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Advances and emerging research trends in maritime transport logistics: environment, port competitiveness and foreign trade

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Abstract:

The operations of international trade drive global economies, with maritime transport serving as a key pillar in market connectivity and acceleration. The opportunities presented by Industry 4.0 to connect supply chain actors through integrated logistics pose a challenge that fuels the number of studies in this area, with a particular interest in the transportation stage due to its responsibilities for efficiency. This study conducts a systematic literature review by analyzing scientometric aspects and identifying research trends related to maritime transportation logistics. The PRISMA methodology, graph theory, and bibliometric indicators such as indegree, betweenness, and outdegree were employed to process the information related to maritime transportation logistics from the Scopus and Web of Science databases spanning from 2000 to 2022. The gathered information and results were processed and analyzed using R-studio and Bibliometrix tools. The documents were classified as original, structural, and research trends, with the latter focused on topics related to the environment, port competitiveness, logistics optimization, and economics. The conclusions underscore the urgency of mitigating greenhouse gas emissions in maritime transport, optimizing port logistics processes, and addressing economic complexities to ensure sustainability and competitiveness in global trade. Finally, an agenda for future research in the field is presented.

Key words:

Maritime transport, industry 4.0, Foreign trade, optimization, tree of science.

1. Introduction

The logistics associated with maritime transportation and its related activities of planning, control, distribution, and supply chain management have generated competitive advantages and opportunities for profitability and efficiency among the involved stakeholders (Rojas et al., 2021). The logistical processes in the sector are drivers of supply chain globalization and the various factors related to international trade conditions (Valionienė & Plačienė, 2020). These characteristics have positioned maritime transportation as the dominant mode compared to air and land transport (Sánchez, 2020), accounting for over 90% of the total volume of trade (Lozano Arguello, 2021; Zhou, Stephen, et al., 2021).

As a global energy consumer, maritime transportation contributes to the negative impact of climate change, accounting for 2.7% of CO_2 emissions from the international shipping industry (Senčila & Jurgelāne-Kaldava, 2020; Coşofreţ et al., 2020). Despite the fact that the sectors with a greater environmental impact are land and air transportation rather than maritime (Lee et al., 2019), maritime transportation has faced additional costs associated with greenhouse gas emissions and air pollution in order to mitigate its actions (Vierth & Merkel, 2020).

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Furthermore, global policies have been implemented to promote sustainable activities for the development of nations and the conscious utilization of resources, such as the Sustainable Development Goals (SDGs) (Mincomercio, 2021).

In recent years, the study of maritime transportation has gained relevance among the scientific community and shipping companies due to the identified repercussions in economic and environmental areas (Mondello et al., 2021). On the other hand, the complexity of the transit network and its variable behavior have required the incorporation and definition of factors to manage supply chains in the maritime transportation industry (Lin et al., 2020). Meanwhile, the conditions of the sector have presented significant challenges related to the importance of improving coordination, increasing flexibility in port dwell times, enhancing service levels, improving transportation infrastructure, implementing technological information systems, and developing efficient shipping routes and networks (Sumantri, 2020a). Additionally, other aspects arising from the Covid-19 pandemic have reshaped the previously considered logistical administration (Enriquez & Sáenz, 2021), leading maritime transportation services to operate under challenging dynamics involving scientific knowledge, political decisions, and societal acceptance and consent (Kleine-Kampmann et al., 2021).

The impact of maritime transportation logistics on global economies, as well as technological, social, and environmental aspects, has sparked interest in bibliographic studies from various perspectives. On one hand, elements involved in logistic system operations have been considered based on demand and service quality (Giannopoulos & Aifandopoulou-klimis, 2004). Another literature review identified the combined application of the Delphi method and multicriteria decision-making in maritime transportation research (Arof, 2015). Furthermore, the impact of innovation and the economy on environmental regulations applied to shipping in Northern Europe has been studied (Makkonen & Repka, 2016). Subsequently, the success and shortcomings of policies implemented over a 20-year period in the short-sea shipping industry in Europe were analyzed (Suárez-Alemán, 2016). A systematic mapping of research related to green ports and maritime logistics was conducted, identifying research sources and those with potential for further study (Davarzani et al., 2016).

Subsequent studies performed systematic literature reviews with different objectives. One review aimed to identify technological mechanisms used in maritime cargo transportation (Bălan, 2018). Another review identified trends in innovation applied to the shipping industry in the maritime sector (Koukaki & Tei, 2020). Additionally, another approach analyzed scientific articles with environmental and economic impacts using life cycle assessment and costing methods in maritime transportation (Mondello et al., 2021). Finally, a review was conducted on logistics studies related to simulation and optimization in maritime transportation (Zhou, Ma, et al., 2021).

Despite the unquestionable relevance of the topic, no studies have been identified thus far that conduct a systematic literature review that deeply analyzes studies from the last two decades with an evaluation of trends in maritime transportation logistics. To address this, bibliometric techniques are employed using publications registered in the Scopus and Web of Science databases from 2000 to 2022. Tools such as R-studio and the Tree of Sciences (ToS) are also utilized to analyze authors, countries, journals, institutions, and other key documents related to maritime transportation logistics (Josten et al., 2003).

This work is divided into four sections. The first section describes the methodology for obtaining and analyzing information. The second section presents the scientific mapping of the knowledge area. Subsequently, the third section focuses on network construction and the identification of research trends in maritime transportation logistics. Finally, the fourth section presents the conclusions and recommendations for future work.

2. Methods

Two stages, namely scientific mapping and network construction were carried out in the field of maritime transportation logistics. The first stage involved analyzing publications registered in the Scopus and Web of Science databases from 2000 to 2022 to conduct the bibliometric analysis. Subsequently, the network construction phase identified the original documents, structural documents, and research trends using the R-studio software and the Tree of Science theory.

The search equation incorporated the terms “maritime logistics” and “maritime transport”. The articles identified in the two analyzed databases

were processed in the R-studio software, resulting in a total of 627 non-duplicated documents and an overlap level of 71.33%.

The methodological framework for selecting the documents to be included in the analysis was Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). This methodology serves as a guideline for identifying, selecting, evaluating, and synthesizing study documents (Page et al., 2021). Figure 1 presents the inclusion and exclusion criteria considered, resulting in the identification of 78 studies for the development of this work. The inclusion documents were acquired following the methodology outlined in the "Network Construction" section, where graph theory and bibliometric indicators were applied to identify the supporting (roots), structuring (stem), and enhancing (leaves) documents shaping research trends in the study topic.

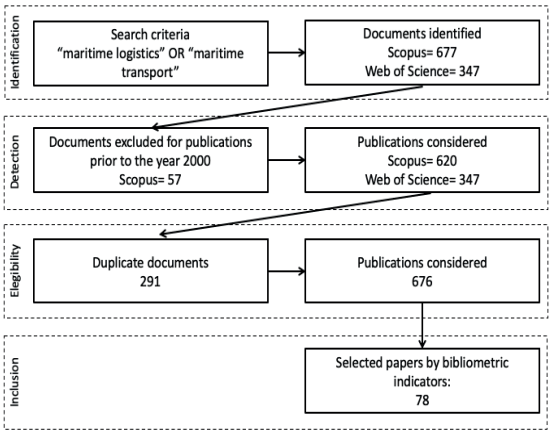

Figure 1. Consultation documents.

2.1. Scientific mapping

The bibliometric procedures recommended by Zupic and Cater (2015) for studying citations, word co-occurrence, co-citations, co-authorship, and bibliographic coupling were initially employed. The Scopus and Web of Science databases were chosen due to their global relevance (Pranckutė, 2021; Zhu & Liu, 2020) and their contributions to various fields of knowledge (Echchakoui, 2020). Additionally, the Bibliometrix tool (Aria & Cuccurullo, 2017) was implemented to facilitate the integration of bibliographic information from different databases. This tool has been widely used and validated in various studies (Acevedo et al., 2020; Di Vaio et al., 2021; Duque, Samboni, et al., 2020; Duque, Trejos, et al., 2021; Landinez et al., 2019; Queiroz & Fosso Wamba, 2021; Secinaro et al., 2021; Tani et al., 2018).

2.2. Network construction

The citation network was constructed using graph theory to consider the typology and characteristics of the network, with references from the publications analyzed using the R-studio software (Wallis, 2007; S. Yang et al., 2016). Subsequently, bibliometric indicators were identified, including Indegree, which quantifies the number of times a document has been referenced by others (Wallis, 2007); Betweenness, which measures the degree of intermediation and centrality of each element within a network (Freeman, 1977); and Outdegree, which represents the number of times a particular node cites others or the number of connections of each document (Wallis, 2007). The identification of original and structural documents in the scientific network was based on the results of the Indegree and Betweenness indicators, while research trends were determined using the Outdegree indicator in the form of clusters. The proposed methodology has been validated in various studies in different areas of knowledge (Buitrago et al., 2020; Duque & Cervantes, 2019; Duque et al., 2021; Ramos et al., 2021; Duque et al., 2020; Duque et al., 2021; Trejos-Salazar et al., 2021; Rubaceti et al., 2022; Clavijo-Tapia et al., 2021; Torres et al., 2021; Alzate & Giraldo, 2023). Additionally, a cocitation map was created to visualize the subareas or research streams within the field of study, following the proposals of Gurzki and Woisetschläger (2017) and Zuschke (2020).

3. Results

3.1. Bibliometric results

The number of publications per year on maritime transport logistics, as recorded in the Scopus and Web of Science databases between 2000 and 2022, is presented in Figure 2. The increasing trend line highlights the interest of the scientific community in this field of study, which has been boosted in the last 5 years with 50% of the publications falling within the study period. Overall, there has been an annual growth rate of 15.77%, and specifically, a growth rate of 12.12% between the year 2019 and the immediately following year, with the latter representing the highest peak among all the years analyzed.

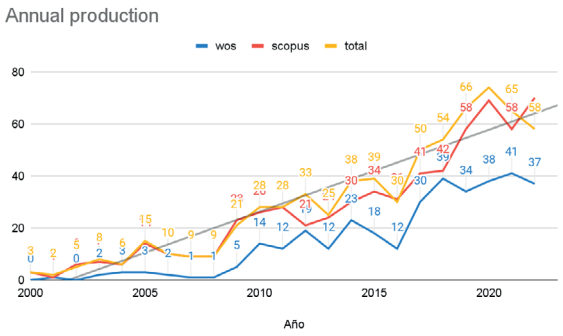

Figure 2. Annual publications.

The top 10 countries with the highest number of publications are highlighted in Table 1, with the United Kingdom, Spain, Poland, and China occupying the top positions, contributing to 30.92% of the total documents in the field. Greece and Norway are also noteworthy, as they have a significant number of publications, accounting for a combined 8.66% of the publications. Additionally, three collaboration groups led by the United Kingdom, Germany, and China stand out, indicating collaboration among countries within these groups. However, collaboration between countries from different groups is also evident.

The main journals, based on the number of publications and H-index, are presented in Table 2. However, other indicators such as quartiles and the Scimago Journal Report (SJR) are also considered in the analysis. Maritime Policy and Management and Maritime Economics and Logistics, both from the United Kingdom, occupy the first and second positions, respectively, with contributions of 21 and 14 documents. It is worth noting that the top-ranked journals are located in Quartile 1, with Sustainability Switzerland showing the best indicators. On the other hand, Marine Policy stands out as the journal with the highest H-index and SJR, despite its eighth position in terms of number of publications. In terms of countries, the United Kingdom and the Netherlands stand out for the number of journals publishing in the field.

The relevance of authors based on their involvement in publications related to maritime transport logistics is presented in Table 3, considering three aspects: number of publications, number of citations, and H-index. Gordon Wilmsmeier from the University of the Andes is the author with the highest number of publications, followed by Dong-wook Song from the World Maritime University. Harilaos N. Psaraftis, ranked 7th, has the highest number of citations (4671), and Adolf K.Y. Ng has the highest H-index. Regarding the authors' affiliations, a diverse representation of countries is identified, with the 10 authors on the list coming from different cities.

In terms of co-citations and collaboration among authors, Figure 3 presents the most prominent groups. The networks show strong participation of the authors presented in Table 3, of which the top three authors are leaders of the most representative author collaboration groups. The largest group involves Gordon Wilmsmeier, Jason Monios, and Adolf Ng, who are highly influential authors in the field of study. Additionally, Dond-wook Song and Kum Fai Yuen have significant involvement in the networks they lead, with Photis M. Panayides and Eonseogn Lee also being visible, both belonging to the top 10 authors. On the other hand, the citation network identifies three groups, two of which have thicker networks that suggest the degree of

Table 1. Participation by country.

Country/Region	Number of publications	% participation	Network of collaboration among countries
United Kingdom	50	8,83%	
Spain	43	7,60%	
Poland	42	7,42%	
China	40	7,07%	
Germany	39	6,89%	
Italy	39	6,89%	
United States	32	5,65%	
Australia	31	5,48%	
Greece	25	4,42%	
Norway	24	4,24%	

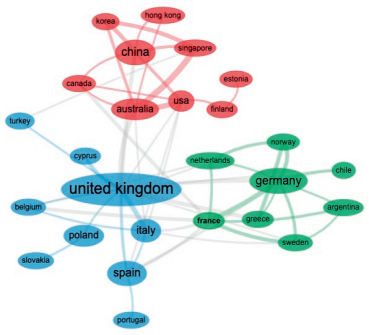

Table 2. Main journals in maritime transportation logistics.

No	Source	No. of records	% participation	Quartile SJR	H-index (SJR)	SJR-2020	Country
1	Maritime Policy and Management	21	4%	Q1	57	1,05	United Kingdom
2	Maritime Economics and Logistics	14	2%	Q1	54	0,67	United Kingdom
3	Sustainability Switzerland	13	2%	Q1	85	0,61	Switzerland
4	Journal of Maritime Research	9	2%	-	9	0	Spain
5	Journal of Coastal Research	8	1%	Q3	90	0,25	United State
6	International Journal of Logistics Research and Applications	7	1%	Q1	33	0,8	United Kingdom
7	Wmu Journal of Maritime Affairs	7	1%	Q1	19	0,59	Germany
8	Marine Policy	6	1%	Q1	95	1,36	United Kingdom
9	Transportation Research Procedia	6	1%	-	40	0,66	Netherlands
10	Asian Journal of Shipping and Logistics	6	1%	Q1	22	0,7	Netherlands

Table 3. Characteristics of the main authors.

No	Author	# of publications	# of citations	H-index	Institution
1	Wilmsmeier, Gordon	10	1391	20	Universidad de Los Andes, Bogotá, Colombia
2	Song, Dong-wook	9	2790	23	World Maritime University, Malmo, Sweden
3	Yuen, Kum Fai	8	1981	25	Nanyang Technological University, Singapore City, Singapore
4	Monios, Jason	6	1303	20	KEDGE Business School, Talence, France
5	Ng, Adolf K.Y.	6	2786	34	St. John's College, Winnipeg, Winnipeg, Canada
6	Panayides, Photis M.	6	2064	26	Cyprus University of Technology, Limassol, Cyprus
7	Psaraftis, Harilaos N.	6	4671	30	Technical University of Denmark, Lyngby, Denmark
8	Thai, V.V.	5	1723	26	RMIT University, Melbourne, Australia
9	Lee, Paul Tae Woo	5	1467	23	Zhejiang University, Hangzhou, China
10	Lee, Eonseong	5	121	5	Pusan National University, Busan, South Korea

co-citation among the authors in the network. It is worth noting that there are also co-citations between different groups, and in this section, new authors such as Notteboom and Wang make significant contributions.

3.2. Research trends in maritime transport logistics

The original studies that support the theme and indicate emerging research trends are presented in Figure 4. The most relevant topics related to the

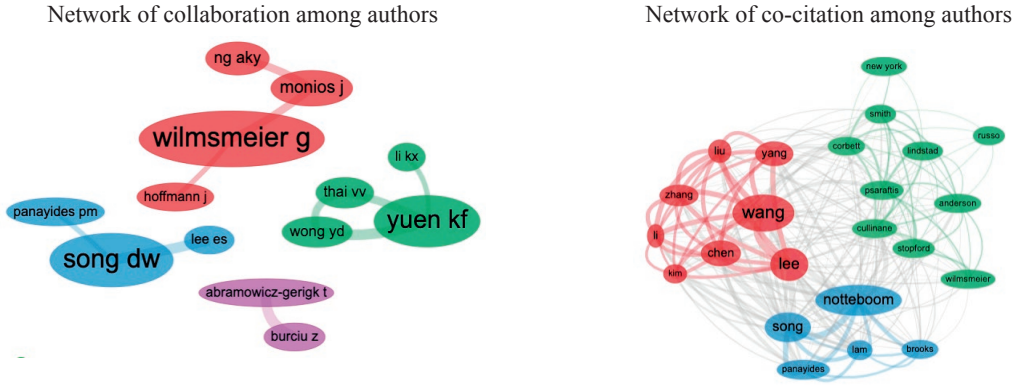

Figure 3. Network of collaboration and cocitation between authors.

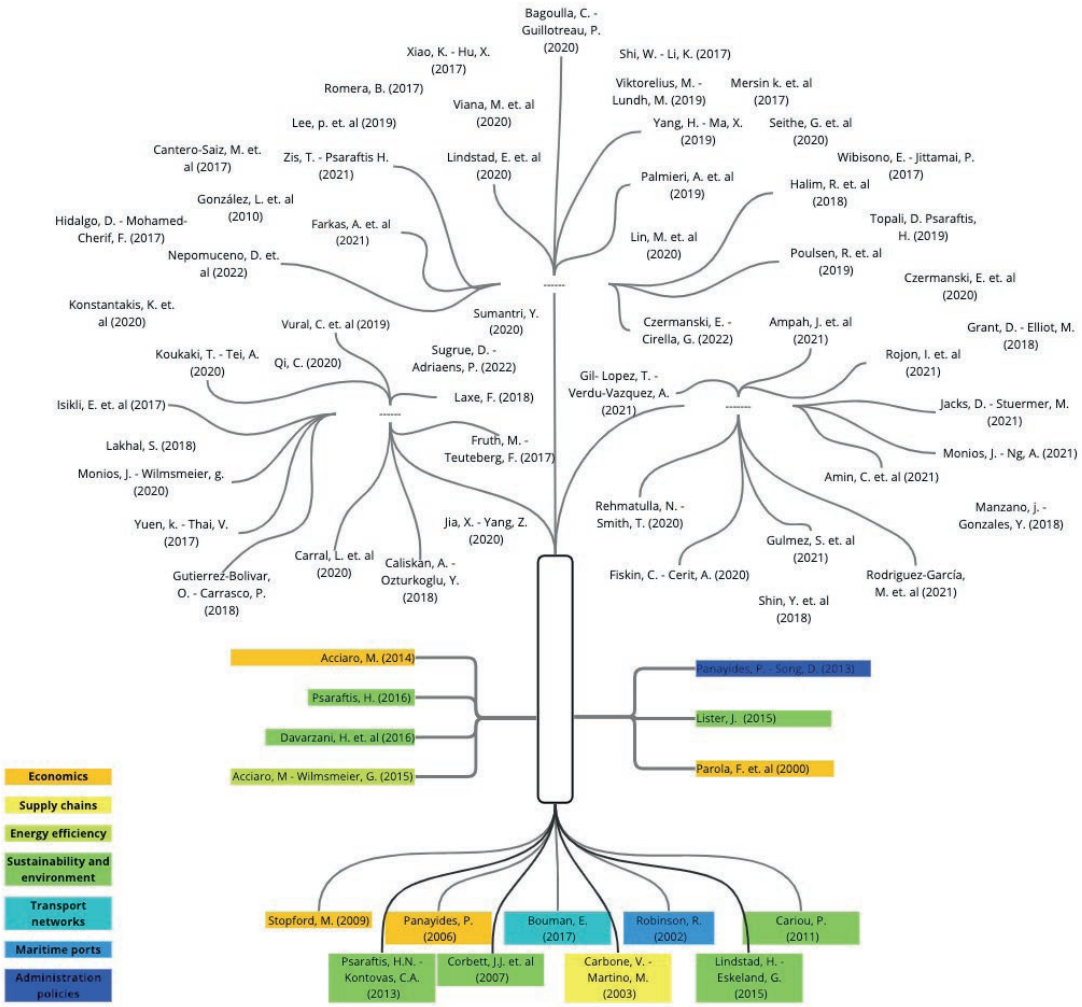

Figure 4. Knowledge tree in maritime transport logistics.

root of studies in maritime transport logistics are maritime economics (Panayides, 2006; Stopford, n.d.), transport networks (Bouman et al., 2017), maritime ports (Robinson, 2002), supply chains (Carbone & De Martino, 2003), and primarily sustainability and the environment (Cariou, 2011; Corbett et al., 2007; Lindstad & Eskeland, 2015; Psaraftis & Kontovas, 2013). The documents belonging to the trunk, which provide structure and link the original documents to research perspectives, have directed the theme towards energy efficiency (Acciaro & Wilmsmeier, 2015), sustainability and the environment (Davarzani et al., 2016; Lister, 2015; Psaraftis, 2016), economics (Acciaro, 2014; Parola et al., 2015), and maritime administration policies (Panayides & Song, 2013). Meanwhile, the documents located in the leaves, corresponding to streams and research trends, have directed studies towards digitization and technology (Schaumburg et al., 2020), intelligent transportation (Caliskan & Ozturkoglu, 2018), resource consumption (Işıklı et al., 2020; Seithe et al., 2020), supply chain integration (Shin et al., 2018; Yuen & Thai, 2017), and primarily network design (Castillo Hidalgo & Zohra Mohamed-Chérif, 2017; Lakhal, 2017; Palmieri et al., 2019; Wibisono & Jittamai, 2017) and sustainability, the environment, and climate change (Bagoulla & Guillotreau, 2020; Carral et al., 2020; Farkas et al., 2021; Halim et al., 2018; Monios & Wilmsmeier, 2020; Poulsen et al., 2018; Psaraftis & Kontovas, 2020; Romera, 2017; H. Yang & Ma, 2019; Zis et al., 2020; Zis & Psaraftis, 2022).

The research trends related to maritime transport logistics have mainly focused on 4 major groups (Table 4). The first group is called “Environmental

Table 4. Research trends in maritime transportation logistics.

Research trend & References	
1. Environmental Impacts of Maritime Transport 	2. Port networks and optimization of logistics processes 
Wang et al. (2021); Bouman et al. (2017); Faber et al. (2009); Psaraftis & Kontovas (2020); Ampah et al. (2021); Gil-Lopez & Verdu-Vazquez (2021); Viana et al. (2014); Bach et al. (2020); Farkas et al. (2021) and Zis & Psaraftis (2022)	Song & Panayides (2012b); Huybrechts et al. (2002); Sumantri (2020b); Carbone & De Martino (2003); Belyaev et al. (2020); Song & Panayides (2012a); Porter (2011); Evangelista & Morvillo (1999); Lin et al. (2020) and Jia & Yang (2020)
3. Port Competitiveness in the Supply Chain 	4. Economic aspects of foreign trade 
Bierwirth & Meisel (2015); Zhou, Ma, et al. (2021); Fagerholt et al. (2010); Wang & Meng, (2012); Romero et al. (2013); Meng & Wang (2011); Tagawa et al. (2021); Moscoso-López et al. (2021); Imai et al. (1997) and Chen et al. (2022).	Button & Nijkamp (1997); Wilmsmeier (2016); Wilmsmeier et al. (2006); Sánchez et al. (2003); Martínez-Zarzoso & Nowak-Lehmann (2007); Jacks & Stuermer (2021); Rojon et al. (2021); Sugrue & Adriaens (2022); Chang et al. (2020) and Lei & Bachmann (2020).

Impacts of Maritime Transport," as indicated by the words suggesting a relationship between shipping operations and fuel emissions, resource consumption, and other sustainability aspects. Group 2, "Supply Chain and International Shipping," integrates distribution logistics activities with competitiveness, service, and port strategies. Group 3, "Port Networks and Vehicle Routing," involves the distribution network activities with cargo terminals, management, and route design. Finally, Cluster 4, "Economic Aspects of International Trade," considers logistics operations, efficiency associated with network activities, and the economic implications of maritime transport.

Trend 1. Environmental Impacts of Maritime Transport

The most relevant cluster in terms of the number of publications is related to greenhouse gas (GHG) emissions from maritime transport. Research in this area has focused on understanding the causes of GHG emissions and developing strategies to minimize

these emissions in order to achieve the goals set by the International Maritime Organization (IMO) for 2030 and 2050, which are related to reducing carbon intensity in ships.

Maritime transport is the main player in international trade, with a fleet of over 90,000 vessels worldwide, and an average annual increase in operations of 3.12% (Wang et al., 2021). This mode of transport is responsible for 3.3% of global CO_2 emissions and 6.1% of the total emissions in the European Union. GHG emissions from maritime transport reached 1,056 million tonnes of CO_2 in 2018, accounting for more than 2.89% of the global total (Wang et al., 2021). Despite the inclusive initiatives and policies aimed at reducing emissions, it is projected that they will continue to grow disproportionately, with efficiency and competitiveness being among the main drivers. Furthermore, it is estimated that by 2050, emissions could increase by 150% to 250% due to the tripling of international trade (Bouman et al., 2017; Faber et al., 2009).

The urgency of addressing GHG emissions and exploring decarbonization options in maritime transport has led to studies on the IMO's strategies and the need to incorporate new alternatives to reduce CO_2 emissions by 40% in 2030 and 50% in 2050 (Psaraftis & Kontovas, 2020). One of the potential solutions is the use of clean marine fuels such as liquefied natural gas, methanol, ammonia, and hydrogen (Ampah et al., 2021). Other studies have examined the implications of ships in Spanish ports, finding that the use of natural gas can achieve fuel savings of over 20% compared to traditional fossil fuels while significantly reducing CO_2, NO_x, and SO_x emissions (Gil-Lopez & Verdu-Vazquez, 2021). In general, issues such as GHG emissions reported in coastal areas of European countries, which are related to air quality, the atmosphere, and public health, highlight the need to continue existing measures and pay attention to the primary particles emitted by ships (Viana et al., 2014).

On the other hand, other strategies have been proposed and developed to mitigate the environmental impact of maritime transport. These include the use of electric batteries and hydrogen, which has been applied in coastal transport in Norway, suggesting it as a viable alternative for the future (Bach et al., 2020). Another study conducted an analysis of the results and potential benefits of applying low-friction anti-fouling coatings on ships, finding that it is possible to achieve potential energy savings and reduce CO_2 emissions into the atmosphere (Farkas et al., 2021). Another strategy involved analyzing the consequences of reducing power and speed in container ships on GHG emissions, with a focus primarily on perishable food exports from South America to China. The results highlighted a significant reduction in emissions, increased ship efficiency, and no adverse effects on the quality of perishable goods (Zis & Psaraftis, 2022).

Trend 2. Port Competitiveness in the Supply Chain

The highlighted elements in this perspective consider aspects related to logistics and the entities involved in it, supply chain management, business activities and decisions, and port operations. Companies organize their processes in order to optimize their logistics work and gain a competitive advantage over others. Meanwhile, ports play a significant role in international trade and seek to improve performance and overcome industry-specific challenges.

Globalization and the growing development of industries have a significant influence on the demand for maritime transport and logistics in the supply chain. Maritime transport is the primary mode of transportation for goods, accounting for over 90% of global commercial cargo movement. Therefore, the role played by maritime transport and ports in the global economy is influential and of interest for study (Song & Panayides, 2012b). One of the most notable elements of international trade is port activity, which facilitates the circulation of thousands of tons of various goods and connects different parts of the world through globalization. As a result, maritime ports have become logistics centers and industrial hubs that need to be certified and at the forefront of technical, computer, and technological updates to be recognized as key nodes in maritime transit (Huybrechts et al., 2002).

Despite the significant efforts made by ports to be globally competitive, challenges related to supply chain integration still persist as a central aspect of business transformation and economic growth. Various studies have focused on identifying and seeking alternatives to address specific issues. For example, the Indonesian port logistics system faces challenges in the transit of goods related to regulations on import and export of special goods, third-party logistics, port infrastructure, adoption of new technologies, and connectivity in maritime routes. The solution to this problem could involve coordination and cooperation among institutions

to facilitate paperwork and logistics procedures, improving the flexibility of waiting times at each port, investing in infrastructure, and ultimately developing new routes and transport networks (Sumantri, 2020b). Another studied approach has been the capacity of ports to integrate into all phases of the logistics process. The port of Le Havre in the Renault supply chain was used as an example, where business data were collected from port personnel, logistics staff, and external authorities. The study concluded that ports still lack significantly advanced research and knowledge in terms of business economics (Carbone & De Martino, 2003). This situation affects port efficiency, considering that maritime ports, as global connectors, contribute to international competitiveness based on their economic development and utilization of their geographical position (Belyaev et al., 2020).

The logistics of maritime transportation, considered one of the main factors providing competitive advantages to economies, has driven research to identify activities and areas that will enable it to stay at the forefront, increase its relevance, and improve operations management. After an exhaustive data review, it was concluded that the most relevant thematic areas are those related to ecological and sustainable issues, maritime transport networks, and ports as key players in the entire logistics process. These aspects should consider security and operational aspects that facilitate the supply chain (Song & Panayides, 2012a). Regarding competitive advantages, each of the factors that should be considered for a company or organization to excel over others were analyzed, identifying the importance of relationships with suppliers, customers, and, most importantly, being rigorous and careful in each phase of the logistics process and supply chain to enhance processes sustainably and profitably (Porter, 2011).

In light of the above, companies must explore methods or ways that allow them to obtain strategic leverage through alliances between shipping companies, carriers, freight forwarders, and other entities in the logistics chain, providing value and integration to the supply chain. However, these activities have been primarily observed in the maritime phase for space utilization and not in aspects such as shared use of human resources and marketing activities (Evangelista & Morvillo, 1999). Other studies have identified deficiencies in logistics networks, such as in Taiwan, where interviews with professionals in the maritime network revealed gaps that affect and influence the network, including weak links between the port and cargo owners, cultural and political norms, and container flow (Lin et al., 2020). Furthermore, another research in the field proposed identifying key points to achieve flexibility in maritime logistics through the collection and classification of background information based on importance and the identification of these points in logistical challenges (Jia & Yang, 2020).

Trend 3. Port networks and optimization of logistics processes

The efforts made by various entities involved in international trade processes enable the smooth functioning and development of logistics management and goal achievement. In this regard, the main aspects addressed in Perspective 2 are entirely related to the efforts made by researchers to automate processes, improve, facilitate, schedule, and efficiently allocate all aspects to be considered in logistics networks, particularly in ports and their surroundings. It is worth noting that by 2015, there were still not enough advancements in topics related to port arrivals, berthing, and algorithm assignment and modification (Bierwirth & Meisel, 2015). Although significant contributions have been made since then, the field currently requires further exploration.

Operational actors in maritime logistics, as well as researchers, constantly face changes and challenges resulting from new technologies, specifically Industry 4.0. Optimization in maritime logistics is one of the extensive fields of study in this area, aiming to bring new solutions and automate common processes in the logistics management of international trade (Zhou, Ma, et al., 2021). The efforts made are diverse; however, the focus remains on process improvement through activities such as the incorporation of new methodologies, techniques, and/or procedures that facilitate decision-making and strategic planning. Furthermore, validation in real-world applications is crucial. For instance, applied research in a Norwegian shipping company employed stochastic aspects to effectively configure port planning considering contract sizes and contractual conditions (Fagerholt et al., 2010).

Significant progress has been identified in the literature on operational research and its application in ports since 2009. Some of the efforts related to the improvement and development of the logistics process involved the creation of a program to design itineraries for regular liner vessel arrivals, considering

uncertainties at sea and in the port, along with vessel speed. The implementation of a mixed integer non-linear programming model led to the conclusion that it can be beneficial for vessels to occasionally violate maximum allowed schedules in terms of reducing costs by reducing average speed and fuel cost savings (Wang & Meng, 2012). Subsequently, another study presented a methodology to address ship routing problems, travel times, and constraint management that arise during maritime transportation, resulting in meeting customer requirements in terms of delivery times (Romero et al., 2013).

Among the challenges of operations research, reducing delivery times and fuel levels while increasing operational efficiency are key. To address these challenges, a practical problem was proposed to determine the optimal combination of container ship deployment frequency and navigation speed. The method used was the e-optimal algorithm based on branch and bound, which yielded an optimal and efficient solution for practical problems related to fuel consumption, time, and service frequency (Meng & Wang, 2011). Another study utilized a mixed integer programming model to solve an optimization problem between shipping companies and cargo owners. Four factors were considered in problem resolution: cargo demand, fuel price, ship size, and time value. The results of this study can assist port management personnel in implementing precautionary measures against potential changes in networks, depending on which of the four aforementioned factors are affected (Tagawa et al., 2021).

Other studies, problem formulations, model creations, and research aimed at improving, strategizing, and optimizing maritime logistics include the following: a problem of forecasting perishable food cargo flows at the port of Algeciras, Spain was presented. Machine learning methods were employed, analyzing data from 2010 to 2017 to provide predictions as accurately as possible, using statistical and machine learning approaches. Results included a prediction accuracy of over 13% for fresh fruits and 11% for vegetables (Moscoso-López et al., 2021). Furthermore, two assignment problems focused on optimizing time reduction in ports and maritime transportation were presented. An Asian port berth assignment problem aimed at reducing port stay times and dissatisfaction in terms of berth order. An algorithm called BAP was used to find the optimal assignment that minimizes the total sum of times, enabling informed decision-making by port operators for more optimal port operations (Imai et al., 1997). Additionally, an optimal multi-objective time slot assignment model for maritime transportation was developed, using the NSGA-II algorithm. The obtained methods can assist carriers in solving their assignment problems and provide assistance in regular container line maritime logistics (Chen et al., 2022).

Trend 4. Economic aspects of foreign trade

Maritime transportation is directly linked to variables such as port infrastructure, service efficiency, types of goods, and geographical aspects, among others. These variables collectively define freight costs, which is the most relevant topic in perspective 4. Similarly, a country's economy is closely related to maritime transportation, as it is the primary mode of global goods transportation. Therefore, price fluctuations in maritime transportation can have beneficial or detrimental effects depending on the case and the territory in which they occur.

The liberalization and globalization of markets have generated constant changes and movements, particularly in supply and demand. Maritime transportation is proposed as a method of economic integration that promotes development and competitiveness through agreements between economic networks. However, inherent problems exist, and this article recommends political solutions that can foster development and provide appropriate responses to various conditions (Button & Nijkamp, 1997). Based on the above, it is understood that maritime transportation is a key pillar of global economies. Analyzing the main factors that drive maritime transportation prices, with a focus on Latin America, is of interest. The aim is to suggest both political and port measures that can contribute to regional development and increased competitiveness (Wilmsmeier, 2016).

Several factors that affect maritime transportation prices are mentioned in various documents. Analyses were conducted on different port characteristics and their impact on price variations, such as operational efficiency, port infrastructure, and interport connectivity. It is concluded that if ports have significant advancements, development, and efficiency, their prices will increase when offering services. Therefore, faster and more reliable services are more beneficial in terms of service provision but not in terms of pricing (Wilmsmeier et al., 2006). Furthermore, the variables with the greatest

impact on price fluctuations in maritime and river transportation were identified, with a focus on Latin American ports and their impact according to their level of efficiency. This information was used to construct a cost model for maritime and river transportation, primarily based on port efficiency. It was concluded that port efficiency is directly related to maritime and river freight costs, considering other variables that directly impact prices, such as product type, insurance costs, and product price (Sánchez et al., 2003).

As a result of another research, the determinants impacting maritime and land transportation freight prices for exports from Spain to Turkey and Poland were analyzed independently. Variables such as unit values, distance traveled, service quality and structure, among others, were taken into account. The results obtained showed that the actual distance is not a determining indicator of maritime transportation freight costs. Instead, service efficiency and quality have a greater impact. In the case of land transportation, geographical distance is more important (Martínez-Zarzoso & Nowak-Lehmann, 2007).

Furthermore, factors influencing long-term maritime transportation costs were identified by analyzing documents from 1850 to 2020. The main factors that modify prices include supply and demand, types of goods, origin and destination, geographic determinants, among others (Jacks & Stuermer, 2021). Another literature review defined the relationship between maritime carbon pricing and transportation costs. Determinants of maritime transportation costs, such as geography, infrastructure, current politics, goods to be transported, and economic development, were analyzed. It was concluded that maritime carbon pricing would directly affect developing countries, as they lack the necessary capacity to adapt to changes due to inequalities and technological development disadvantages (Rojon et al., 2021).

The transportation industry is closely linked to international trade, meaning that the maritime transportation economy is directly influenced by the volume of global commercial transactions. While maritime transportation generates significant capital, millions of dollars are also wasted in its logistical processes. For instance, delays in dredging operations at several U.S. ports have caused economic losses due to waiting times, leading to inefficiency and logistic delays. Political solutions have been sought, but the only conclusion reached is that dredging prices have increased by more than 250% in the past 30 years, creating inefficiencies and imbalances between intended savings and actual expenses. To address this, a model was created to understand the ports' needs based on demand, enabling beneficial financing decisions (Sugrue & Adriaens, 2022).

On another note, the analysis of different economic blocs and their relationship and impact on maritime transportation revealed that economic blocs generate economic networks that are highly beneficial for maritime transportation (Chang et al., 2020). Finally, another study determined the relationship between port efficiency and maritime transportation costs, considering dock utilization, labor time, and vessel docking time. All these aspects collectively influence service efficiency and provision, directly relating to the value of maritime transportation freight (Lei & Bachmann, 2020).

4. Conclusions and future work

In terms of scientometric analysis, publications related to maritime transportation logistics have shown a growing trend of 15.77% annually, particularly since 2018 when it surpassed the general trend line. The countries with the highest number of documents were the United Kingdom, Spain, and Poland, demonstrating collaborative work within the same network that includes other significant countries in the field such as Italy and Belgium. Regarding journal relevance, 70% of the publications in the top 10 are classified in Q1, with Europe leading in participation. Among the authors, Gordon Wilmsmeier, affiliated with Colombia, stands out for having the highest number of publications (10); Harilaos Psaraftis from Denmark has the highest number of citations (4671); and Adolf Ng from Canada has the highest H-index (34).

Network analysis using graph theory and bibliometric indicators highlight the study themes of the originating documents, including supply chains, transportation networks, and sustainability in operations, primarily. In terms of structure, there is a focus on natural resources and the economy. The research trends have been grouped into four main areas, which are the environmental impact of maritime transportation, process optimization in response to industry 4.0, port competitiveness in the supply chain, and the economic aspects of foreign trade.

Table 5. Future lines of research.

Trend	Proposal for future lines of research	References
Trend 1: Environmental Impacts of Maritime Transport	Sustainable technologies and alternatives that minimize GHGs.	Bach et al. (2020)
	Policies and regulations for the transition to alternative fuels.	Ampah et al. (2021)
Trend 3. Port networks and optimization of logistics processes	Strategic planning effects on maritime transportation.	Fagerholt et al. (2010)
	Optimization problems based on meteorological conditions.	Romero et al. (2013)
	Effects of medium-term demand variability.	Meng & Wang (2011)
Trend 4: Economic aspects of foreign trade	Study of increased volumes of trade data and caused imbalances.	Wilmsmeier et al. (2006)
	Efficiency measures for large sets of ports, and their consequences on international trade.	Sánchez et al. (2003)

The previously outlined research trends establish future themes to provide continuity to proposed investigations (Table 5). Emphasizing the critical importance of sustainability, logistics efficiency, and economic aspects in the maritime transport context, these trends suggest specific areas for research. The proposals encompass exploring sustainable technologies, crafting regulations for fuel transitions, understanding the effects of strategic planning, addressing optimization challenges based on meteorological conditions, studying medium-term demand variability, and examining measures for port efficiency. Each proposed theme reflects critical areas deserving substantial attention due to their impact on the sustainability, efficiency, and economic dimensions of this pivotal industry.

In environmental terms, research on sustainable and alternative technologies garners global interest, particularly in embracing cleaner and more efficient solutions to mitigate environmental impact and enhance industrial competitiveness. Spearheading this effort, the establishment and execution of regulatory policies would serve as a guiding beacon, supporting the maritime industry's transition towards sustainable practices.

On the strategic planning front, studies wield significant potential to reshape port management and maritime routes. Delving into aspects such as medium-term demand variability opens doors to more precise and efficient planning, easing resource management and enhancing adaptability to demand fluctuations. Similarly, addressing optimization challenges tied to meteorological conditions contributes to the safety and efficiency of maritime transport when facing adverse weather conditions.

Lastly, the economic lens on international trade, coupled with the current data-centric landscape, poses a challenge in devising strategies to handle vast volumes of data. Specifically, delving into efficiency measures at ports could pave the way for smoother international trade, grounded in well-informed decisions and economic equilibrium within the maritime sector.

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References

Acciaro, M. (2014). A real option application to investment in low-sulphur maritime transport. *International Journal of Shipping and Transport Logistics, 6*(2), 189-212. https://doi.org/10.1504/IJSTL.2014.059570

Acciaro, M., & Wilmsmeier, G. (2015). Energy efficiency in maritime logistics chains. *Research in Transportation Business & Management* (17), 1-7. https://doi.org/10.1016/j.rtbm.2015.11.002

Acevedo, J. P., Robledo, S., & Sepúlveda, M. Z. (2020). Subáreas de internacionalización de emprendimientos: una revisión bibliográfica. *Económicas CUC, 42*(1), 249-268. https://doi.org/10.17981/econcuc.42.1.2021.Org.7

Alzate, P., & Giraldo, D. (2023). Tendencias de investigación del blockchain en la cadena de suministro: transparencia, trazabilidad y seguridad. *Revista Universidad y Empresa, 25*(44), 1–29. https://doi.org/10.12804/revistas.urosario.edu.co/empresa/a.12451

Ampah, J. D., Yusuf, A. A., Afrane, S., Jin, C., & Liu, H. (2021). Reviewing two decades of cleaner alternative marine fuels: Towards IMO's decarbonization of the maritime transport sector. *Journal of Cleaner Production, 320*, 128871. https://doi.org/10.1016/j.jclepro.2021.128871

Aria, M., & Cuccurullo, C. (2017). bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal of Informetrics, 11*(4), 959-975. https://doi.org/10.1016/j.joi.2017.08.007

Arof, A. M. (2015). The application of a combined Delphi-AHP method in maritime transport research-A review. *Asian Social Science, 11*(23), 73-82. https://doi.org/10.5539/ass.v11n23p73

Bach, H., Bergek, A., Bjørgum, Ø., Hansen, T., Kenzhegaliyeva, A., & Steen, M. (2020). Implementing maritime battery-electric and hydrogen solutions: A technological innovation systems analysis. *Transportation Research Part D: Transport and Environment, 87*, 102492. https://doi.org/10.1016/j.trd.2020.102492

Bagoulla, C., & Guillotreau, P. (2020). Maritime transport in the French economy and its impact on air pollution: An input-output analysis. *Marine Policy, 116*, 103818. https://doi.org/10.1016/j.marpol.2020.103818

Bălan, C. (2018). The disruptive impact of future advanced ICTs on maritime transport: a systematic review. *Supply Chain Management: An International Journal, 25*(2), 157-175. https://doi.org/10.1108/SCM-03-2018-0133

Belyaev, S. G., Dorogov, N. I., Kapitonov, I. A., & Asabina, S. N. (2020). Ensuring competition in the context of globalization of maritime transport services. *Journal of Entrepreneurship and Sustainability Issues, 7*(3), 1597-1611. https://doi.org/10.9770/jesi.2020.7.3(12)

Bierwirth, C., & Meisel, F. (2015). A follow-up survey of berth allocation and quay crane scheduling problems in container terminals. *European Journal of Operational Research, 244*(3), 675-689. https://doi.org/10.1016/j.ejor.2014.12.030

Bouman, E. A., Lindstad, E., Rialland, A. I., & Strømman, A. H. (2017). State-of-the-art technologies, measures, and potential for reducing GHG emissions from shipping - A review. *Transportation Research Part D: Transport and Environment, 52*, 408-421. https://doi.org/10.1016/j.trd.2017.03.022

Buitrago, S., Duque, P., & Robledo, S. (2020). Branding Corporativo: una revisión bibliográfica. *Económicas CUC, 41*(1). https://doi.org/10.17981/econcuc.41.1.2020.Org.1

Button, K., & Nijkamp, P. (1997). *Network industries, economic stability and spatial integration (No. 97-047/3)*. Tinbergen Institute Discussion Paper. https://www.econstor.eu/handle/10419/85723

Caliskan, A., & Ozturkoglu, Y. (2018). Maritime Logistics. In *Intelligent Transportation and Planning: Breakthroughs in Research and Practice* (pp. 822-845). IGI Global. https://doi.org/10.4018/978-1-5225-5210-9.ch036

Carbone, V., & De Martino, M. (2003). The changing role of ports in supply-chain management: an empirical analysis. In *Maritime Policy & Management*, *30*(4), 305-320). https://doi.org/10.1080/0308883032000145618

Cariou, P. (2011). Is slow steaming a sustainable means of reducing CO_2 emissions from container shipping? *Transportation Research Part D: Transport and Environment, 16*(3), 260-264. https://doi.org/10.1016/j.trd.2010.12.005

Carral, L., Fernández-Garrido, C., Vega, A., & Sabonge, R. (2020). Importance of the Panama canal in the reduction of CO_2 emissions from maritime transport. In *International Journal of Sustainable Transportation*, *14*(11), 819-832. https://doi.org/10.1080/15568318.2019.1632994

Castillo Hidalgo, D., & Zohra Mohamed-Chérif, F. (2017). La configuración de las redes de transporte marítimo en África noroccidental (1880-1939). *Investigaciones de Historia Económica - Economic History Research, 13*(2), 81-92. https://doi.org/10.1016/j.ihe.2016.02.001

Chang, S.-M., Huang, Y.-Y., Shang, K.-C., & Chiang, W.-T. (2020). Impacts of regional integration and maritime transport on trade: with special reference to RCEP. *Maritime Business Review, 5*(2), 143-158. https://doi.org/10.1108/MABR-03-2020-0013

Chen, J., Xu, Q., Zhang, H., Wan, Z., & Yu, M. (2022). Bilateral slot exchange and co-allocation for liner alliance carriers of containerized maritime logistics. *Advanced Engineering Informatics, 51*, 101479. https://doi.org/10.1016/j.aei.2021.101479

Clavijo-Tapia, F. J., Duque-Hurtado, P. L., Arias-Cerquera, G., & Tolosa-Castañeda, M. A. (2021). Organizational communication: a bibliometric analysis from 2005 to 2020. *Clío América, 15*(29). https://doi.org/10.21676/23897848.4311

Corbett, J. J., Winebrake, J. J., Green, E. H., Kasibhatla, P., Eyring, V., & Lauer, A. (2007). Mortality from Ship Emissions: A Global Assessment. *Environmental Science & Technology, 41*(24), 8512-8518. https://doi.org/10.1021/es071686z

Coșofreț, D., Avram, E. R., & Corduneanu, D. (2020). Economic policies to reduce CO_2 emissions in maritime transport. *Scientific Bulletin of Naval Academy, 23*(2), 98-101. https://doi.org/10.21279/1454-864X-20-I2-013

Davarzani, H., Fahimnia, B., Bell, M., & Sarkis, J. (2016). Greening ports and maritime logistics: A review. *Transportation Research Part D: Transport and Environment, 48*, 473-487. https://doi.org/10.1016/j.trd.2015.07.007

Di Vaio, A., Palladino, R., Pezzi, A., & Kalisz, D. E. (2021). The role of digital innovation in knowledge management systems: A systematic literature review. *Journal of Business Research, 123*, 220-231. https://doi.org/10.1016/j.jbusres.2020.09.042

Duque, P., & Cervantes, L. S. (2019). Responsabilidad Social Universitaria: una revisión sistemática y análisis bibliométrico. *Estudios Gerenciales, 35* (153 Oct-Dic 2019), 451-464. https://doi.org/10.18046/j.estger.2019.153.3389

Duque, P., Samboni, V., Castro, M., Montoya, L. A., & Montoya, I. A. (2020). Neuromarketing: Its current status and research perspectives. *Estudios Gerenciales, 36*(157). https://doi.org/10.18046/j.estger.2020.157.3890

Duque, P., Toro, A., Ramírez, D., & Carvajal, M. E. (2020). Marketing viral: Aplicación y tendencias. *Clío América, 14*(27), 454-468. https://doi.org/10.21676/23897848.3759

Duque, P., Meza, O. E., Giraldo, D., & Barreto, K. (2021). Economía Social y Economía Solidaria: un análisis bibliométrico y revisión de literatura. *REVESCO. Revista de Estudios Cooperativos, 138*, e75566-e75566. https://doi.org/10.5209/reve.75566

Duque, P., Meza, O., Zapata, G., & Giraldo, J. (2021). Internacionalización de empresas latinas: evolución y tendencias. *Económicas CUC, 42*(1). https://doi.org/10.17981/econcuc.42.1.2021.Org.1

Duque, P., Trejos, D., Hoyos, O., & Chica, J. C. (2021). Finanzas corporativas y sostenibilidad: un análisis bibliométrico e identificación de tendencias. *Semestre Económico, 24*(56), 25-51. https://doi.org/10.22395/seec.v24n56a1

Echchakoui, S. (2020). Why and how to merge Scopus and Web of Science during bibliometric analysis: the case of sales force literature from 1912 to 2019. *Journal of Marketing Analytics, 8*(3), 165-184. https://doi.org/10.1057/s41270-020-00081-9

Enriquez, A., & Sáenz, C. (2021). Primeras lecciones y desafíos de la pandemia de COVID-19 para los países del SICA. CEPAL. https://repositorio.cepal.org/bitstream/handle/11362/46802/1/S2100201_es.pdf

Evangelista, P., & Morvillo, A. (1999). Alliances in Liner Shipping: an Instrument to Gain Operational Efficiency or Supply Chain Integration? *International Journal of Logistics Research and Applications, 2*(1), 21-38. https://doi.org/10.1080/13675569908901570

Faber, J., Markowska, A., Nelissen, D., & Davidson, M. (2009). Technical support for European action to reducing Greenhouse Gas Emissions from international maritime transport. https://dare.uva.nl/record/1/401570

Fagerholt, K., Christiansen, M., Magnus Hvattum, L., Johnsen, T. A. V., & Vabø, T. J. (2010). A decision support methodology for strategic planning in maritime transportation. *Omega, 38*(6), 465-474. https://doi.org/10.1016/j.omega.2009.12.003

Farkas, A., Degiuli, N., Martić, I., & Vujanović, M. (2021). Greenhouse gas emissions reduction potential by using antifouling coatings in a maritime transport industry. *Journal of Cleaner Production, 295*, 126428. https://doi.org/10.1016/j.jclepro.2021.126428

Freeman, L. C. (1977). A Set of Measures of Centrality Based on Betweenness. *Sociometry, 40*(1), 35. https://doi.org/10.2307/3033543

Giannopoulos, G. A., & Aifandopoulou-klimis, G. (2004). Inland Maritime Transport in Greece after the Lifting of the Cabotage and Full Liberalization: A Review. Part 1: The Situation "before" and Expected Impacts. *Transport Reviews, 24*(4), 465-483. https://doi.org/10.1080/0144164042000181699

Gil-Lopez, T., & Verdu-Vazquez, A. (2021). Environmental Analysis of the Use of Liquefied Natural Gas in Maritime Transport within the Port Environment. *Sustainability: Science Practice and Policy, 13*(21), 11989. https://doi.org/10.3390/su132111989

Gurzki, H., & Woisetschläger, D. M. (2017). Mapping the luxury research landscape: A bibliometric citation analysis. *Journal of Business Research, 77*, 147-166. https://doi.org/10.1016/j.jbusres.2016.11.009

Halim, R. A., Kirstein, L., Merk, O., & Martinez, L. M. (2018). Decarbonization Pathways for International Maritime Transport: A Model-Based Policy Impact Assessment. *Sustainability: Science Practice and Policy, 10*(7), 2243. https://doi.org/10.3390/su10072243

Huybrechts, M., Meersman, H., Van de Voorde, E., Van Hooydonk, E., Verbeke, A., & Winkelmans, W. (2002). IMIS.

Imai, A., Nagaiwa, K. 'ichiro, & Tat, C. W. (1997). Efficient planning of berth allocation for container terminals in Asia. *Journal of Advanced Transportation, 31*(1), 75-94. https://doi.org/10.1002/atr.5670310107

Işıklı, E., Aydın, N., Bilgili, L., & Toprak, A. (2020). Estimating fuel consumption in maritime transport. *Journal of Cleaner Production, 275*, 124142. https://doi.org/10.1016/j.jclepro.2020.124142

Jacks, D. S., & Stuermer, M. (2021). Dry bulk shipping and the evolution of maritime transport costs, 1850-2020. *Australian Economic History Review, 61*(2), 204-227. https://doi.org/10.1111/aehr.12220

Jia, X., & Yang, Z. (2020). Key antecedents to achieving flexibility in maritime logistics industry: empirical evidence from China. *International Journal of Shipping and Transport Logistics, 12*(5), 399-425. https://doi.org/10.1504/IJSTL.2020.109884

Josten, E. J. C., Ng-A-Tham, J. E. E., & Thierry, H. (2003). The effects of extended workdays on fatigue, health, performance and satisfaction in nursing. *Journal of Advanced Nursing, 44*(6), 643-652. https://doi.org/10.1046/j.0309-2402.2003.02854.x

Kleine-Kampmann, S., Schöll, M., Ehlers, L., Hewelt, E., Götsch, U., Göbels, K., Ippisch, S., Seidel, J., Thanheiser, M., Schindler, B., Kalkowski, M., Boldt, M., Dirksen-Fischer, M., von Münster, T., Jeglitza, M., Chmielewska, J., Sangs, A., Mouchtouri, B., Rexroth, U., & An der Heiden, M. (2021). [Air and maritime transport during the COVID-19 pandemic in Germany: challenges for the public health service]. *Bundesgesundheitsblatt, Gesundheitsforschung, Gesundheitsschutz, 64*(4), 454-462. https://doi.org/10.1007/s00103-021-03297-x

Koukaki, T., & Tei, A. (2020). Innovation and maritime transport: A systematic review. *Case Studies on Transport Policy, 8*(3), 700-710. https://doi.org/10.1016/j.cstp.2020.07.009

Lakhal, S. (2017). A Study on the Maritime Transport Network Design under Different Charter Rates: The Case of LNG Transport between Qatar and Turkey. *Operations and Supply Chain Management: An International Journal, 11*(1), 13-25. https://doi.org/10.31387/oscm0300196

Landinez, D. A., Robledo Giraldo, S., & Montoya Londoño, D. M. (2019). Executive Function performance in patients with obesity: A systematic review. *Psychologia, 13*(2), 121-134. https://doi.org/10.21500/19002386.4230

Lee, P. T.-W., Kwon, O. K., & Ruan, X. (2019). Sustainability challenges in maritime transport and logistics industry and its way ahead. *Sustainability (Switzerland), 11*(5). https://doi.org/10.3390/su11051331

Lei, Q., & Bachmann, C. (2020). Assessing the role of port efficiency as a determinant of maritime transport costs: evidence from Canada. *Maritime Economics & Logistics, 22*(4), 562-584. https://doi.org/10.1057/s41278-019-00135-5

Lindstad, H., & Eskeland, G. S. (2015). Low carbon maritime transport: How speed, size and slenderness amounts to substantial capital energy substitution. *Transportation Research Part D: Transport and Environment, 41*, 244-256. https://doi.org/10.1016/j.trd.2015.10.006

Lin, M. S.-M., Potter, A., & Pettit, S. (2020). Relationship heterogeneity in Taiwanese maritime logistics service supply chains. *Supply Chain Management: An International Journal, 26*(3), 385-401. https://doi.org/10.1108/SCM-03-2019-0116

Lister, J. (2015). Green shipping: Governing sustainable maritime transport. *Global Policy, 6*(2), 118-129. https://doi.org/10.1111/1758-5899.12180

Lozano Arguello, D. K. (2021). Impacto del transporte marítimo de china y estados unidos, coyuntura de Colombia en el comercio internacional. http://repositorio.uan.edu.co/handle/123456789/4677

Makkonen, T., & Repka, S. (2016). The innovation inducement impact of environmental regulations on maritime transport: a literature review. *International Journal of Innovation & Sustainable Development, 10*(1), 69-86. https://doi.org/10.1504/IJISD.2016.073413

Martínez-Zarzoso, I., & Nowak-Lehmann, F. D. (2007). Is distance a good proxy for transport costs? The case of competing transport modes. *The Journal of International Trade & Economic Development, 16*(3), 411-434. https://doi.org/10.1080/09638190701527186

Meng, Q., & Wang, S. (2011). Optimal operating strategy for a long-haul liner service route. *European Journal of Operational Research, 215*(1), 105-114. https://doi.org/10.1016/j.ejor.2011.05.057

Mincomercio. (2021). Política de turismo sostenible. Ministerio de Comercio, Industria y Turismo. https://www.mincit.gov.co/minturismo/calidad-y-desarrollo-sostenible/politicas-del-sector-turismo/politica-de-turismo-sostenible/politica-de-turismo-sostenible-9.aspx

Mondello, G., Salomone, R., Saija, G., Lanuzza, F., & Gulotta, T. M. (2021). Life Cycle Assessment and Life Cycle Costing for assessing maritime transport: a comprehensive literature review. *Maritime Policy & Management*, 1-21. https://doi.org/10.1080/03088839.2021.1972486

Monios, J., & Wilmsmeier, G. (2020). Deep adaptation to climate change in the maritime transport sector - a new paradigm for maritime economics? *Maritime Policy & Management, 47*(7), 853-872. https://doi.org/10.1080/03088839.2020.1752947

Moscoso-López, J. A., Urda, D., Ruiz-Aguilar, J. J., González-Enrique, J., & Turias, I. J. (2021). A machine learning-based forecasting system of perishable cargo flow in maritime transport. *Neurocomputing, 452*, 487-497. https://doi.org/10.1016/j.neucom.2019.10.121

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *Revista Española de Cardiologia, 74*(9), 790-799. https://doi.org/10.1016/j.recesp.2021.06.016

Palmieri, A., Parola, F., Song, D.-W., & Baglieri, E. (2019). Integrating firms in a complex network: evidence from maritime logistics. *International Journal of Logistics Research and Applications, 22*(1), 64-77. https://doi.org/10.1080/13675567.2018.1474860

Panayides, P. M. (2006). Special issue of "maritime economics and logistics" MEL. *Maritime Economics & Logistics, 8*(1), 1-2. https://doi.org/10.1057/palgrave.mel.9100146

Panayides, P. M., & Song, D.-W. (2013). Maritime logistics as an emerging discipline. *Maritime Policy & Management, 40*(3), 295-308. https://doi.org/10.1080/03088839.2013.782942

Parola, F., Satta, G., & Panayides, P. M. (2015). Corporate strategies and profitability of maritime logistics firms. *Maritime Economics & Logistics, 17*(1), 52-78. https://doi.org/10.1057/mel.2014.18

Porter, M. E. (2011). *Competitive Advantage of Nations: Creating and Sustaining Superior Performance*. Simon and Schuster.

Poulsen, R. T., Ponte, S., & Sornn-Friese, H. (2018). Environmental upgrading in global value chains: The potential and limitations of ports in the greening of maritime transport. *Geoforum; Journal of Physical, Human, and Regional Geosciences, 89*, 83-95. https://doi.org/10.1016/j.geoforum.2018.01.011

Pranckutė, R. (2021). Web of Science (WoS) and Scopus: The Titans of Bibliographic Information in Today's Academic World. *Publications, 9*(1), 12. https://doi.org/10.3390/publications9010012

Psaraftis, H. N. (2016). Green Maritime Logistics: The Quest for Win-win Solutions. *Transportation Research Procedia, 14*, 133-142. https://doi.org/10.1016/j.trpro.2016.05.049

Psaraftis, H. N., & Kontovas, C. A. (2013). Speed models for energy-efficient maritime transportation: A taxonomy and survey. *Transportation Research Part C: Emerging Technologies, 26*, 331-351. https://doi.org/10.1016/j.trc.2012.09.012

Psaraftis, H. N., & Kontovas, C. A. (2020). Decarbonization of Maritime Transport: Is There Light at the End of the Tunnel? *Sustainability, 13*(1), 237. https://doi.org/10.3390/su13010237

Queiroz, M. M., & Fosso Wamba, S. (2021). A structured literature review on the interplay between emerging technologies and COVID-19 - insights and directions to operations fields. *Annals of Operations Research*, 1-27. https://doi.org/10.1007/s10479-021-04107-y

Ramos, V., Duque, P., & Vieira, J. A. (2021). Responsabilidad Social Corporativa y Emprendimiento: evolución y tendencias de investigación. *Desarrollo Gerencial, 13*(1), 1-34. https://doi.org/10.17081/dege.13.1.4210

Robinson, R. (2002). Ports as elements in value-driven chain systems: the new paradigm. *Maritime Policy & Management, 29*(3), 241-255. https://doi.org/10.1080/03088830210132623

Rojas, D., Angel, E., Rivera N: Plazas, & Malaver, Y. (2021). Conceptos de Logística en Colombia. Escuela de Ciencias Básicas, tecnología e Ingeniería (ECBTI).

Rojon, I., Lazarou, N.-J., Rehmatulla, N., & Smith, T. (2021). The impacts of carbon pricing on maritime transport costs and their implications for developing economies. *Marine Policy, 132*, 104653. https://doi.org/10.1016/j.marpol.2021.104653

Romera, B. M. (2017). *Regime Interaction and Climate Change: The Case of International Aviation and Maritime Transport*. Routledge.

Romero, G., Durán, G., Marenco, J., & Weintraub, A. (2013). An approach for efficient ship routing. *International Transactions in Operational Research: A Journal of The International Federation of Operational Research Societies*. https://doi.org/10.1111/itor.12021

Rubaceti, N. A. B., Giraldo, S. R., & Sepulveda, M. Z. (2022). Una revisión bibliográfica del Fintech y sus principales subáreas de estudio. *Económicas CUC, 43*(1). https://doi.org/10.17981/econcuc.43.1.2022.Econ.4

Sánchez, B. C. (2020). El transporte marítimo internacional entre el cambio climático y el coronavirus. bie3: *Boletín IEEE, 18*, 451-468.

Sánchez, R. J., Hoffmann, J., Micco, A., Pizzolitto, G. V., Sgut, M., & Wilmsmeier, G. (2003). Port Efficiency and International Trade: Port Efficiency as a Determinant of Maritime Transport Costs. *Maritime Economics & Logistics, 5*(2), 199-218. https://doi.org/10.1057/palgrave.mel.9100073

Schaumburg, H., Korablev, V., & Ungvari, L. (2020). *Technological Transformation: A New Role For Human, Machines And Management: TT-2020*. Springer Nature. https://doi.org/10.1007/978-3-030-64430-7

Secinaro, S., Francesca, D. M., Brescia, V., & Calandra, D. (2021). Blockchain in the accounting, auditing and accountability fields: a bibliometric and coding analysis. *Accounting, Auditing & Accountability Journal*, *35*(9), 168-203. https://doi.org/10.1108/AAAJ-10-2020-4987

Seithe, G. J., Bonou, A., Giannopoulos, D., Georgopoulou, C. A., & Founti, M. (2020). Maritime Transport in a Life Cycle Perspective: How Fuels, Vessel Types, and Operational Profiles Influence Energy Demand and Greenhouse Gas Emissions. *Energies, 13*(11), 2739. https://doi.org/10.3390/en13112739

Senčila, V., & Jurgelāne-Kaldava, I. (2020). Analysis of maritime transport activity factors influencing global warming. *24th International Scientific Conference on Transport Means* 2020. Kauno Technologijos Universitetas.

Shin, Y., Thai, V., & Fai, Y. K. (2018). The impact of supply chain relationship quality on performance in the maritime logistics industry in light of firm characteristics. *The International Journal of Logistics Management, 29*(3), 1077-1097. https://doi.org/10.1108/IJLM-10-2016-0227

Song, D.-W., & Panayides, P. (2012a). Maritime Logistics: Contemporary Issues. Emerald Group Publishing. https://doi.org/10.1108/9781780523415

Song, D.-W., & Panayides, P. (2012b). Maritime Logistics: A Complete Guide to Effective Shipping and Port Management. Kogan Page Publishers.

Stopford, M. (n.d.). *Maritime Economics.* Routledge. New York, USA.

Suárez-Alemán, A. (2016). Short sea shipping in today's Europe: A critical review of maritime transport policy. *Maritime Economics & Logistics, 18*(3), 331-351. https://doi.org/10.1057/mel.2015.10

Sugrue, D., & Adriaens, P. (2022). Maritime transport efficiency to inform demand-driven user fees for harbor infrastructure. *Journal of Waterway, Port, Coastal and Ocean Engineering, 148*(1). https://doi.org/10.1061/(asce)ww.1943-5460.0000695

Sumantri, Y. (2020a). Analyzing the Three Supply Chain Flows in the Maritime Logistics and Distribution Industry. *Journal of Distribution Science, 18*(12), 45-54.

Sumantri, Y. (2020b). Analyzing the three supply chain flows in the maritime logistics and distribution industry. *Journal of Distribution Science*. https://www.koreascience.or.kr/article/JAKO202000569364259.page

Tagawa, H., Kawasaki, T., & Hanaoka, S. (2021). Exploring the factors influencing the cost-effective design of hub-and-spoke and point-to-point networks in maritime transport using a bi-level optimization model. *The Asian Journal of Shipping and Logistics, 37*(2), 192-203. https://doi.org/10.1016/j.ajsl.2021.03.001

Tani, M., Papaluca, O., & Sasso, P. (2018). The System Thinking Perspective in the Open-Innovation Research: A Systematic Review. *Journal of Open Innovation: Technology, Market, and Complexity, 4*(3), 38. https://doi.org/10.3390/joitmc4030038

Torres, G., Robledo, S., & Berrío, S. R. (2021). Orientación al mercado: importancia, evolución y enfoques emergentes usando análisis cienciométrico. *Criterio Libre, 19(*35), 326-340. https://doi.org/10.18041/1900-0642/criteriolibre.2021v19n35.8371

Trejos-Salazar, D. F., Duque, P. L., Montoya, L. A., & Montoya, I. A. (2021). Neuroeconomía: una revisión basada en técnicas de mapeo científico. *Revista de Investigación, Desarrollo e Innovación, 11*(2), 243-260. https://doi.org/10.19053/20278306.v11.n2.2021.12754

Valionienė, E., & Plačienė, B. (2020). Evaluation methodology of seaport governance and maritime transport attractiveness dependence based on comparison of seaports governance on the eastern coast of baltic sea. *24th International Scientific Conference on Transport Means 2020*. Kauno Technologijos Universitetas.

Viana, M., Hammingh, P., Colette, A., Querol, X., Degraeuwe, B., Vlieger, I. de, & van Aardenne, J. (2014). Impact of maritime transport emissions on coastal air quality in Europe. *Atmospheric Environment, 90*, 96-105. https://doi.org/10.1016/j.atmosenv.2014.03.046

Vierth, I., & Merkel, A. (2020). Internalization of external and infrastructure costs related to maritime transport in Sweden. *Research in Transportation Business and Management*. https://doi.org/10.1016/j.rtbm.2020.100580

Wallis, W. D. (2007). *A Beginner's Guide to Graph Theory* (Springer (ed.)). Birkhäuser Boston. https://doi.org/10.1007/978-0-8176-4580-9

Wang, S., & Meng, Q. (2012). Liner ship route schedule design with sea contingency time and port time uncertainty. *Transportation Research Part B: Methodological, 46*(5), 615-633. https://doi.org/10.1016/j.trb.2012.01.003

Wang, S., Zhen, L., Psaraftis, H. N., & Yan, R. (2021). Implications of the EU's inclusion of maritime transport in the emissions trading system for shipping companies. *Engineering, 7*(5), 554-557. https://doi.org/10.1016/j.eng.2021.01.007

Wibisono, E., & Jittamai, P. (2017). Multi-objective evolutionary algorithm for a ship routing problem in maritime logistics collaboration. *International Journal of Logistics Systems and Management, 28*(2), 225-252. https://doi.org/10.1504/IJLSM.2017.086357

Wilmsmeier, G. (2016). International Maritime Transport Costs: Market Structures and Network Configurations. https://doi.org/10.4324/9781315589442

Wilmsmeier, G., Hoffmann, J., & Sanchez, R. J. (2006). The Impact of Port Characteristics on International Maritime Transport Costs. *Research in Transportation Economics, 16*, 117-140. https://doi.org/10.1016/S0739-8859(06)16006-0

Yang, H., & Ma, X. (2019). Uncovering CO_2 Emissions Patterns from China-Oriented International Maritime Transport: Decomposition and Decoupling Analysis. *Sustainability: Science Practice and Policy, 11*(10), 2826. https://doi.org/10.3390/su11102826

Yang, S., Keller, F. B., & Zheng, L. (2016). *Social Network Analysis: Methods and Examples*. SAGE Publications. https://doi.org/10.4135/9781071802847

Yuen, K. F., & Thai, V. (2017). Barriers to supply chain integration in the maritime logistics industry. *Maritime Economics & Logistics, 19*(3), 551-572. https://doi.org/10.1057/mel.2016.10

Zhou, C., Ma, N., Cao, X., Lee, L. H., & Chew, E. P. (2021). Classification and literature review on the integration of simulation and optimization in maritime logistics studies. *IISE Transactions, 53*(10), 1157-1176. https://doi.org/10.1080/24725854.2020.1856981

Zhou, C., Stephen, A., Cao, X., & Wang, S. (2021). A data-driven business intelligence system for large-scale semi-automated logistics facilities. *International Journal of Production Research, 59*(8), 2250-2268. https://doi.org/10.1080/00207543.2020.1727048

Zhu, J., & Liu, W. (2020). A tale of two databases: the use of Web of Science and Scopus in academic papers. *Scientometrics, 123*(1), 321-335. https://doi.org/10.1007/s11192-020-03387-8

Zis, T. P. V., & Psaraftis, H. N. (2022). Impacts of short-term measures to decarbonize maritime transport on perishable cargoes. *Maritime Economics & Logistics, 24*(3), 602-629. https://doi.org/10.1057/s41278-021-00194-7

Zis, T. P. V., Psaraftis, H. N., Tillig, F., & Ringsberg, J. W. (2020). Decarbonizing maritime transport: A Ro-Pax case study. *Research in Transportation Business & Management, 37*, 100565. https://doi.org/10.1016/j.rtbm.2020.100565

Zupic, I., & Čater, T. (2015). Bibliometric Methods in Management and Organization. *Organizational Research Methods, 18*(3), 429-472. https://doi.org/10.1177/1094428114562629

Zuschke, N. (2020). An analysis of process-tracing research on consumer decision-making. *Journal of Business Research, 111*, 305-320. https://doi.org/10.1016/j.jbusres.2019.01.028