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Green Deal and financing sustainable transport in Europe: A target costing analysis☆

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ABSTRACT

This study investigates how Europe financed an efficient and environmentally friendly transport system and supported clean shipping investments from 2012 to 2021. Grounded in target costing theory, which aims to maximize a product's future success, this paper evaluates several green European financing pools and their effectiveness in facilitating the Green Deal transformation of the transport system. Utilizing a unique dataset from the Clean Shipping Project Platform, the results of this study indicate that Europe's environmental and financial support primarily stemmed from the European Investment Bank (EIB) which began backing green investments in 2010. The findings reveal a cautious yet significant contribution of the EIB towards climate protection in the shipping industry and identify challenges in financing smaller firms and innovative technologies thus emphasizing the need for strategic fund allocation to align with the EU's climate goals. These insights have critical policy implications for EU-based financing of European environmental policies prior to the proclamation of the Green Deal, which preceded the 2021–2028 budget period, as well as for the available climate funding mechanisms aimed at achieving the COP26 targets.

1. Introduction

Europe aims to develop a modern, integrated transport system to enhance its global competitiveness and address the challenges of sustainable and inclusive regional development. A crucial step toward this goal is establishing infrastructure that facilitates efficient, effective, and sustainable transport systems and maritime supply chain management (International Maritime Organization (IMO), 2019). Achieving this objective necessitates a clean shipping industry with a target of reducing greenhouse gas emissions from international shipping by at least 50% by 2050 (IMO, 2019). The shipping industry plays a pivotal role in the European Union (EU) as 77% of its external trade is transported by sea (European Environment Agency–EEA, 2021). Maritime transport is Europe's second-most preferred mode of freight transport, accounting for 90% of global freight volume and involving more than 900 key seaports (United Nations Conference on Trade and Development–UNCTAD, 2021).

In the context of reducing shipping emissions, the Baltic Sea Region (BSR) has taken a leading role due to the 2015 establishment of Emission Control Areas (ECAs) in Northern Europe, including the Baltic Sea and the North Sea. The Sulfur Emissions Control Areas (SECA) regulations in the BSR mandate the use of low-sulfur fuel or expensive abatement

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technologies that limit sulfur content to 0.1% (Jiang et al., 2014). Consequently, the BSR serves as a testbed for the green-blue shipping transition in European maritime transport. While the primary motivation for implementing SECA regulations was environmental, these regulations have imposed additional costs on the shipping industry. Olaniyi and Prause (2019) and Prause and Olaniyi (2019) estimate that SECA regulations cost shipowners around €550 million per year, with an additional €3 million per year in administrative burdens, predominantly borne by shipowners. Despite these costs there has been no significant increase in transport costs or changes in transport patterns in the BSR which is likely due to low fuel prices between 2016 and 2021.

However, recent studies indicate that most technological compliance measures have been costly and involved high capital utilization potentially resulting in wasted resources (Atari et al., 2019). Notably, shipowners who installed scrubbers to comply with SECA regulations experienced increased fuel consumption and CO2 emissions which partially negated the intended emissions reductions. Scrubbers do not reduce CO2 emissions therefore necessitating additional abatement devices for energy efficiency. Clean shipping regulations primarily benefit through healthier air, reduced pollution, and improved environmental conditions which benefit BSR inhabitants but impose costs on the shipping industry and private businesses. Reinhold et al. (2019) highlighted that better air conditions in the BSR reduced premature deaths by about 1000 annually.

The European Commission, through the European Investment Bank (EIB), has pledged substantial support for these efforts (Papageorgiou, 2016). The EIB is a major financer of climate action both globally and at the European level (EIB, 2020a, 2020b). Achieving the objectives of the Paris Agreement and the European Green Deal activities — which aim for climate neutrality by 2050 through the European Climate Law and Pact — requires trillions in investments (United Nations Climate Change Conference–COP26, 2022; United Nations Climate Change Conference–COP26, 2021). Given the significant financial commitments made for emissions regulation compliance, this study examines the extent to which the pledged financial support for clean shipping investments has impacted maritime businesses and aligned with European environmental policy while questioning Europe's readiness to meet COP26 targets in the medium-to long-term.

The primary research questions addressed in this study are: first, how have European institutions financially supported clean shipping investments in recent years? Second, what has been the focus of this financing, and how have these investments performed financially? Third, to what extent has the pledged financial support impacted maritime businesses and aligned with European environmental policy?

Against this background, this paper explores the financial backing for clean shipping sourced from European institutions such as the EIB and other European financial support schemes. Using target-costing theory in financial management (Michiharu, 1989; Gagne and Discenza, 1995), the EIB's financial interventions in the context of green financing for clean shipping investments is assessed (Potkány and Škultétyová, 2019). A unique secondary data analysis is utilized and is complemented by expert interviews and surveys with stakeholders and managers of European shipping businesses, and case studies from recent BSR-centered clean European projects. A forward-looking analysis is provided to evaluate the role of clean financing in achieving COP26 targets, particularly from the Green Deal perspective within maritime transport.

More specifically, this paper studies the efficiency of the Green Deal program in financing clean shipping projects from 2012 to 2021 with a focus on the European Investment Bank's critical role in supporting green investments in Europe. To achieve this, a mixed-methods approach is used, combining target costing analysis along with expert interviews and case studies. Specifically, a target cost analysis is employed to assess the alignment of EIB financing with the European Union policy objectives while a quantitative and qualitative analyses examine the funding trends, the project distributions, and the stakeholder perspectives. This study highlights that the EIB has allocated €6.5 billion in financing maritime projects across Europe but only €1 billion was allocated to clean shipping. Most funding supported transitional technologies like (Legal and General Global Technology - LNG) and scrubbers rather than innovative solutions such as ammonia or e-fuels. The findings also show evidence of regional disparities with Italy, Spain, and the Netherlands receiving the largest finance shares. Finally, through a benchmark analysis of the EIB activities against the European climate initiatives (namely, the Green Deal objectives in relation to the COP26 goals), this paper argues that the regional disparities and misaligned priorities highlight the need for improved fund allocation to meet the European climate goals. Overall, the findings aim to guide decision-makers in Europe and financial institutions to better support clean maritime projects, enhance accessibility for smaller players, and promote long-term sustainable technologies.

The novelty of this study lies in its assessment of the European clean shipping financing landscape and its efficacy concerning the Green Deal in the maritime industry. It provides stakeholders, regulators, and European policy makers with critical insights into green funding mechanisms that facilitate the decarbonization of the shipping industry. The findings reveal that, while support projects have facilitated several maritime investments, these primarily benefited larger firms with more than 250 employees.

The remainder of this paper is structured as follows: The next section reviews the environmental and economic impacts of maritime transport and the role of the EIB as the European Union's lending arm. Section 3 details the methods used in the study. Section 4 presents the study results, followed by a discussion of their implications in Section 5. The final section concludes the study.

2. Literature review

2.1. Economic and environmental impacts of maritime transport

Globally, the transport sector contributes 27% of all greenhouse gas emissions with maritime transport accounting for about 11% of transport sector emissions (International Energy Agency–IEA, 2021). In response, the European Commission has formulated action plans to promote sustainable transport strategies including the short-sea shipping agenda, motorways of the sea concepts, green transport corridors based on multimodality, and the reactivation of inland waterways (Hunke and Prause, 2013; Hämäläinen et al., 2022).

The shipping industry faces numerous challenges including high investment costs, fluctuating fuel prices, and geopolitical issues (Bakkar, 2019; Danish et al., 2019). Emissions from shipping in Europe are significant sources of energy consumption, pollution, and harmful emissions such as SOx and NOx per ton-kilometer compared to trucking (Hjelle, 2014; López-Navarro, 2013). Growing concerns about the environmental impact of shipping activities (Tiquio et al., 2017) highlight the higher emissions of noxious gases such as CO2, NOx, and SOx (Eyring et al., 2005; Khezri et al., 2022). Additionally, the industry uses toxic materials (Grote et al., 2016), produces noise pollution (Chen et al., 2017), and creates waste (Wilewska-Bien et al., 2016) including exhaust gas emissions, odor, noise, ballast water, and solid waste. Furthermore, shipping relies heavily on high energy consumption (Poulsen and Johnson, 2016).

Climate change and air pollution from shipping emissions have heightened environmental concerns and have prompted significant changes to maritime regulations (Ren and Lützen, 2015). The International Convention for the Prevention of Pollution from Ships (MARPOL), Annex VI, addresses emissions and bunker fuel requirements thereby regulating sulfur content in bunker fuel (Danish et al., 2019; Lindstad et al., 2015). Other regulations include the Anti-Fouling System (AFS) and Ballast Water Management conventions (Psaraftis, 2019). Recently, there has been an increased focus on greenhouse gas emissions from shipping, particularly in the context of climate change discussions. This shift led to the International Maritime Organization's (IMO) 2050 zero-emissions target, emphasizing alternative fuels and energy reduction within the shipping sector (IMO, 2019). In 2021, the Glasgow Climate Change Conference (COP26) underscored the urgent need to transition to a net-zero economy to meet the Paris Agreement goals. A key aspect of this transition is shifting from fossil fuels to renewable energy as electricity and heat production account for a significant portion of global greenhouse gas emissions (Environmental Protection Agency–EPA, 2022). COP26 called for a faster transition from coal to clean power (COP26, 2022). Regulatory pressures are expected to drive green innovations and increase demand for diverse financing options (Khezri et al., 2022). Regulations can raise corporate awareness and stimulate innovation supported by clean financing alternatives as suggested by Porter and van der Linde (1995).

Following the Russia-Ukraine conflict, political and economic sanctions against Russia have led to concerns about gas supply shortages in Europe thus necessitating a reassessment of national energy plans (Tosun and Eshraghi, 2022; Aysan et al., 2023; Bakkar et al., 2024). This situation places additional pressure on the shipping sector with new environmental constraints and rising energy prices (Liu et al., 2021; Aysan et al., 2023). Consequently, finding greener ways to power global shipping operations has become imperative, particularly in Europe (Felício et al., 2021). Numerous green marine initiatives worldwide aim to comply with environmental regulations and develop new technical solutions to reduce the impact of shipping on the marine environment (Det Norske Veritas–DNV, 2019; American Bureau of Shipping–ABS, 2019; Kennedy et al., 2019).

In addition, current studies on the environmental impact of maritime transport reveal that the international shipping sector is responsible for approximately 90% of global transport volume. It is a crucial component of European transport, carrying 75% of external European trade and 36% of intra-EU trade (European Commission, 2021). Despite its economic importance and role in global supply chains, shipping remains a significant source of greenhouse gas emissions (Psaraftis, 2019). The industry heavily relies on fossil fuels with CO2 emissions increasing from 138 million tons in 2018 to 145 million tons in 2019 (European Commission, 2021). Maritime transport accounts for 3–4% of total European CO2 emissions (Bakkar et al., 2021). As a response to this, European institutions have taken numerous initiatives to mobilize public and institutional funds towards strategic investments, including the Green Shipping Guarantee Program as well as the European Fund for Strategic Investments to fill the financing gap and revive investment in sustainable shipping across Europe (Bakkar, 2019). This framework aims to facilitate financing environmentally friendly vessels while encouraging the adoption of alternative fuels like LNG and ammonia. Specifically, the Green Shipping Guarantee Program has received support from the Connecting Europe Facility Debt Instrument which is dedicated to advancing cleaner maritime transportation and equipping ships with renewable energy solutions and sustainable technologies.

At firm level, new business models are being developed to assess various investment scenarios for maritime abatement technologies and identify best financial practices in clean shipping across Europe. Olaniyi and Gerlitz (2019) discuss energy contracting models for LNG between maritime fuel producers and ship operators. Atari et al. (2019) employ real-option analysis for clean shipping investments and have developed a web-based tool that enables investors to evaluate the efficiency of abatement technologies. Olaniyi and Prause (2020) analyze waste heat recovery systems for ships, examining the economic and operational conditions favorable for their installations. Gerlitz et al. (2022) discuss the potential ammonia as alternative marine fuels in the Baltic Sea Region. Bakkar et al. (2020) explore maritime energy management from the perspective of clean shipping and used portfolio models to reduce investment risks. Philipp (2020) highlights the potential of blockchain technologies for the efficient utilization of alternative fuels in the shipping sector. Panagakos et al. (2014) emphasize the importance of innovative interventions for sustainable and cost-effective options. However, the actual capacity of stimulated innovations to comply with regulations remains uncertain (Bergqvist et al., 2015).

2.2. The European Investment Bank clean financing pools

The shipping industry, a significant contributor to global greenhouse gas emissions, is under pressure to adopt cleaner technologies and practices. Green financing is essential for transforming the shipping industry into a more sustainable sector. However, to maximize its impact financial mechanisms must be equitable, transparent, and aligned with global climate goals (Schinas et al., 2018). Collaboration among regulators, financial institutions, and industry players will be crucial in overcoming existing barriers and accelerating the transition to greener maritime practices (Rizou, 2023).

The potential of institutional investors to finance clean energy initiatives is immense. Institutional investors, such as the European Investment Bank (EIB), are key players in funding the transition to a low-carbon economy. Development banks play a significant role in stimulating investment and economic growth across Europe and, based on the volume of its borrowing and lending, the EIB can be categorized as such. Its role as part of the economic policy toolkit for overcoming investment weaknesses cannot be overemphasized. One of the core attributes of the bank is its ability to finance infrastructure projects that support small and medium-sized enterprises (SMEs) and foster innovation, thereby addressing market failures and promoting economic development (Wruuck et al., 2015). Where private investment in green shipping is limited, the EIB, as a development bank, can play a pivotal role in bridging the financing gap by ensuring that environmental objectives are met across Europe.

Serving as the lending arm of the European Union (EU), the EIB focuses on key priority areas such as climate change, environmental sustainability, infrastructure, and cohesion (Tzoumanika, 2019; EIB, 2020a). Due to its capacity to act counter-cyclically, the EIB can increase lending during economic downturns to mitigate the effects of reduced private sector investment and provide crucial financing for green maritime projects such as the development of energy-efficient vessels and sustainable port infrastructure (Gutierrez et al., 2011).

Hence, by collaborating closely with other European institutions the EIB aims to foster European integration and development (Gaudet, 2016; Bakkar et al., 2021). The EIB functions in alignment with the European Commission which can be viewed as its primary client. The European Commission formulates the demand for the EIB's banking activities, particularly those related to the European Union's Green Deal initiatives (EIB, 2020b). In this framework, the EIB operates under a target costing model where the European political level sets the objectives and the bank seeks to realize these objectives through its service portfolio, primarily by providing suitable capital for the required activities.

In 2019, the EIB declared itself the world's first international climate bank by pledging to cease investments in fossil fuel projects by the end of 2021 and to mobilize €1 trillion for climate-related projects by 2030. This strategy closely aligned with the European Green Deal which focuses on the facilitation of a sustainable transition across member states. The bank employs various financial instruments (including loans, equity investments, and guarantees) to support projects that contribute to environmental sustainability (Kavvadia, 2023). The EIB's focus on financing the green transition presents significant opportunities for the shipping industry to access funding for sustainable initiatives. By aligning projects with the EIB's environmental criteria maritime businesses can secure support for investments in cleaner technologies and practices.

However, among other issues, policy inconsistencies, government policies, the lack of suitable investment vehicles, and standardized definitions for green investments deter investment and complicate decision-making. Additionally, financial risk perception, particularly regarding emerging technologies, poses significant obstacles to the willingness to fund smaller economies (Kaminker and Stewart, 2012).

The overarching aim of the European Union's Green Deal is to achieve climate neutrality by 2050. In this context, green financing targets the reduction of CO_2 emissions from various sources with the European transport sector being a significant focus due to its responsibility for about 20% of all CO_2 emissions (European Commission, 2021; EIB, 2020b). A major challenge to this effort may be the willingness to balance economic development with environmental goals and to avoid disparities in funding allocation among EU countries.

A recent study by Ebeling (2022) examined the determinants of the allocation of EIB green investments and discovered that these investments are predominantly directed toward more economically advanced EU countries while smaller countries are left out. Specifically, the results show that higher GDP per capita, as well as larger national environmental expenditures, increase the likelihood of green loan allocations by the bank.

This situation raises questions about the true objectives of the loans and the controversial balancing act between economic and environmental goals. For profit reasons, the dichotomy faced by the EIB between promoting economic development and achieving environmental goals cannot be overlooked. If the EIB claims to support climate-friendly projects, the distribution of green investments should not inadvertently favor wealthier nations within the EU. This challenges the goal of balancing the dual objectives of fostering economic cohesion across the EU and advancing environmental sustainability.

2.3. Target costing

Target costing is an approach used in product development and life cycle costing to create products with specific functionalities and customer-oriented features while ensuring desired profitability (Ansari et al., 2006). This approach gained global attention in the 1990s, particularly after Japanese firms successfully implemented target costing and contributing to their competitive advantage over Western enterprises. Cooper and Slagmulder (1997) provide an early exploration of Japanese strategic cost management techniques highlighting how target costing practices contributed to Japan's economic success in the 1970s and 1980s.

Target costing involves decomposing the target cost, which is the maximum cost budget allocated for a product, down to the component level and incorporating special product characteristics that represent customer value (Cooper, 1992). This approach aligns customer values with corresponding cost budgets for realization thereby ensuring that products meet the demands and needs of customers across different market segments. As a result, customers are willing to pay for products that embody their desired specifications and functionalities upon introduction. The strong customer orientation during the design and planning process has led to the development of various methods linking target costing with empirical, particularly statistical, instruments.

Cost management techniques such as target costing and (particularly in this vein) green target costing (GTC) can help the EU manage costs while meeting environmental objectives. These techniques ensure that investments in green technologies are both economically viable and sustainable (Mahdi and Khudair, 2023). This is particularly relevant for the shipping industry where efficiency and environmental compliance are critical. This will guide policymakers and financial institutions, such as the EIB, toward strategic investment allocation so that investments can be directed toward projects that demonstrate a balance between cost efficiency and environmental benefits.

Target costing can also serve as a strategic tool to commercialize product and service innovations. As a pricing strategy, a product's selling price is determined first and efforts are made to ensure that the product can be produced at a cost that allows for profitability at that price (Ansari and Bell, 1998). This approach emphasizes designing products that meet customer expectations while controlling costs from the early stages of development. By focusing on the customer's willingness to pay, the EIB and policymakers can design financing programs that align with market demands and ensure competitiveness as well as profitability. This practice is referred to as market-driven design by Jiang and Hansen (2016). Thus, the entire financing initiative encourages the incorporation of cost considerations during its design phase to commercialize innovative products or services that are both desirable to customers (in this case, shipowners and other related companies) and cost-effective to launch (Clifton et al., 2003).

Europe can make significant investments in promoting sustainable maritime transport that aligns with the objectives of the European Green Deal, enabling maritime companies to develop environmentally friendly technologies and vessels that meet regulatory standards and customer expectations while adhering to budget constraints. In addition, this strategic approach aids in allocating funds to projects that offer the best value for money and environmental impact (Ewert and Christian, 1999). It is also important to emphasize that these financings must be cost-effective for all parties to enhance competitiveness, strengthen the EU's position in the global market, and support the EU's broader environmental and economic goals.

A notable method is the combination of target costing with conjoint analysis something that is widely used in product development (Moore et al., 1999). In their work, Haryanti et al. (2022) defined green finance as financial management activities that incorporate environmentally friendly and sustainable concepts. While concentrating on a regional level they examined a local industry's adoption of green finance to enhance economic conditions and emphasized its potential to improve regional economies through sustainable business practices. Combining their analysis with disjointed analysis (DA), related to value engineering, is highlighted as a crucial method for determining product specifications and designs by analyzing competitors' products. This approach aids companies in identifying opportunities for product development and cost reduction. While differing in scope and specific focus areas, Haryanti et al.'s work supports this study by underscoring the significance of green financing in promoting sustainable economic practices. In other words, Haryanti et al.'s regional analysis complements the broader European perspective by illustrating how green finance can be applied at both local and continental levels to achieve economic and environmental objectives.

Other approaches include the analytical hierarchy process (AHP) methodology and the technique for order of preference by similarity to ideal solution (TOPSIS) methodology for ranking product developments that incorporate customer-specified functionality bundles with related cost budgets (Hwang and Yoon, 1981; Chen, 2000; Cooper, 1992). Target costing has increasingly been applied in the business world, extending to project design and management of energy efficiency investments and life-cycle costing concepts through the approach of target value design (Taka, 1993).

Since its introduction in the Japanese automotive industry in the 1960s, target costing has been applied in both production and service sectors. Academic interest in target costing grew significantly later with key contributions from scholars such as Monden and Hamada, 1991, Cooper (1992), and Cooper and Slagmulder (1997). Currently, target costing is recognized as a powerful strategic tool that goes beyond traditional cost-plus pricing strategies to emphasize customer satisfaction through demand-driven levels of quality and functionality at minimal costs (Monden and Lee, 1993).

The literature reveals a gap in the study of target costing within the banking sector which is understandable given that financial intermediation services, especially investment credits, are not standard products but depend on individual investment properties. However, this situation changes when a financial institution is linked to a political mission with specific objectives. In the case of the EIB, the bank acts as the financial agent of the European Commission, executing the European financial and environmental agendas. The European Union, as the sole client, dominates the demand side of the bank's activities. Consequently, the EIB must strategically allocate funds to fulfill this demand.

Thus, this study examines the EIB's role in green financing by addressing the gap in the literature regarding the application of target costing approaches in the banking sector.

3. Data and methodology

The current research is based on both primary and secondary data as well as the outcomes of projects executed in the Baltic Sea Region (BSR) between 2015 and 2021 (Prause and Olaniyi, 2019; Atari et al., 2019; Bakkar et al., 2021). The authors utilize a variety of data sources including unique secondary data from expert interviews and surveys with different stakeholders and managers of European shipping firms. Additionally, case studies were conducted within the framework of four BSR-centered European clean shipping projects: GoLNG, EnviSuM, CSHIPP, and Connect2SmallPorts.[1]

In-depth expert interviews, surveys, and observations were conducted on clean shipping projects at five major ports (Rostock, Hamburg, Tallinn, Turku, and Helsinki) that are among the highest passenger traffic ports around the BSR. The questions addressed topics such as access to funds, state funding, green funding systems, the processes to gain access, success rates in accessing these funds, and awareness of other funding opportunities from the European Fund for Strategic Investment (EFSI) and other green funding partnerships.

The experts' interview involves twelve shipping firm mangers from Germany, Estonia and Finland.[2] The ship types considered in the study include only those financed by the EIB loans with the primary aim of evaluating different energy efficiency and emission reduction technologies for ships. The evaluations were collected and synthesized using a mixed approach of fuzzy analytical hierarchy process (FAHP) and fuzzy technique for order preference by similarity to an ideal solution (FTOPSIS) (Li et al., 2016; Nisar et al., 2022; Wang et al., 2023).[3]

Additionally, the study incorporates primary data sources from the Eurostat database, energy reports, and evaluation reports from 2012 to 2021. Recognizing that sustainable development requires the involvement of all stakeholders (Migone, 2007), the study emphasizes continuous dialogue among scientists, policymakers, industries, and society representatives, adhering to the principles of the United Nations Economic Commission for Europe (UNECE) Convention for achieving the "Europe 2020" growth goals (UNECE, 1998).

The study accesses the EIB's open project database and analyzes financed projects between 2012 and 2021. While the EIB is a significant source of green financial support in Europe other public and private funding pools and programs also exist with regional, national, or sectoral focuses. These often cater more to local needs, particularly benefiting smaller firms (Danish Ship Finance–DKS, 2020). Nonetheless, analyzing the EIB's financed projects is pertinent because this institution directly supports European policy and its related action plans.

The target costing methodology used in this study involves three main components: target cost setting, which includes the target price, target profit, and total cost; cost allocation to individual product components; and target cost realization. In the context of green financing, the key factors of the European preferences are twofold: reducing greenhouse gas emissions and optimizing financing to achieve maximal congruence between the demand side (greenhouse gas reduction) and the supply side (green lending policies and clean financial strategies).

The level of congruence between the demand and supply of functionalities is typically expressed by a target cost control diagram, including tolerance zones, as shown in Fig. 1 which is adapted from Potkány and Škultétyová (2019). High customer satisfaction is achieved when the benefits and costs of demanded functionalities meet within the target cost range, ideally near the bisecting line in the diagram. This methodological approach ensures that financial strategies align closely with environmental goals thus promoting sustainable development within the maritime industry.

In the case of green financing by the European Investment Bank (EIB), the situation can be evaluated by comparing the EIB's issued credits for green investments with the greenhouse gas emissions across different business sectors. Specifically in the shipping industry, Potkány and Škultétyová (2019) suggest that green shipping investments should constitute approximately 5% of all EIB financing related to climate change. Therefore, this paper's analysis benchmarks the EIB's activities up to 2021 using a target costing approach. The study further examines the extent to which the EIB finances innovative green investments compared to more conservative projects that primarily deliver short-term effects in addressing climate change.[4]

4. Findings and discussions

4.1. Voice of the maritime industry

As a starting point, the group of experts assigned importance weights to three criteria: (i) economy and finance, (ii) applicability and practicability, and (iii) reliability and measurability. Using the fuzzy analytical hierarchy process (FAHP) method, they determined the importance weights for each criterion. The results in this study show that reliability and measurability was considered the most important criterion, followed by economy and finance, and, lastly, applicability and practicability.

Once the importance weights of the three criteria were established, the experts ranked the most important energy efficiency measures for three ship types: (i) general cargo, (ii) container, and (iii) bulker. The weighting revealed that reliability and measurability had the highest rating at approximately 40%, followed by economy and finance at about 33%, and applicability and practicability at around 27%.

The three main criteria for energy efficiency were further broken down into ten sub-criteria. The economic criteria include: (i) energy efficiency potential, (ii) investment cost, (iii) operation and maintenance cost, and (iv) payback period performance. The applicability and practicability criteria consist of: (i) practicality level of planning, (ii) procurement and installation process, (iii) practicality level of operational procedures, and (iv) control over measure. The reliability and measurability criteria include: (i) monitorability and measurability of outputs, (ii) scientifically proven effectiveness, (iii) technical/operational maturity, (iv) preferred/widespread implementation, and (v) experience and knowledge at business level.

Using the FAHP method, the importance weights were also determined for each sub-criterion. Among the top five sub-criteria, the highest weight was assigned to energy efficiency potential, followed by monitorability and measurability of outputs, practicality level of operational procedures, technical/operational maturity, and operation/maintenance cost. These top five sub-criteria accounted for about 60% of the total weights with economic criteria dominating, followed by those from reliability and measurability, and one from applicability and

[1] For more insights see GoLNG: (http://www.golng.eu/), EnviSuM: (https://interreg-baltic.eu/project/envisum/), CSHIPP (https://cshipp.eu/): and Connect2SmallPorts: (https://connect2smallports.eu/). Authors participated as project partners.

[2] The data is confidential due to the involvement of actual fleets from existing shipping firms.

[3] For more details on the experts' interviews methodology and questions see Appendix B.

[4] More information on the definitions, the sources, and the summary statistics of these variables are presented in Appendix A. Table A1 presents the definitions and descriptive statistics of the variables used in the target costing analysis. It also provided insights about the breakdown of the EIB loans by industry and region. On average, the results show that clean shipping benefit from 32% of the total loans. Tables A2 presents the correlation matrix, results do not indicate major collinearity issues.

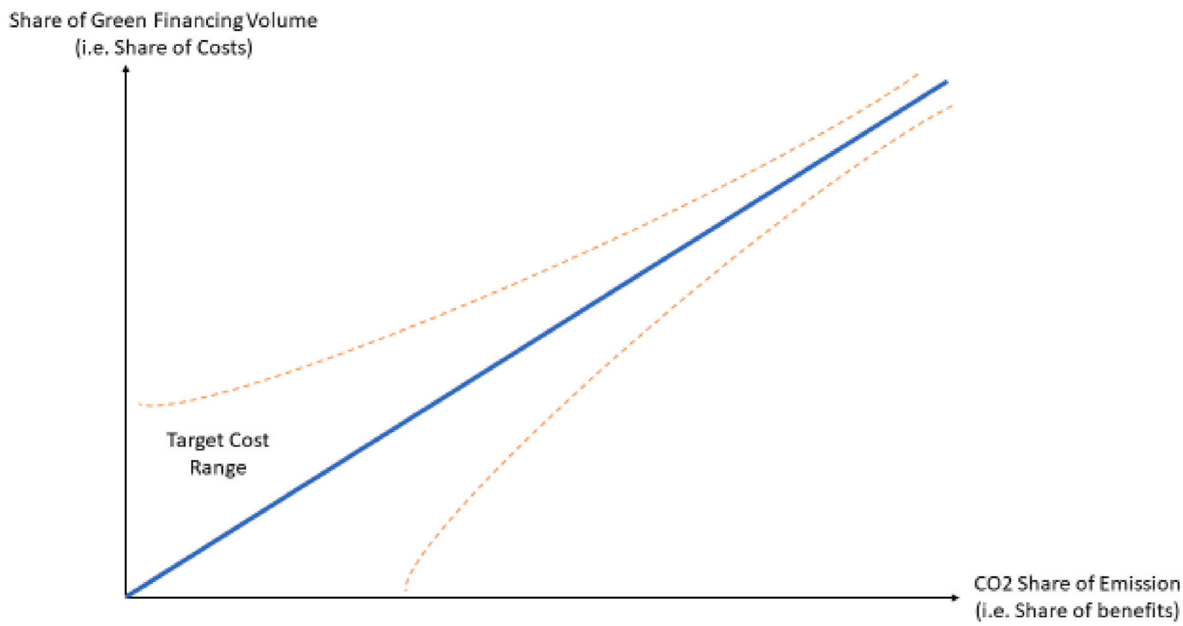

Fig. 1. Target costing control diagram.

practicability. The dominance of economic and financial aspects grew even further when considering the sixth-ranked sub-criterion of investment costs. Consequently, economic and financial sub-criteria accounted for about 50% of the weight of the top six sub-criteria which together accounted for approximately two-thirds of the total weights.

This analysis suggests that the financial aspects of abatement technologies, combined with measurability and technical maturity, are the primary drivers of improvements in energy efficiency and emission reductions in the maritime sector as indicated by expert evaluations.

4.2. Univariate analysis

In relation to the issue under study, Figs. 1 and 2 present the percentage of annual GDP growth, renewable energy investment, and green finance. This data provides context and supports the analysis of how these factors interact in the pursuit of enhanced energy efficiency and reduced emissions in the maritime sector.

Fig. 2 illustrates the number of grants for the maritime industry funded by the EIB in Europe and globally. The data shows that the number of clean investment projects granted in Europe increased in 2021 compared to 2020 while the number of projects funded outside Europe decreased. Specifically, the EIB funded 12 projects in Europe in 2020 and 14 in 2021 whereas the number of funded projects outside Europe dropped from 18 in 2020 to 16 in 2021.

Fig. 3 provides additional evidence regarding the monetary value of these clean investment projects. The results show that from 2019 to 2021, the EIB tripled its funding for clean investment projects both in Europe and globally. In 2019, approximately €260K was awarded to

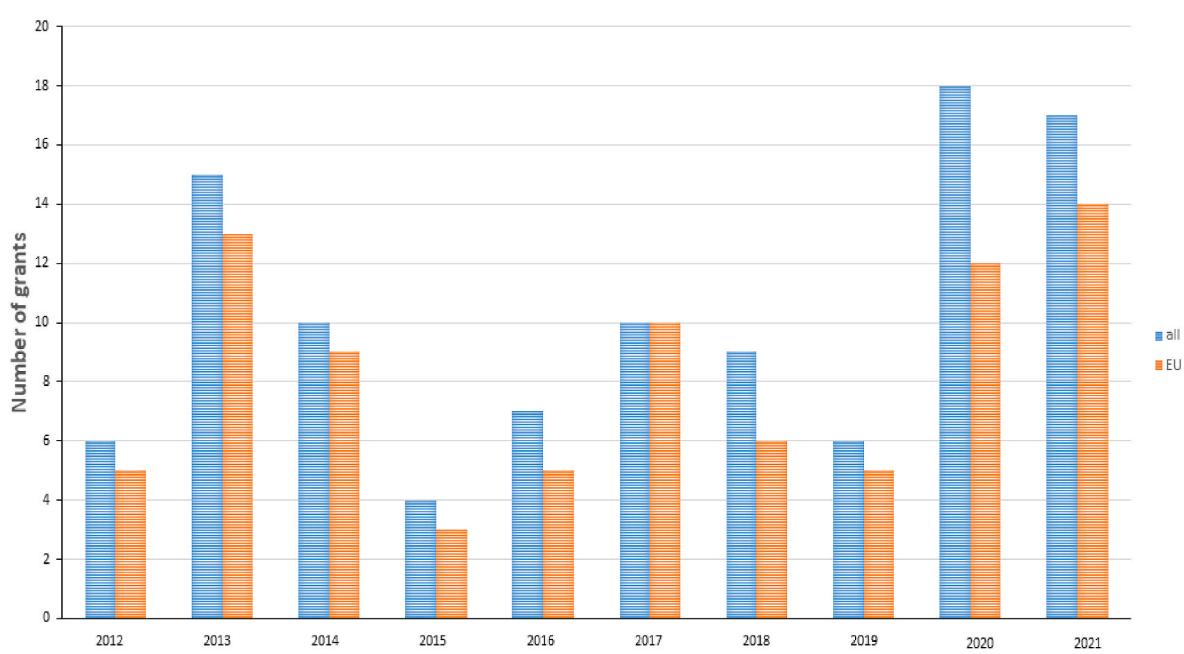

Fig. 2. Number of grants funded for maritime.

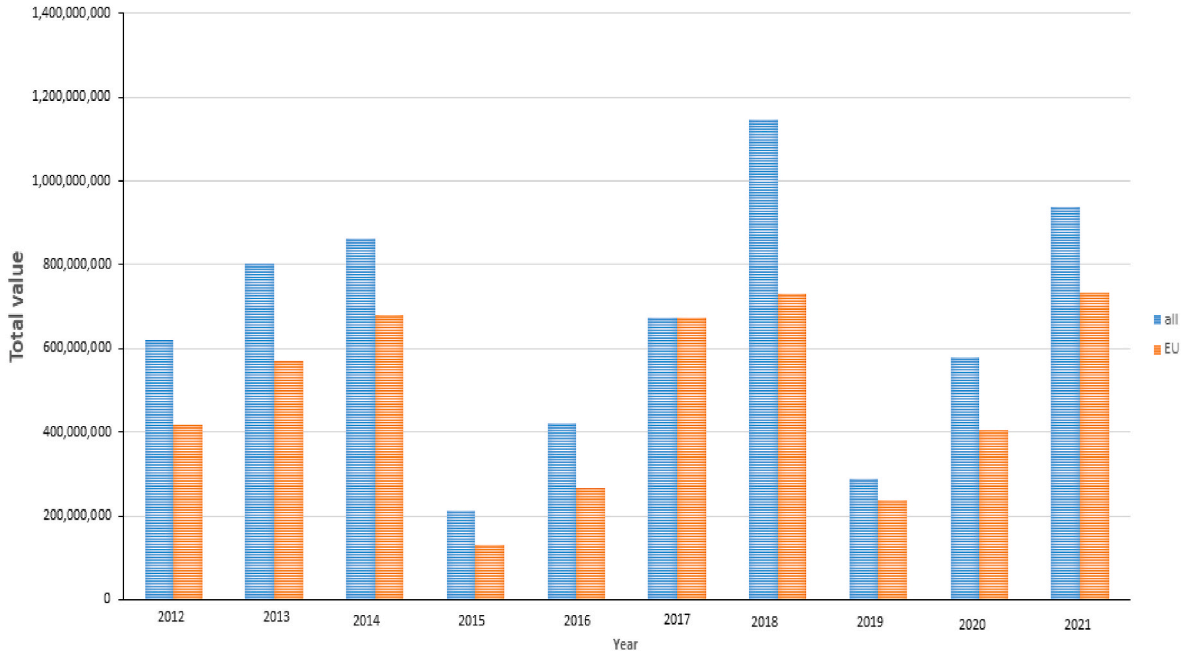

Fig. 3. Maritime grant funding.

European clean investment projects which increased to €775K in 2021. Similarly, non-EU projects received €300K in 2019, rising to €930K in 2021. Despite this significant increase the total funding in 2021 was still slightly lower than the total funds granted in 2018.

Fig. 4–7 present results for Europe from 2012 to 2021. Figs. 4 and 5 illustrate that during this period the EIB granted 34 projects to Italy, nine projects to Spain, and seven projects to the Netherlands. These projects correspond to clean investment grants of approximately €1.6 billion for Italy, €600 million for Spain, and €760 million for the Netherlands. Bakkar et al. (2021) indicate that these three countries have benefited from strategic funding programs aimed at developing green mobility in ports, supporting local governments in low-carbon strategies, and enhancing public engagement for sustainable public transport to achieve the Paris Agreement goals on climate change adopted in 2015 (COP21). Overall, these three countries received about 90% of the EIB's green investment funds.

Interestingly, Fig. 6–7 present similar results, specifically for clean investment projects in the European maritime (shipping) industry. These figures highlight that the EIB, and thus Europe, must intensify efforts to support and finance clean maritime investments. Fig. 6 shows that the number of grants for the shipping industry in Europe over the last decade has been relatively low compared to the total number of clean investments granted. In 2021, the EIB granted five projects in the shipping industry which was up from three in 2020. However, in 2015 and 2019 no clean investment projects in the shipping industry were supported in Europe. Furthermore, the number of clean grants for the

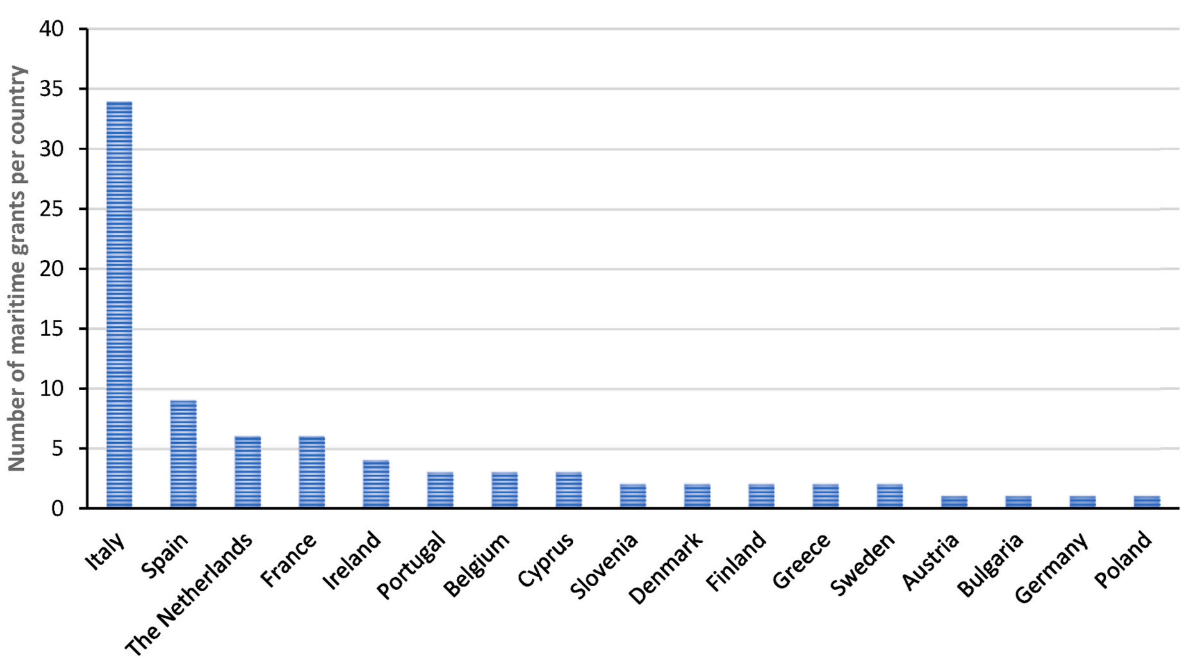

Fig. 4. Number of maritime grants in Europe.

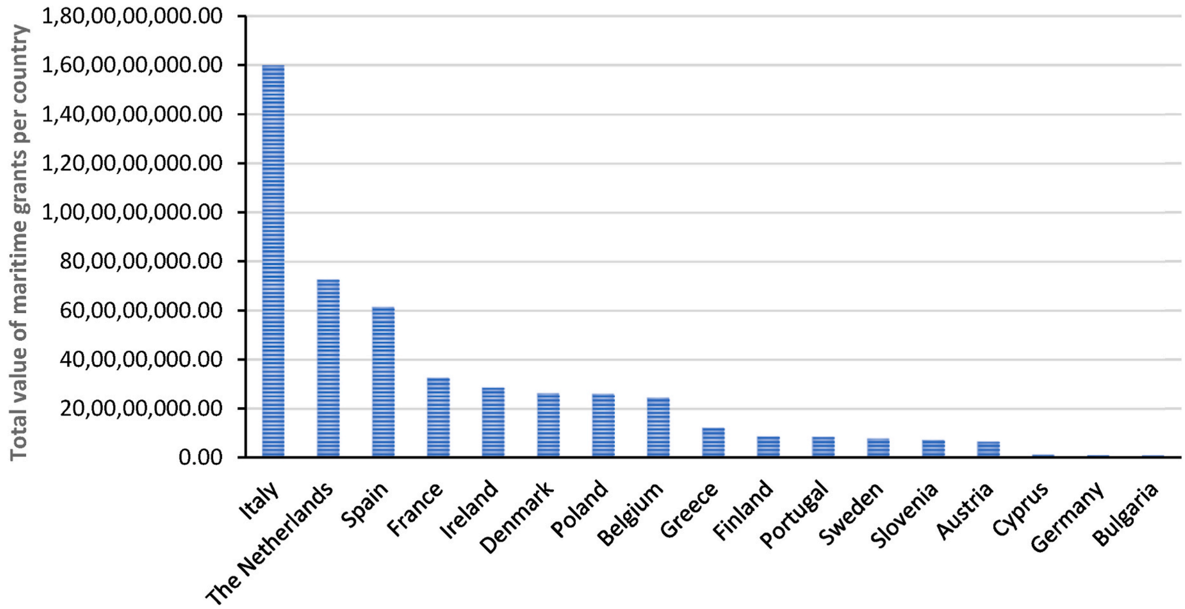

Fig. 5. Total maritime grant funding per country.

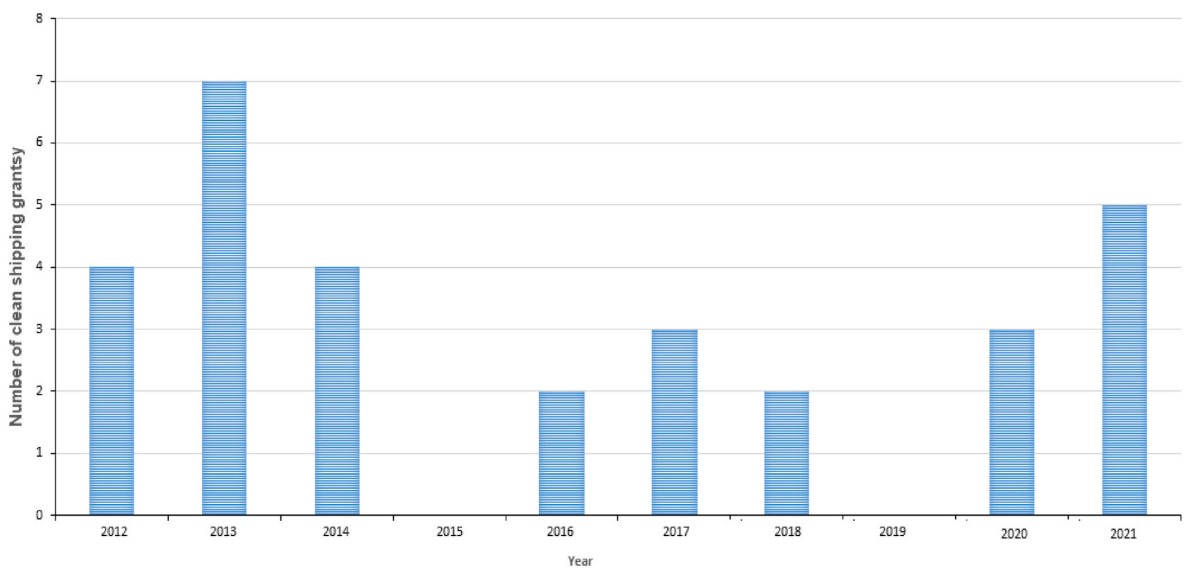

Fig. 6. Number of clean shipping grants in Europe.

shipping industry drastically decreased from seven in 2013. Fig. 7 provides more evidence of these green grants to the shipping industry by country over the last ten years (2012–2021).

The previous findings show that Italy and Cyprus received the most grants with 21 and three grants respectively targeting clean investments in the shipping industry. In contrast, Finland and the Netherlands each received two grants for the shipping industry. These results raise questions about the actual involvement of the maritime industry in the green transition across Europe. Bakkar et al. (2021) argue that the European Commission, the European Bank for Reconstruction and Development, and the EIB have created alternative funding mechanisms to support the green shipping transition. They have implemented initiatives such as the European Investment Advisory Hub and the European Investment Project Portal to assist stakeholders in the maritime industry in accessing the European green loan market.

4.3. How do stakeholders navigate clean shipping risks?

This section focuses on the economic challenges and financing risks associated with clean shipping investments. It examines the management decisions of actors in the BSR shipping business namely ship owners, fuel producers, and ship supply firms. Based on the conducted interviews, surveys, and case studies, the primary dilemmas of shipowners in the clean shipping business in Europe are highlighted as follows. First, high investment requirement: compliant fuel requires high investments from fuel producers (LS-fuel) or fuel users for abatement technologies. (i) Fuel-producing firms must make strategic business decisions involving high investments and significant financial risks in the maritime fuel markets. (ii) Ship operators, while facing smaller investment in abatement technologies, must finance these costs through freight rates which are themselves exposed to significant financial risks in the maritime transport market. Second, challenges in cost-effective fuel and technology choices. These challenges include (i) numerous

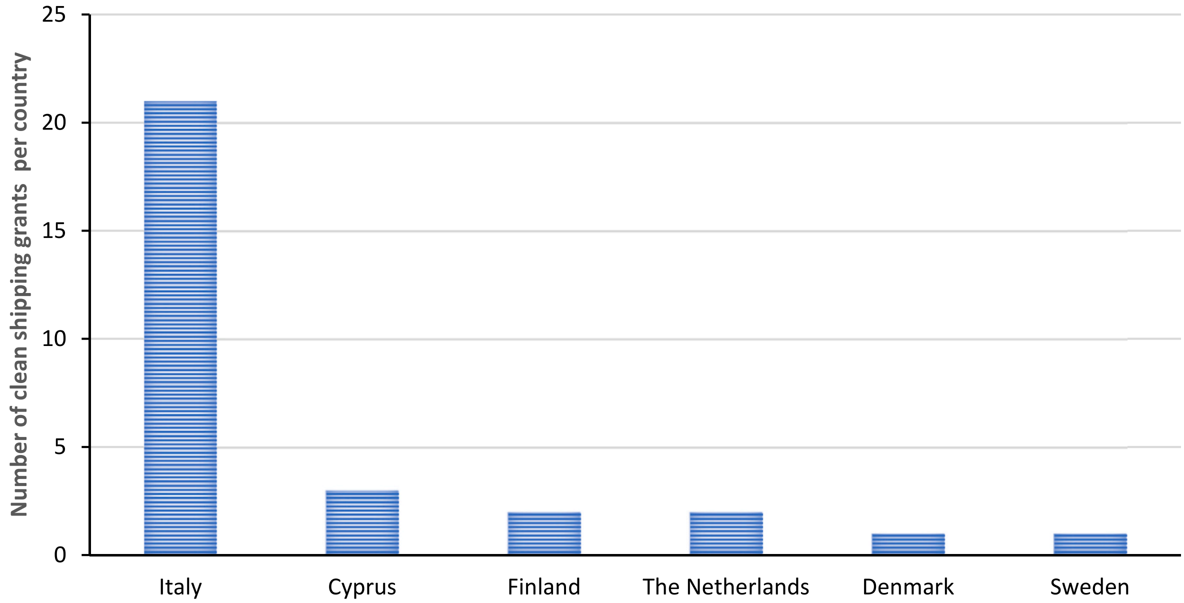

Fig. 7. Number of clean shipping grants in the most benefiting EU countries.

compliance options available (e.g., compliant/non-fossil fuels, scrubbers, LNG), each with varying levels of cost-effectiveness and implementation challenges, (ii) bunkering prices are highly volatile and erratic at present, further complicating decision-making processes and (iii) the adoption of scrubber and LNG installations on ships has been slow thus indicating reluctance or uncertainty in investing in these technologies, and (iv) smaller firms in particular face a shortage of financial resources and generally low creditworthiness thus limiting their ability to secure funding for clean technologies.

Moreover, ship owners' management decisions are influenced by the fear of sub-optimal solutions that could delay investment choices, potentially resulting in the loss of strategic opportunities. There is also the concern that postponing abatement investment decisions might place shipowners in a disadvantageous position, particularly with rising fuel prices, as noted by Olaniyi and Prause (2020). This uncertainty is compounded by the difficulty in securing financing for the installation of abatement technologies, a challenge that particularly affects smaller shipping firms (Atari et al., 2019).

Additional factors driving the need for financial support for clean investments include the high investment costs, the long lifetimes of these investments, high capital utilization, and the associated financial risks. Moreover, most banks, including the EIB, operate under limited liability and capital constraints while also facing pressure from stakeholders and market conditions (Gillan et al., 2021; Nisar et al., 2022; Wang et al., 2023).

Overall, the high risks, including financial risks, associated with clean shipping investments emphasize the need to develop risk assessment and mitigation strategies. Such policies could include providing financial guarantees or insurance mechanisms to reduce the perceived risks for investors and, in turn, encourage more investment flows into the sector. Integrated support mechanisms that combine EIB financing with other national funding programs could be useful in providing comprehensive financial packages for maritime projects across Europe. This approach will reduce duplication of efforts and maximize the impact of available funds.

4.4. How does the EU fund clean shipping?

The overarching aim of European approaches is to build a modern integrated transport system that enhances global competitiveness and meets the challenges of sustainable, smart, and inclusive growth. The first step is ensuring a well-functioning infrastructure that can efficiently, safely, and sustainably transport people and goods through the Trans-European Transport Network policy.

These programs offer scenarios and build knowledge on the most efficient and cost-effective solutions for further reducing emissions and pollution from ships in the Baltic Sea. Key international initiatives supporting clean shipping include the International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI, the Convention on Long-Range Transboundary Air Pollution, and the European Sulfur Directive 2012/33/EU which provide instruments for quantifying the socio-economic and environmental impacts of shipping in the Baltic Sea Region. Clean shipping-related activities also include the Convention on the Protection of the Marine Environment of the Baltic Sea (Helsinki Convention) which aims to achieve a good environmental status of the sea. This contributes to implementing the HELCOM Baltic Sea Action Plan (2007) and follow-up Ministerial commitments (Declarations from Moscow, 2010; Copenhagen, 2013) to achieve a Baltic Sea unaffected by eutrophication.

Other relevant policies include the Integrated Maritime Policy (IMP), which encompasses the Marine Strategy Framework Directive (MSFD) and Water Framework Directive, as well as the European Strategy for the Baltic Sea Region (EUSBSR) and policies aimed at mitigating climate change including the United Nations Framework Convention on Climate Change (UNFCCC).

Several EU funding programs provide financial support for projects implementing the TEN-T, such as:

- Connecting Europe Facility (CEF). This provides financial support for strategic investment in transport, energy, and digital infrastructure.
- European Fund for Strategic Investments (EFSI). This supports investment in key sectors through financial guarantees.
- Horizon 2020. This provides funding for research and development projects aiming to transfer innovative ideas from the lab to the market.
- European Structural and Investment Funds (ESIFs) including:
  - o Cohesion Fund (CF). This supports projects that reduce economic and social disparities and promote sustainable development in 15 cohesion Member States.
  - o European Regional Development Fund (ERDF). This aims to strengthen economic and social cohesion in the EU by correcting imbalances between its regions.

4.5. Does the EIB enhance efficient financing of clean maritime projects?

An analysis of the EIB database for 2012 to 2021 reveals that the total signed financial volume for the transport sector was approximately €123 billion, averaging €12 billion annually. The highest share of finance went to land-based transportation. In contrast, the signed volume for the maritime sector amounted to about €6.5 billion, representing only about 5% of the total financed volume from the EIB. The largest share of maritime investments was dedicated to port improvements and construction. Of the finances for the maritime sector, approximately €1 billion was committed to clean shipping projects, representing about 15% of all financed maritime projects.

Comparing these figures to the economic and environmental importance of maritime transport in Europe, it becomes evident that maritime transport is under-represented in transport financing support from the EIB. Maritime's share of economic figures and environmental and emission values within the transport industry is double the allocated financing from the EIB. Considering emissions from maritime shipping operations in Europe alone, this finance value ranges at the lower boundary of 3–4%.

The EIB's conservative approach to finance budgeting for the shipping sector, focusing on projects like scrubber and LNG investments, reveals a transitional rather than long-term commitment to clean shipping. Moreover, most firms receiving clean shipping credits/support are larger enterprises indicating that smaller ship owners are disproportionately low in the finance support database. Although smaller ship owners can apply for regional or national financing, creating a financing tandem with the EIB and a national bank tends to favor larger firms to reduce administrative costs and make financing more profitable for national banks through larger volumes.

Hence, larger firms benefited disproportionately from the EIB's financing while smaller shipping companies face significant challenges in securing financing for clean investments. It is important to create policies that help them gain easier access to financial support. Tailored financial instruments or grants that reduce administrative burdens and improve creditworthiness would be beneficial. Similarly, Europe should focus on creating policies that promote long-term investments in sustainable maritime technologies rather than transitional solutions. Care should be taken to address disparities and inequalities in funding opportunities across different European countries.

To better understand the financing strategies, the authors examined the categories of financed projects.

- LNG bunkering vessel. A €20 million loan from the EIB to the Public Gas Corporation of Greece SA (DEPA) for constructing a new LNG bunkering vessel based in Piraeus, Greece (2020).
- Scrubber retrofit financing:
  - o €110 million loans for Dutch ship management firm Spliethoff from ING and the EIB to finance retrofitting 42 vessels (nearly half of the fleet) with exhaust gas cleaning systems and ballast water management systems (2018–19).
  - o €50 million loan for Finnlines from the EIB to help complete its €100 million environmental technology investment programs including the installation of scrubbers (2016).
  - o Det Forenede Dampskibs- Selskab(DFDS). Retrofitting scrubbers for 18 vessels and LNG dual-fuel engines for 5 vessels (2014).
- Improved environmental vessel design:
  - o €10.1 million for Eureka Shipping from Dutch Bank ABN AMRO and the EIB to finance the construction of three cement carrier vessels under the Green Shipping Guarantee Program (GSGP). This vessel design represents an improvement to the overall environmental performance of the promoter's fleet currently operating in EU SECA waters under an EU flag (2019). Three new ships will be laid up in the Netherlands.
- New LNG vessel *Honfleur* for Brittany Ferries:
  - o Planned to enter service in April 2019 on the Caen-Ouistreham (France) and Portsmouth (UK) route.
  - o Société Générale acted as the leading arranger of €142.6 million financing for the acquisition of the Honfleur ferry commissioned by Brittany Ferries including a €49.5 million tranche fully guaranteed by the EIB.
  - o The ferry is still under construction and has yet to start operations.
  - o Brittany Ferries ordered the Honfleur in 2017 from the German shipyard Flensburger Schiffbau-Gesellschaft (FSG) for €200 million.
  - o Construction began in 2018 and the ship was launched in December 2018.
  - o Final works were planned to be completed by May 2019 after which regular servicing would begin.
  - o The completion of the vessel was delayed by several years and the Honfleur remained unfinished until Brittany Ferries cancelled the order in 2020.
  - o Norway-based SIEM acquired the Honfleur from Flensburger Schiffbau-Gesellschaft (FSG) to prevent insolvency proceedings for FSG. SIEM provided loans to finance the construction of the Honfleur which are yet to be repaid.

Since 2010, clean shipping financing from the EIB consists of about 30 direct projects representing approximately 3% of all projects in the database which includes 1045 transport projects from the EIB. Additionally, one interview revealed that, as part of the European Commission, 2021 program, a project sum of about €10 million was allocated to the ShipFC-Consortium for the ammonia-driven supply vessel *Viking Energy*.

These clean investments share common characteristics and reflect the EIB's conservative policy. The firms that received EIB credits for maritime investments are all large enterprises with over 250 employees. The focus has primarily been on LNG issues with the exception of one large scrubber project. Both technologies, scrubbers and LNG, are considered transition technologies in shipping as SECA regulations are the beginning of a longer process of greening global shipping which will include Nitrogen Emissions-Controlled Areas (NECA) and decarbonizing ship emissions.

Since 2015, the SECA regulations have been implemented in Northern Europe making the topic of alternative fuels prominent on the political agenda for years. However, alternative fuels like bio- and e-fuels, as well as non-carbon-based fuels such as ammonia, should be included in the EIB database from 2020. So far, they have only been considered under other European Union programs like Horizon 2020. This may be due to the conservative nature of the shipping industry which hesitates to adopt highly innovative and unproven technologies. Additionally, the EIB's orientation towards financing established technologies in traditional business operations may play a role.

In countries like Denmark, France, Germany, and the Netherlands, national programs finance highly innovative maritime technologies to safeguard their competitive advantages in the maritime industry.

The Honfleur case warrants closer examination. The EIB database only highlights signed contracts between 2010 and 2020 but does not indicate the investments' success. The Honfleur contract supported an LNG ferry between France and the UK, was ordered in 2017, and was scheduled to start service in 2019. Due to construction delays and the interim insolvency of the building shipyard, the ship remains under construction. The Honfleur case became public due to news from the shipyard workers' union. Overall, this case highlights the need for better monitoring and reporting of funded projects' progress and success. Implementing tracking mechanisms and transparent reporting standards will help assess the actual impact of investments and ensure accountability.

On the whole, this study's results argue for the necessity of more investigations to verify the success rate of maritime projects financed by the EIB and directly connected to new financial pledges made to the

Adaptation Fund of COP26 which totals around €350 million (United Nations on Climate Change, 2021). If previous commitments are not met new obligations may not be achieved. A similar strategy may apply to the Least Developed Countries Fund (LDCF).

5. Conclusion and policy implications

In Europe, the shipping industry is actively striving to contribute to a greener marine environment and cleaner shipping practices. However, shipping lines' emissions have been identified as a significant source of pollution, prompting the implementation of several clean shipping regulations in Europe. The industry is leveraging the latest technologies at both manufacturing and funding levels to minimize the environmental impact of new ships. As a result, an increasing number of shipping companies and operators are investing in green and clean technologies thus creating new financial challenges for maritime investors.

This paper investigates European support programs including loans from the European Investment Bank, the green loan by the Loan Market Association, and other specific European funding pools and support schemes primarily dedicated to clean shipping investments and R&D activities. The paper provides a critical analysis of the efficacy of these European green pools and private funding initiatives in assisting stakeholders to transition toward clean shipping technology investments.

Using target costing theory along with expert interviews and case studies, this paper shows that, over the 2012–2021 period, the European Investment Bank allocated €123 billion to the transport sector with €6.5 billion directed to maritime projects, of which only €1 billion (about 0.9% of the total budget allocated to finance transport) was earmarked for clean shipping initiatives (corresponding to only 30 maritime projects). It was found that most of the clean shipping financing projects are dedicated to supporting transitional technologies and scrubber strategic investment. In contrast, alternative areas and innovative solutions like LNG, energy-saving design, and ammonia-based projects represent only a minor portion of the investments. These findings indicate a clear imbalance between the issued financings and the importance of the shipping sector for global transportation and maritime emissions. In addition, it was observed that there were regional disparities in strategic fund allocation with countries like Italy, Spain, and the Netherlands receiving the largest shares of maritime grants while countries like Finland and Denmark received smaller amounts. The analysis was extended by showing the existence of a financing disproportionality dilemma across firms and show that most of the investments and grants benefit larger enterprises with over 250 employees, leaving smaller firms at a disadvantage due to the administrative burdens of the grants' applications and their low creditworthiness. When the in-depth interviews were investigated, the analyses reveal that experts and maritime stakeholders prioritize financial aspects of abatement technologies, reliability, and technical maturity when assessing clean projects, energy efficiency, and emission reductions in the maritime sector thereby emphasizing the need for more financial support for renewable energy solutions to support sustainable shipping.

Furthermore, it was also demonstrated that although all stakeholders in the shipping industry are involved and willing to contribute to the European Union's global goal for decarbonization and clean shipping industry, there is a need for strategic planning in fund dissemination and support to maximize impact. To achieve the COP26 targets, the focus should shift from successful project implementation benefiting only a few major players in the industry to achieving a customer-pleasing outcome that considers broader industry and environmental goals.

On the whole, this paper's findings reveal a conservative approach to financing the clean shipping industry in Europe focusing primarily on supporting established technologies like LNG bunkering vessels and scrubbers. In the future, this setup is likely to limit the adoption of more innovative solutions, such as ammonia or e-fuels, which are enjoying increasing interest on the decarbonization agenda of the maritime sector. However, the findings do not provide any compelling evidence that the EIB's financing strategies are closely aligned with the European Union's climate policies and goals such as those outlined in the Paris Agreement and the European Green Deal. The case studies used, including the LNG vessel *Honfleur* for Brittany Ferries, exhibit inadequate monitoring and reporting mechanisms that make it difficult to evaluate the success and impact of funded projects. These findings highlight gaps between the current funding strategies and the ultimate European climate objectives to ensure that shipping investments align effectively with Europe's long-term sustainability objectives.

Policy-wise, it was argued that maritime transport is currently underrepresented in the EIB funding compared to its economic and environmental significance. Policymakers should consider increasing the allocation of funds specifically for clean maritime investments to ensure better alignment with the sector's needs and potential environmental impacts, ensuring the shipping industry's alignment with 2050 climate neutrality goals.

The results bear critical policy implications for both policymakers and industry stakeholders in the maritime industry. On the one hand, policymakers should increase maritime funding, especially for innovative technologies like ammonia and e-fuels, and ensure equitable distribution across regions. Tailored financial instruments and simplified processes should improve access for smaller companies. Funding strategies must align with EU climate goals supported by robust monitoring mechanisms and risk-sharing initiatives like co-financing schemes. Collaboration between the EIB and national programs can further enhance resource efficiency for the shipping industry. On the other hand, stakeholders should prioritize adopting innovative, zero-carbon technologies and develop business models that integrate energy efficiency to improve funding accessibility. Partnerships with policymakers and funders, advocating for equitable policies, and investing in workforce training will enable smoother deployment of green technologies. Together, these measures can drive a more sustainable and inclusive transition in maritime transport.

Equitable distribution of green financing to support both less-developed and more-developed member states in their environmental initiatives should not be a choice but a critical necessity. The EIB's allocation trends, as described by Ebeling (2022), further emphasize the risk of unequal progress in greening the EU shipping industry. Addressing these disparities is critical to ensuring the industry's cohesive and inclusive transformation to support the broader goals of the European Green Deal and sustainable development.

This paper, however, is also subject to some limitations while opening avenues for future studies. First, due to data challenges, the analysis relies on unique and confidential data on European countries and firms benefiting from green financing which does not entirely represent the current market conditions across all European countries. This could affect the accuracy of the findings as well as the generalizability of the conclusions outside the European context. Second, there were assumptions regarding the methodology used. The target costing analysis often requires assumptions about future costs, technological advancements, and policy impacts. These assumptions may not fully capture the complexity and uncertainties related to the shipping industry yet the main findings were tested against the inputs from the interviews with shipping professionals. Third, the Green Deal and related policies are subject to change based on political, economic, and social factors. This study may not have accounted for future policy shifts or the introduction of new regulations that could significantly impact the current effect of sustainable transport financing.

Finally, this study provides policy-driven insights on the efficiency of European green loans in enhancing a clean and sustainable maritime industry from 2011 to 2020. However, several areas warrant further investigation to develop one's understanding. Future research could extend the temporal scope beyond 2021 to capture recent trends and shocks, such as the COP28 outcomes, which showed that shipping is striving for investments, and the Russia-Ukraine conflict and the Red Sea tension which present high uncertainty for shipping investments and the clean energy transition. Including other factors such as climate risks, economic uncertainty, and international environmental agreements could provide a more comprehensive view. Utilizing micro-level data, such as commercial bank-level or shipping firm-level data, could provide granular insights into the impacts and contributions of different entities in the green loan market and also may help identify the shipping lines' funding dynamics, risk management, and thus more accurate policy implications. Integrating alternative econometric models and using machine learning would help improve the predictions of investment outcomes and identify optimal funding strategies for different shipowners. From a technical point of view, future research could bridge the gap between Peng et al. (2024), Li et al. (2024), and this paper and adopt explainable machine learning techniques to build accurate models to assess the efficiency of institutional programs in financing clean shipping investments.

CRediT authorship contribution statement

Yassine Bakkar: Writing – review & editing, Writing – original draft, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Eunice Bark:** Writing – review & editing, Writing – original draft, Resources, Methodology, Investigation, Data curation. **Gunnar Prause:** Writing – review & editing, Writing – original draft, Supervision, Project administration. **Shajara Ul-Durar:** Writing – review & editing, Writing – original draft, Validation, Project administration.

Informed consent

All participants in this study volunteered themselves during the entire research process, and their consent was taken at inception.

Ethical approval

The entire research process is in line with our institutional research ethics policy. We declare that all ethical standards are met and complied with in true letter and spirit.

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Declaration of competing interest

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

Appendix A. Descriptive statistics

Table A1Summary statistics.

Variables	Description	Source	Mean	SD	Median	P10	P25	P75	P90
1. Loans (in millions EUR)									
Transport sector									
	Loans given to transport sector in Europe.	European Investment Bank (EIB) loans platform.	117.55	150.57	65.00	5.00	20.95	161.76	294.63
Maritime EU									
	Loans given to maritime industry in Europe.	EIB loans platform.	59.03	54.68	43.35	12.68	27.75	75.00	100.00
SECA Region									
	Loans given to maritime industry in both Baltic Sea and North Sea SECA Region.	EIB loans platform.	56.12	67.00	31.20	6.68	15.00	56.00	215.00
Clean Shipping									
	Loans given to clean shipping projects in Europe.	EIB loans platform.	38.03	36.83	30.01	4.29	15.00	35.49	90.00
2. CO2 Share of Emissions									
	Carbon dioxides share of emission share (i.e., share of benefits)	Climate Watch Data.	11.93	1.68	13.22	9.77	10.19	11.98	14.56
3. Share of Green Financing									
	Non-performing loans to gross loans	EIB loans platform.	1.22%	1.13%	0.90%	0.26%	0.57%	1.55%	2.07%
4. GDP growth									
	The annual growth rate of a country's GDP.	World Development Indicators (WDI) and World Economic Outlook (WEO)	2.07	2.05	1.62	0.3	0.50	2.62	2.97

This table provides summary statistics, description, and source of the main different variables used in this paper's empirical analyses.

Table A2
Pearson correlation matrix

	(1)	(2)	(3)	(4)
(1) Loans	1			

(continued on next page)

Table A2 (*continued*)

	(1)	(2)	(3)	(4)
(2) CO2 Share of Emissions	0.055 (0.00)	1		
(3) Share of Green Financing	0.928 (0.000)	0.058 (0.000)	1	
(4) GDP Growth	−0.161 (0.000)	0.112 (0.000)	−0.161 (0.000)	1

Table provides information on the Pearson correlation coefficients for the variables of this paper's analyses for the period from 2006 to 2021. Definitions and sources for all the variables are in Panel A of Table A1. In parentheses below the correlation coefficients are their corresponding *p*-values.

Appendix B. Expert interview methodology

Twelve formal and semi-formal expert interviews were conducted in Finland and Germany. These sessions aimed to enrich and benchmark information collected from the European Fund for Strategic Investment (EFSI) and other green funding partnerships by focusing on what experts and business owners consider important regarding regulatory tools and interventions from the EU.

Three variables were considered to be Economy and Finance, Applicability and Practicability, and Reliability and Measurability. After providing background information each expert was asked to rate these variables in order of importance concerning their expectations for regulatory intervention.

Although the authors aimed for face-to-face interviews, phone or video calls were used when in-person meetings were impractical. Each interview session lasted between 10 and 15 min. The findings highlight areas where shipowners expect regulatory interventions and potential areas for enhancement, fostering evidence-based policymaking in the maritime sector. Details of the interview questions are presented in Table B1 as follows:

Table B1
Expert interview questions

	Interview Questions
1	Please state what you do and your country of residence.
2	Which shipping regulations are you familiar with?
3	Can you describe your level of satisfaction with the regulatory support received from the EU concerning the regulations you mentioned?
4	Please rate the following variables in order of importance to your company and explain why you think so: • Economy and Finance • Applicability and Practicability • Reliability and Measurability

Data availability

Data will be made available on request.

References

American Bureau of Shipping–ABS, 2019. ABS, MAN & SDARI join forces to develop ammonia-fueled feeder vessel. Press release: 12.05.2019, available at: https://ww2.eagle.org/en/news/press-room/abs-man-sdari-develop-ammonia-fueled-feedervessel.html. (Accessed 7 April 2020).
Ansari, S., Bell, J., 1998. Target costing: profit planning in disguise. Account. Finance 3 (1), 2–4.
Ansari, S., Bell, J., Okano, H., 2006. Target costing: uncharted research territory. Handbooks Manag. Accou. Res. 2, 507–530.
Atari, S., Bakkar, Y., Olaniyi, E.O., Prause, G., 2019. Real options analysis of abatement investments for Sulphur emission control areas compliance. J. Entrepren. Sustain. Iss. 6 (3).
Aysan, F.A., Bakkar, Y., Ul-Durar, S., Kayani, U.N., 2023. Natural resources governance and conflicts: retrospective analysis. Resour. Pol. 85 (A), 103942.
Bakkar, Y., 2019. New politics for financing clean shipping. Baltic Rim. Econo. 3 (2558).
Bakkar, Y., Ben, Jabeur S., Si, Mohammed S., Ben, Arfi W., 2024. Environmental transition dynamics under external conflict risk: new evidence from European countries. J. Clean. Prod. 472 (25), 143510.
Bakkar, Y., Olaniyi, E., Prause, G.K., Prokopenko, O., 2021. Manual of best practices in clean shipping financing in europe. https://cshipp.eu/wp-content/uploads/2021/03/Manual-of-Best-Practices-in-Clean-Shipping-Financing-in-Europe.pdf. (Accessed 7 January 2022).
Bakkar, Y., Robal, T., Prause, G., 2020. A Web-Based Economic Decision Tool for Abatement Investments for Shipping Industry. Springer. LNNS 117.
Bergqvist, R., Turesson, M., Weddmark, A., 2015. Sulphur emission control areas and transport strategies-the case of Sweden and the forest industry. European Transp. Res. Rev. 7 (2), 1–15.
Clifton, B., Townsend, W., Bird, H., Albano, R., 2003. Target Costing: Market Driven Product Design. ESE Group, Princeton.
Chen, C.T., 2000. Extensions of the TOPSIS for group decision-making under fuzzy environment. Fuzzy Set Syst. 114 (1), 1–9.
Chen, F., Shapiro, G.I., Bennett, K.A., Ingram, S.N., Thompson, D., Vincent, C., Russell, D.J.F., Embling, C.B., 2017. Shipping noise in a dynamic sea: a case study of grey seals in the Celtic Sea. Mar. Pollut. Bull. 114, 372–383.
Cooper, R., 1992. Implementing Activity-Based Cost Management. The Institute of Management Accountants. Productivity Press, Portland, OR, USA.
Cooper, R., Slagmulder, 1997. Target Costing and Value Engineering. Productivity Press, Portland, OR, USA. ISBN 9781563271724.
Danish, K., Baloch, M.A., Mahmood, N., Zhang, J.W., 2019. Effect of natural resources, renewable energy and economic development on CO2 emissions in BRICS countries. Sci. Total Environ. 678, 632–638.
Danish Ship Finance–DKS, 2020. *Green Pools and Funds for the shipping industry, Danish shipping*, copenhagen. https://www.shipfinance.dk/media/2020/dsf-sustainability-report-2019.pdf. (Accessed 2 August 2021).
Det Norske Veritas–Dnv, G.L., 2019. Comparison of alternative marine fuels. Sea\LNG Ltd, Report No.: 2019-0567 (document No.: 11C8I1KZ-1). https://sea-lng.org/wp-content/uploads/2020/04/Alternative-Marine-Fuels-Study_final_report_25.09.19.pdf. (Accessed 7 April 2020).
Ebeling, A., 2022. European investment bank loan appraisal, the EU climate bank? International Economics 172, 203–216.
Environmental Protection Agency–EPA, 2022. Global Greenhouse Gas Emissions Data. Website of the United States Environmental Protection Agency. https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data. (Accessed 8 June 2022).
European Commission, 2021. Report from the commission 2020 annual report on CO2 emissions from maritime transport, C (2021) 6022. https://ec.europa.eu/clima/system/files/2021-08/swd_2021_228_en.pdf. (Accessed 2 September 2021).
European Environment Agency–EEA, 2021. EU maritime transport: first environmental impact report. https://www.eea.europa.eu/highlights/eu-maritime-transport-first-environmental. (Accessed 2 September 2022).
European Investment Bank–EIB, 2020a. Accelerating europe's transformation. Investment report. https://www.eib.org/attachments/efs/economic_investment_report_2019_en.pdf. (Accessed 2 September 2021).

European Investment Bank–EIB, 2020b. Transport overview 2020. https://www.eib.org/attachments/thematic/transport_overview_2020_en.pdf. (Accessed 2 September 2021).

Ewert, R., Christian, E., 1999. Target costing, co-ordination and strategic cost management. European Accounting Review 8 (1), 23–49.

Eyring, V., Köhler, H., Van Aardenne, J., Lauer, A., 2005. Emissions from international shipping: 1. The last 50 years. J. Geophys. Res. 110, 17305.

Felício, J.A., Rodrigues, R., Caldeirinha, V., 2021. Green shipping affects sustainable economy and environmental performance. Sustainability 13 (8), 4256.

Gagne, M.L., Discenza, R., 1995. Target costing. Journal of Business & Industrial Marketing 10 (1), 16–22.

Gaudet, F., 2016. EIB's Green Shipping Financing Programme. European Sustainable Shipping Forum, Brussels.

Gillan, S.L., Koch, A., Starks, L.T., 2021. Firms and social responsibility: a review of ESG and CSR research in corporate finance. Journal of Corporate Finance 66, 101889.

Grote, M., Mazurek, N., Gräbsch, C., Zeilinger, J., Le Floch, S., Wahrendorf, D.S., Höfer, T., 2016. Dry bulk cargo shipping — an overlooked threat to the marine environment? Mar. Pollut. Bull. 110, 511–519.

Gutierrez, E., Rudolph, H.P., Homa, T., Beneit, E.B., 2011. Development banks: role and mechanisms to increase their efficiency. World Bank Policy Research Working Paper 5729.

Hämäläinen, E., Inkinen, T., Olaniyi, E.O., 2022. Low emission choices in freight transport: comparing land and short sea shipping alternatives. Dynamics in Logistics, LDIC 2022. Springer, Cham. https://doi.org/10.1007/978-3-031-05359-7_17.

Haryanti, E., Siswati, E., Widya, R., 2022. Green financing ss an alternative for improving regional economic conditions. Asia Pacific Journal of Business Economics and Technology 2 (1), 45–53.

Hjelle, H.M., 2014. Atmospheric emissions of short sea shipping compared to road transport through the peaks and troughs of short-term market cycles. Transp. Rev. 34, 379–395.

Hunke, K., Prause, G., 2013. Management of green corridor performance. Transport and Telecommunication 14 (4), 292–299.

Hwang, C.L., Yoon, K., 1981. Multiple Attribute Decision Making: Methods and Applications a State-Of-The-Art Survey, vol. 186. Springer Science & Business Media.

International Energy Agency–IEA, 2021. Greenhouse Gas Emissions from Energy: Overview. IEA, Paris. https://www.iea.org/reports/greenhouse-gas-emissions-from-energy-overview.

International Maritime Organization–IMO, 2019. Actions to reduce greenhouse gas emissions from international shipping - implementing the initial IMO strategy for reduction of GHG emissions from ships. http://www.imo.org/en/MediaCentre/HotTopics/Documents/. (Accessed 7 August 2020).

Jiang, L., Hansen, C.Ø., 2016. Target Costing as a Strategic Tool to Commercialize the Product and Service Innovation.

Jiang, L., Kronbak, J., Christensen, L.P., 2014. The costs and benefits of Sulphur reduction measures: Sulphur scrubbers versus marine gas oil. Transportation Research Part D: Transport and Environment 28, 19–27.

Kaminker, C., Stewart, F., 2012. The Role of Institutional Investors in Financing Clean Energy.

Kavvadia, H., 2023. The role of the European Investment Bank in financing the green transition. In: Making the European Green Deal Work. Routledge, pp. 45–59.

Kennedy, E., Botero, J.M., Zonneveld, J., 2019. Hydrohub HyChain 3, analysis of the current state and outlook of technologies for production hydrogen supply chain – technology assessment. www.ispt.eu. (Accessed 21 March 2020).

Khezri, M., Heshmati, A., Khodaei, M., 2022. Environmental implications of economic complexity and its role in determining how renewable energies affect CO2 emissions. Applied Energy 306, 117948. Part B.

Li, X., Chua, J.Y., Yuen, K.F., 2024. A review on maritime disruption management: categories, impacts, and strategies. Transport Policy 154, 40–47.

Li, X., Ming, X., Song, W., Qiu, S., Qu, Y., Liu, Z., 2016. A fuzzy technique for order preference by similarity to an ideal solution–based quality function deployment for prioritizing technical attributes of new products. Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture 230 (12), 2249–2263.

Lindstad, H., Sandaas, I., Strømman, A.H., 2015. Assessment of cost as a function of abatement options in maritime emission control areas. Transportation Research Part D: Transport and Environment 38, 41–48.

Liu, Y., Han, L., Xu, Y., 2021. The impact of geopolitical uncertainty on energy volatility. International Review of Financial Analysis 75, 101743.

López-Navarro, M.Á., 2013. The effect of shared planning by road transport firms and shipping companies on performance in the intermodal transport chain: the case of Ro-Ro short sea shipping. Eur. J. Transp. Infrastruct. Res. 13 (13), 39–55.

Mahdi, Z.H., Khudair, S.Y., 2023. Compatibility between the green target cost and the disjointed analysis and their role in improving product quality and reducing costs: an applied study in aldiwaniyah tire factory. World Economics and Finance Bulletin 20, 81–95.

Michiharu, S., 1989. Target costing and how to use it. Journal of cost management 3 (2), 39–50.

Migone, B.K., 2007. The national security dividend of global carbon mitigation. Energy Policy 35, 5403–5410.

Monden, Y., Hamada, K., 1991. Target costing and kaizen costing in Japanese automobile companies. Journal of Management Accounting Research 3 (1), 16–34.

Monden, Y., Lee, J., 1993. How a Japanese automaker reduces costs. Management Accounting 75 (2), 22–26.

Moore, W.L., Louviere, J.J., Verma, R., 1999. Using conjoint analysis to help design product platforms. Journal of Product Innovation Management: An international publication of the product development & management association 16 (1), 27–39.

Nisar, Q.A., Haider, S., Ameer, I., Hussain, M.S., Gill, S.S., Usama, A., 2022. Sustainable supply chain management performance in post COVID-19 era in an emerging economy: a big data perspective. International Journal of Emerging Markets 18 (12), 5900–5920.

Olaniyi, E.O., Gerlitz, L., 2019. LNG Maritime energy contracting model. Entrepreneurship and Sustainability Issues 7 (1), 574.

Olaniyi, E.O., Prause, G., 2020. Investment analysis of waste heat recovery system installations on ships' engines. Journal of Marine Science and Engineering 8 (10), 811. https://doi.org/10.3390/jmse8100811.

Olaniyi, E.O., Prause, G., 2019. SECA regulatory impact assessment: administrative burden costs in the Baltic Sea Region. Transport and Telecommunication 20 (1), 62–73.

Panagakos, G.P., Stamatopoulou, E.V., Psaraftis, H.N., 2014. The possible designation of the Mediterranean Sea as a SECA: a case study. Transportation Research Part D: Transport and Environment 28, 74–90.

Papageorgiou, A., 2016. EIB's financing support for green shipping investments. "POSEIDON MED II Calls at Piraeus" Conference, Piraeus.

Peng, Q., Bakkar, Y., Wu, L., Liu, W., Kou, R., Liu, K., 2024. Transportation resilience under Covid-19 Uncertainty: a traffic severity analysis. Transportation Research Part A: Policy and Practice 179, 103947.

Philipp, R., 2020. Blockchain for lbg maritime energy contracting and value chain management: a green shipping business model for seaports. Environmental and Climate Technologies 23 (3), 329–349.

Porter, M.E., van der Linde, C., 1995. Toward a new conception of the environment competitiveness relationship. J. Econ. Perspect. 9, 97–118.

Potkány, M., Škultétyová, M., 2019. Research into customer preferences of potential buyers of simple wood-based houses for the purpose of using the target costing. Open Engineering 9 (1), 390–396.

Poulsen, R.T., Johnson, H., 2016. The logic of business vs the logic of energy management practice: understanding the choices and effects of energy consumption monitoring systems in shipping companies. J. Cleaner Prod. 112, 3785–3797.

Prause, G., Olaniyi, E.O., 2019. A compliance cost analysis of the SECA regulation in the Baltic Sea. Entrepreneurship and Sustainability Issues 6 (4).

Psaraftis, H.N., 2019. Decarbonization of maritime transport: to be or not to be? Maritime Economics & Logistics 21 (3), 353–371.

Reinhold, K., Järvis, M., Prause, G., 2019. Occupational health and safety aspects of green shipping in the Baltic Sea. Journal of Entrepreneurship and Sustainability Issues 7 (1), 10–24. https://doi.org/10.9770/jesi.2019.7.1 (1).

Ren, J., Lützen, M., 2015. Fuzzy multi-criteria decision-making method for technology selection for emissions reduction from shipping under uncertainties. Transportation Research Part D: Transport and Environment 40, 43–60.

Rizou, D., 2023. The role of finance in achieving green shipping. Australian and New Zealand *Maritime Law Journal*, 37 (1), 1–16.

Schinas, O., Ross, H.H., Rossol, T.D., 2018. Financing green ships through export credit schemes. Transportation Research Part D: Transport and Environment 65, 300–311.

Taka, T., 1993. Target costing at toyota. Journal of Cost Management, spring 7, 2–12.

Tiquio, M.G.J.P., Marmier, N., Francour, P., 2017. Management frameworks for coastal and marine pollution in the European and South East Asian regions. Ocean Coast. Manag. 135, 65–78.

Tosun, O.K., Eshraghi, A., 2022. Corporate decisions in times of war: evidence from the Russia-Ukraine conflict. Finance Res. Lett. 48, 102920, 10.

Tzoumanika, M., 2019. European Investment Bank's green shipping programmes, Luxembourg. https://www.shortsea.gr/wp-content/uploads/2019/06/Maria-Tzoumanika-European-Investment-Bank.pdf. (Accessed 16 July 2020).

United Nations Climate Change Conference–COP26, 2022. Accelerating the transition from coal to clean power. Proceedings of the Website of the UN Climate Change Conference UK. https://ukcop26.org/energy/. (Accessed 16 July 2022).

United Nations Climate Change Conference–COP26, 2021. COP26 outcomes: finance for climate adaptation. In: https://unfccc.int/process-and-meetings/the-paris-agreement/the-glasgow-climate-pact/cop26-outcomes-finance-for-climate-adaptation. (Accessed 29 September 2022).

United Nations Conference on Trade and Development–UNCTAD, 2021. Review of Maritime Transport. Available at: https://unctad.org/system/files/officialdocument/rmt2021_en_0.pdf. (Accessed 29 September 2022).

United Nations Economic Commission for Europe–UNECE, 1998. Convention on access to information, public participation in decision-making, and access to justice in environmental matters. https://unece.org/DAM/env/pp/documents/cep43e.pdf. (Accessed 7 September 2021).

Wang, W., Sun, W., Awan, U., Nassani, A.A., Binsaeed, R.H., Zaman, K., 2023. Green investing in China's air cargo industry: opportunities and challenges for sustainable transportation. Heliyon 9 (8), e19013.

Wilewska-Bien, M., Granhag, L., Andersson, K., 2016. The nutrient load from food waste generated onboard ships in the Baltic Sea. Mar. Pollut. Bull. 105, 359–366.

Wruuck, P., Schildbach, J., Ag, D.B., Hoffmann, R., 2015. Promoting Investment and Growth: the Role of Development Banks in Europe. Deutsche Bank Research.