2. Over-capacity within the different segments
3. Falling new or second-hand ship prices
4. Technological obsolescence, either due to the introduction of more efficient ship models, propulsion methods, or changes in regulation

### 3.4 ESG Costs and the Role of Maritime Informatics

ESG initiatives and investments are opportunity costs impacting the predictability of capital, operational, and voyage costs. They can arise as a consequence of failing to comply with targets and thresholds (e.g. IMO goals for reducing greenhouse gas emissions by at least 50% by 2050) and result in possible fines, higher interest rates, additional capital injections, higher fees to port agents, delays, and rectification of incidents. In many cases, it means no access to borrowing funds.

In this regard, the newly introduced Poseidon Principles (2019) are consistent with the policies and ambitions of the IMO requiring signing banks to align their credit portfolios to responsible environmental targets around carbon emission by reporting the carbon intensity\(^5\) of a ship’s financial exposures based on four principles:

1. Decarbonisation trajectories for each ship type and size class. Signing banks will be required to assess whether the carbon intensity of credit exposures is aligned with the IMO’s greenhouse gas targets. The assessment is performed based on

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\(^5\)Carbon intensity represents the total operational emissions generated to satisfy a supply of transport work (grams of CO\(_2\) per tonne-nautical mile [gCO\(_2\)/tnm]). Carbon intensity is typically quantified for multiple voyages over a period of time (e.g. a year).
parameters such as fuel consumption and distance travelled in terms of Annual Efficiency Ratio.\(^6\)

2. Accountability for using data and information from classification societies and other organisations recognised by the IMO.

3. Enforcement by including precedent covenants and definitions in new loan facilities.

4. Transparency by way of having signing banks to report annually—first report in mid-2020—on their climate alignment to IMO targets.

While the Poseidon Principles only consider the environmental and climate risk aspect of ESG, increasingly social and governance elements are being introduced to assess the impact on capital costs over time.

Key IMO derivatives, including the exclusion of green energy penalties, hinder emerging countries developing their industrial capacities. If the correct metrics are used when determining risk, then developing countries could have greater access to international funding, which is typically reserved for companies in developed countries with established corporate governance. Maritime informatics should seek to aid these developing countries.

4 Maritime Informatics for Financial Decision-Making

Maritime informatics can enable and enhance the predictability of flows through digital data sharing, collaboration, and connectivity among actors and the capabilities within existing operational systems, such as CM. It can disrupt existing financing practices by adding great value to financial analysis of maritime transport services when assessing risks, calculating ratings, and consequently interest margins for a specific loan transaction.

The ability to secure distribution and access to relevant data for each cost category in terms of resiliency, compliance, and sustainability will enhance the sector’s ability to attract new types of financiers, anticipate and mitigate risks, and withstand disruptive events. In the following table, relevant digital data streams\(^7\) for enhancing the financial arm of maritime informatics are identified.

The maritime industry has been traditionally compliance driven. The compliance with upcoming regulations can appreciably drive the CapEx and OpEx. The ESG costs are becoming increasingly important for ship owners, investors, and financiers. Ship owners face a huge variety of ESG risks beginning at the construction phase and continue throughout the trading life of a ship concluding at the end of its

\(^6\)Annual Efficiency Ratio is a carbon intensity metric using data from the IMO Data Collection System collecting consumption data for each type of fuel oil used during a voyage (for further reference IMO Ship Fuel Oil Consumption Database).

\(^7\)A digital data stream is a “continuous digital encoding and transmission of data describing a related class of events” (Pigni, Piccoli, & Watson, 2016).
lifecycle. Maritime informatics have a huge opportunity to shape the way in which capital providers, banks, investors, funds, and other sources of finance address their direct and indirect responsibility into the future. The big data required for this purpose is voluminous and complex that traditional data-processing applications handle inadequately. Digitalisation can help to address impacts of upcoming regulations and compliance. Compliance is fundamental to valid trading of ship, while additional operational costs are generated. For example, with the recent IMO2020 sulphur cap enforcement, bunker procurement processes have become more complex. A sophisticated bunker plan is critical, as hedging of bunkers has become more competitive, thus impacting the overall operating costs. However, digitalisation can provide innovative solutions to tackle these challenges more efficiently by planning voyages carefully while taking regulations into account during cargo and freight evaluations. It can also provide informed decision-making by integrating any operating cost of emission abatement method and compare future bunker requirements to multiple scenarios and thus simulate different bunker impacts on the financial performance of the ship.

Ship owners collect vast volumes of data associated with various equipment onboard to optimise ship performance. However, much of these data are fragmented as data is collected by multiple applications. Further ship owners, equipment manufacturers, classification societies, and shipyards handle this on a ship-by-ship basis. Maritime informatics offers an opportunity to combine this data and can make this knowledge available for improving financial decision-making. The timing for harvesting the benefit of digital data sharing and enhanced transparency is excellent.

The COVID-19 pandemic is sparking an urgency for digitalising flows and processes, thus building resiliency throughout the value chain. Regulators are enhancing frameworks and introducing guidelines and instruction to secure a compliant operational baseline. Finally, stakeholders—whether it is about investors, financiers, and end-consumers—are signing up to sustainable principles and commitments and increasingly putting pressure on the maritime network to disclose accurate and useful information for the economic advantage of the whole sector.

5 Conclusion

Maritime informatics is digital data sharing and enhanced transparency-empowered decision-making through data analytics. It has direct applicability to financial issues for maritime transport. The ability to analyse data to reduce costs and mitigate risks will improve finance management. Data analytics can support:

- Optimal steaming for just-in-time arrivals
- Reduction of unnecessary waiting times by enhanced coordination
- Efficient utilisation of human resources
- Service providers and service consumers while establishing market-based business deals
• Predictive maintenance based on digital twins of key assets and their components
• Optimised cargo planning

These are some examples on how maritime informatics can play a decisive role in the digital transformation of financial decision-making.

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