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The Bibliometric Analysis of Shipyard Risk Management: Toward Integrated Shipyard Risk Management

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ABSTRACT:
This study presents a bibliometric analysis of research trends in shipyard risk management using data retrieved from the Scopus database and visualized through VOSviewer software. The objective is to map the scientific landscape, identify key themes, influential authors, institutions, and emerging topics in the field. A total of 754 publications from 2000-2025 were analyzed using annual trends, author, institution and national collaboration, and keyword co-occurrence. The results reveal significant growth in scholarly interest over the past decade, with major contributions from countries such as United States and China. Key clusters identified include occupational safety and health, environmental, disaster, financial and technical risk, project risk assessment, and human centered risk in shipbuilding. It also discussed the methodology used to assess the risk, that use many kind of Multicriteria Decision Making. The analysis also highlights research gaps and potential directions for future studies, particularly in integrating advanced data analytics, sustainability-oriented risk frameworks as the Integrated Shipyard Risk Management. This study contributes to a deeper understanding of the intellectual structure and evolution of shipyard risk management research.

KEYWORDS:
Shipyard Risk Management, Bibliometric Analysis, Scopus, VOSViewer, Integrated Risk Management

1) Introduction:

Since 80% of global traffic in goods is carried out by sea, the marine sector has a significant economic impact, making shipbuilding a strategic and important business (Neves et al., 2025). For the construction, maintenance, and repair of big vessels, the shipbuilding sector offers crucial services. It supports important industries including transportation, maritime trade, fishing, and tourism by acting as a key sector (Jebbor et al., 2023). Because of its role in the shipping industry, the shipyard is the most crucial component advancing the marine sector overall (Rizwan et al., 2024).

Organizations in a variety of sectors face a variety of hazards in the connected world of today, from economic crises to cyberattacks, necessitating the use of flexible, data-driven crisis management techniques (Qhal, 2025). The results support the scholarly literature by confirming that businesses understand the value of shipyard risk management, despite the fact that the idea is still in its infancy and has not yet been successfully applied in practice. The emphasis was on internal variables, even if the shipyards recognized significant dangers. There were no risk mitigation measures in place because the industry was vulnerable to external environmental threats, which led to the bankruptcy of numerous shipbuilders in Brazil (Ferreira et al., 2018).

Despite the importance of Risk Management in Shipyard Industry, there is no bibliometric study in this subject area. Even in the area of Maritime Industry, there are already many bibliometric study, such as maritime information system, which categorise three main categories: system, information and marine

(Chaudhary et al., 2025); the quay crane operation problem at ports from its inception (Dragović et al., 2025); the maritime supply chain, with particular attention given to maritime logistics (Mohiuddin et al., 2024); maritime safety management and maritime emergency management (Han & Chu, 2025); Internet Technologies and Automated Port Infrastructure Applications (Zou et al., 2025); New Technology and Development of Unmanned Surface Vessels (Yang et al., 2024); and potential uses of blockchain technology in the context of Maritime Single Window and Port Community Systems (Nasser et al., 2025).

In order to fill these gaps, this study intends to methodically look into the following: (1) What is the distribution of technical hot spots, collaborative networks, and research trends in shipyard risk management? (2) What fundamental inconsistencies prevent that systemic integration? (3) How will shipyard risk management develop in the future?

In order to close the gaps, this study examines Scopus databases to evaluate scholarly publications, specifically in the field of shipyard risk management. There are two advantages to the study's findings: first, academic researchers could use the scopes for additional research. Second, the increasing processes and trends in risk management are visible to the shipyard industries. As a result, they are able to gauge other people's efforts to enhance their present risk management procedures.

2) Methodology and Data Collection

2.1. Bibliometric Method

A methodical examination of scientific literature to find patterns, trends, and influence within a discipline is known as bibliometric analysis. Data collecting from pertinent databases, data cleansing and refinement, and applying different bibliometric techniques are important elements in the process of producing meaningful information. Research is increasingly using bibliometric analysis, a comprehensive and well-liked method for looking through and evaluating vast volumes of scientific data (Passas, 2024).

Researchers can uncover important information about technological advancements, policy changes, and market fluctuations in the shipping industry by statistically analyzing indicators like the number of journal articles, citation frequencies, and co-occurrence of keywords in the maritime field. This provides a scientific basis for academic research, industry decision making, and strategic planning (Zou et al., 2025).

Through bibliometric analysis, this study methodically explores the academic environment of shipyard risk management research and implementation from 2000 to 2024. Four methodological pillars make up the analytical framework: (1) the evolution of the publication output mapping research trajectory over time; (2) the dissemination pathways of academic periodicals assessing the effectiveness of knowledge diffusion; (3) the topology of institutional collaboration; and (4) the semantic network analysis of conceptual nodes identifying emerging frontier domains and technological convergence patterns.

2.2. Data Collection

The Scopus database, one of the biggest, most reputable, multidisciplinary abstract and citation databases, was used to perform the bibliographic search (Momani, 2025). Because it has a greater variety of papers, the Scopus database is selected. Consequently, the Web of Science database (WoS) is compared. It was discovered that Scopus was better suited for bibliometric analysis (Gao et al., 2021).

2.3. Information Retrieval

Shipyard marine risk is examined in this systematic review for the years 2000–2025. The following documentation process systematically outlines the methodological transparency and analytical rigor of the keyword selection criteria. (1) Key words: "shipyard" and "risk management" specifically target shipyard operations, including all activities within this industry, and guarantee the search scope's relevancy while weeding out irrelevant subjects. There are only 186 document hits from the initial search. (2) The search parameter is extended to broader semantics in order to broaden the search. Furthermore, the search parameters are expanded to include "shipbuilding" as a synonym for "shipyard," "hazard" as a synonym for "risk," and "control" or "assessment" as a synonym for "management." As a result, 929 document matches are found, beginning in 1968. (3) In order to concentrate on the most recent and pertinent literature, the search is restricted to works published after 1999 and leaves out certain topic areas, including psychology, veterinary medicine, immunology and microbiology, and health professions. There is an 800-document match as a result. (4) The document type is restricted to journal, conference paper, review, and conference review, yielding 754 papers, in order to guarantee that the results are derived from first-hand study.

To guarantee the thoroughness and timeliness of the evaluations, we carefully choose the categories of literature and search parameters. We concentrate on works that were released between 2000 and 2025, since shipyard risk management advanced significantly throughout this time. This timeline takes publishing lags into account and guarantees current insights. We find 754 high-quality papers, including 82 reviews that summarize field trends and 672 publications that focus on particular applications. Table 1 provides specifics about the search parameters.

Table 1. The Parameter for searching

Parameter	Content
Database	Scopus
Time range	2000 – 2025
Document	Article, Conference Paper, Review, Conference Review
Search formula	TITLE-ABS-KEY (("shipyard" OR "shipbuilding") AND ("risk" OR "hazard") AND ("management" OR "control" OR "assessment")) AND PUBYEAR > 1999 AND PUBYEAR < 2026 AND (EXCLUDE (SUBJAREA , "IMMU") OR EXCLUDE (SUBJAREA , "VETE") OR EXCLUDE (SUBJAREA , "PSYC") OR EXCLUDE (SUBJAREA , "HEAL")) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "re") OR LIMIT-TO (DOCTYPE , "cr"))

3] Results and Literature Analysis.

3.1. Analysis of Annual Publication Trends

This review assesses shipyard risk management research from the first 25 years of the twenty-first century to 2025 in an effort to identify trends in publications throughout time and predict future directions. After 2003, there were over 20 publications year, as shown in Figure 1. Additionally, this topic area has two summits. First, in 2007, there were 39 publications; second, there were 45 in 2021. The first peak on 2007 is along with the peak of Enterprise Risk Management Studies (Anton & Nucu, 2020), while the second summit started after Covid-19 global outbreak.

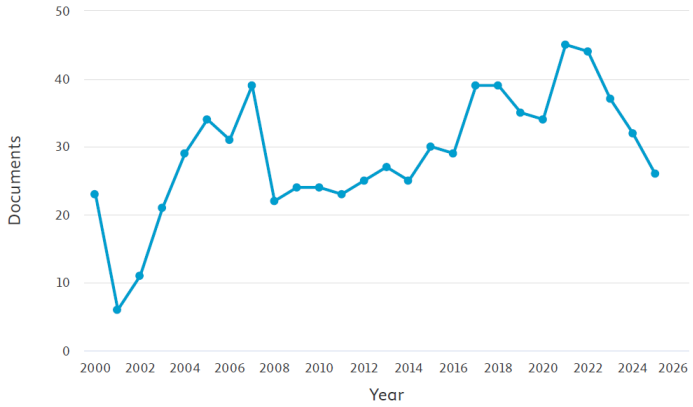

Figure 1. Annual publication statistics trends from 2000 to 2025.

At least 18 publications regarded it as a component of this shipyard's risk management after the global COVID-19 outbreak in 2020. This began in 2021 and resulted in a research output of over 40 publications, 45 in 2022 and 44 in 2023.

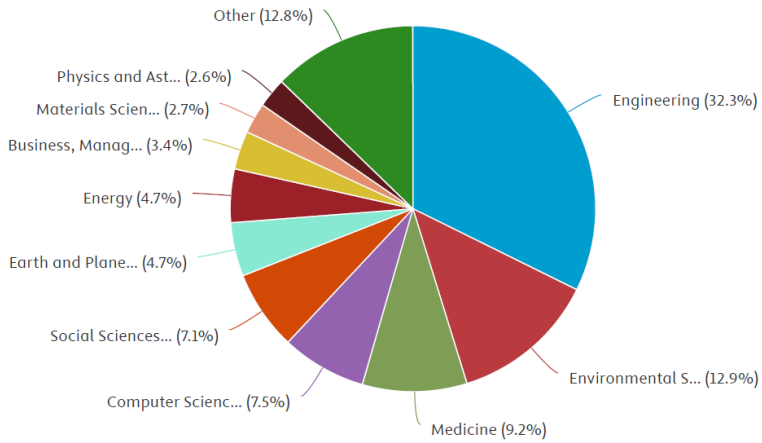

Figure 2. Subject Areas of Publication.

The subject Area of the publication is Engineering, consisting of 430 out of 754 publications, more than half of the papers. This is considered to be 32.3% of all covering subject areas.. It is followed by environmental science for 12.9% as shown in Figure 2.

3.2. Analysis of Source Journal

This analysis includes 754 scholarly works on shipyard risk management published in 110 academic venues. The top 16 most productive periodicals, which make up over 40% of all publications, are listed in Table 2. With 17 articles (4.27%), Ocean Engineering is the most prolific journal. Shipping World and Shipbuilder come in second with 15 publications (3.77%) and Science of the Total Environment with 14 publications (3.52%). This demonstrates their noteworthy impact in the industry.

Table 2. The most productive source

SOURCE TITLE	Publication	Percentage
Ocean Engineering	17	4.27%
Shipping World and Shipbuilder	15	3.77%
Science of the Total Environment	14	3.52%
Marine Pollution Bulletin	13	3.27%
Jane S Defence Weekly	10	2.51%
Proceedings of the International Conference on OMAE	10	2.51%
Intl J. of Environmental Research and Public Health	9	2.26%
Proceedings of the ISOPE	9	2.26%
Safety Science	9	2.26%
Iop Conference Series Materials Science and Engineering	8	2.01%
Journal of Physics Conference Series	8	2.01%
Journal of Ship Production	8	2.01%
Brodogradnja	7	1.76%
Jane S Defence Industry	7	1.76%
Naval Architect	7	1.76%
Proceedings of the Annual Offshore Technology Conference	7	1.76%

Along with the subject area, the occurrence in scholar periodicals with engineering subject area dominating the publication source. It is followed by environmental science publication source and later by safety science.

3.3. Research Collaboration Network Analysis

This section reveals the dynamics of information flow and strategic priorities in shipyard risk management by conducting a multi-level analysis of collaboration patterns through author networks, institutional partnerships, and cross-country alliances.

3.3.1. Analysis of Author Collaboration

Systematic evaluation of the shipyard risk management literature identifies leading academic contributors advancing port automation frameworks and digital maritime systems. Table 3 enumerates the 15 most prolific scholars, whose scholarly output has substantially propelled advancements in intelligent nautical architectures and smart port ecosystems.

Table 3. The most productive author

AUTHOR NAME,	Publication	Percentage	H-Index	Document
Goerlandt F.	6	0.80%	46	176
Lai C.H.	6	0.80%	26	111
Scott R.	6	0.80%	2	843
Anon	5	0.66%	52	73433

Choi	Y.	5	0.66%	4	20
Daniels	R.D.	5	0.66%	28	74
Diaz	R.	5	0.66%	18	104
Frangopol	D.M.	5	0.66%	88	929
Garbatov	Y.	5	0.66%	43	380
Jang	B.	5	0.66%	12	81
Lazakis	I.	5	0.66%	25	101
Marinaccio	A.	5	0.66%	38	238
Pan	C.H.	5	0.66%	27	71
Pitana	T.	5	0.66%	6	53

With six publications apiece, Goerlandt F., Lai C.H., and Scott R. emerged as the most prolific author in the field of shipyard risk management. Goerlandt actively assessing risk in Arctic shipping (Fu et al., 2021) and Canadian coastal disaster that might affect industry such as shipyard (Islam et al., 2023). In addition to demonstrating their professional influence in the field, these writers' high production also demonstrates their contributions to the growth of the shipping sector and marine risk management. They each published hundreds of documents in the relevant field.

Table 4. Request for search based on the authors' collaborative network

Step	Search Request
1	Export the search result from Scopus database to RIS file, named ‘scopus754.ris’
2	Choose the type of data as ‘Create a map based on bibliographic data’
3	Choose data source as ‘Read data from reference manager files’
4	Select the tab RIS, retrieve file ‘scopus754.ris’
5	Set the type of analysis as ‘Co-authorship’, the unit of analysis as ‘Authors’ and the counting method as ‘Full counting’
6	Set the minimum number of documents of an author to three and the minimum number of citations of an author to twenty-five.
7	Select all connected and non connected items.

Academic collaboration patterns in Shipyard risk management are investigated through network topology analysis using VOSviewer 1.6.20. The detailed steps of the algorithm are shown in Table 4. Through this analysis, we were able to uncover collaboration patterns among authors and the composition of research teams within the field. Figure 3 illustrates the author collaboration network for all the literature included in this review, comprising 80 nodes, 117 links, and 27 clusters, with the total link strength 230. Vertex diameter correlates with individual publication output, while edges denote collaborative linkages, with edge weight quantifying collaboration intensity. The bright yellow shows the newer publication, while blue-grey color show older publication.

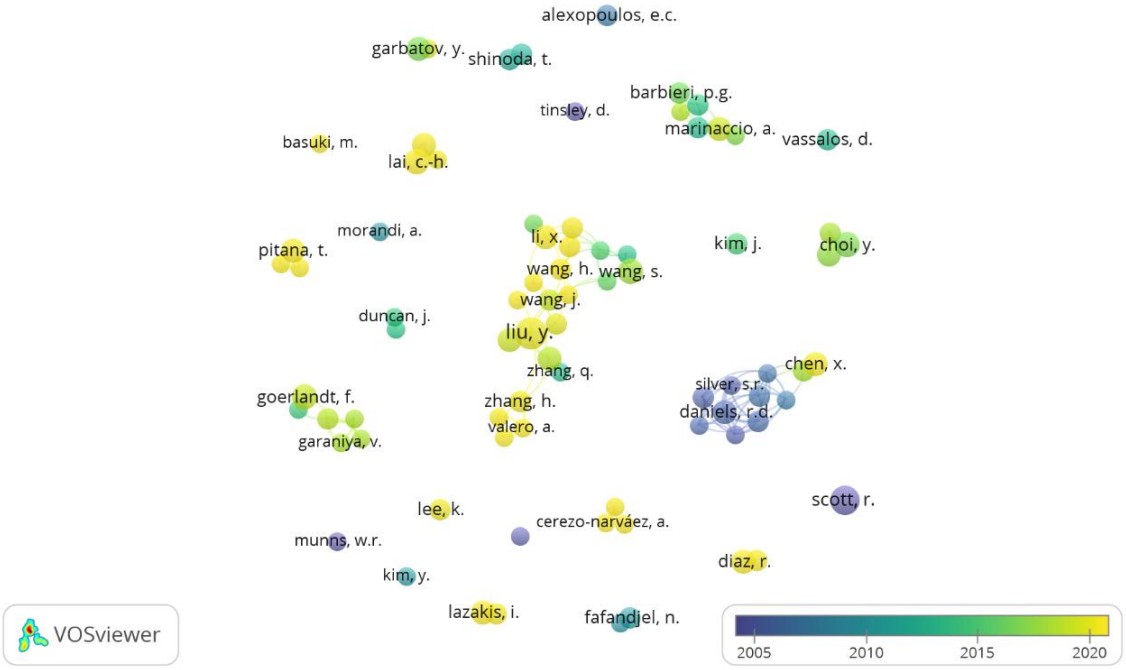

Figure 3. Overlay Visualization of Author's Collaboration network

The first cluster consists of 11 nodes centered in Daniels, R.D., colored blue-grey, showing that the collaboration was made around 2007, when he co-authored at least four publications on occupational health in the Shipyard under the affiliation of the National Institute for Occupational Safety and Health, linked mostly with Schubauer-Berigan, Yiin J.H., and Zaebst D.D.

The second cluster consists of 9 nodes centered on Liu Y., who focuses on ergonomics and occupational risk, and collaborates with Frangopol D.M., who focuses on Reliability Engineering, especially in the shipyard industry, from 2018 to 2021. Frangopol frequently works with Chinese authors, including in Probabilistic risk, sustainability, and utility associated with ship grounding hazards (Liu & Frangopol, 2018).

This cluster is further connected to the third cluster, with Chen Biao in Occupational Health and Yang J., who focused on Maritime Logistics, comprising Safety, Health, and Environmental issues (H. Li et al., 2025). Both cluster shows it is active in recent years, up to 2025. This map shows that the recent publication is dominated by Chinese authors, who have more collaboration nodes.

3.3.2. Analysis of Institutional Collaboration

There are 120 institutions that are affiliated with the publication of 754 papers on shipyard risk management. Table 5 displays the top 10 most productive affiliations, which account for roughly 77.50 percent of the institution. University of Strathclyde from the UK appears in 13 publications (10.83%), making it the most productive institution. With 12 publications, or around 10.00%, Institut Teknologi Sepuluh Nopember from Indonesia ranks second, followed by the National Institute for Occupational Safety and Health and the Chinese Academy of Science, each with eight publications, or 8.33%.

Although United States become the country where is the most research conducted, but there are only two countries that appears in top 10 affiliations., China with Chinese Academy of Science and Shanghai Jiaotong University, and South Korea with Seoul National University and Electronics and Telecommunications Research Institute.

Table 5. The Top 10 prolific institutions

AFFILIATION,	Publication	Percentage
University of Strathclyde	13	10.83%
Institut Teknologi Sepuluh Nopember	12	10.00%
National Institute for Occupational Safety and Health	10	8.33%
Chinese Academy of Sciences	10	8.33%
Seoul National University	9	7.50%

University of Rijeka	9	7.50%
Universidade da Coruña	8	6.67%
Shanghai Jiao Tong University	8	6.67%
Electronics and Telecommunications Research Institute	7	5.83%
Instituto Superior Técnico	7	5.83%

The network topology analysis of institutional cooperation in shipyard risk management is carried out in this study using VOSviewer 1.6.20. Standardized visualization criteria are used: the bright yellow hue denotes the most recent publication, node size represents publishing output, and connection thickness indicates collaboration frequency (methodological details in Table 6).

Table 6. Request for search based on the institutions' collaborative network.

Step	Search Request
1	Export the search result from Scopus database to csv file
2	Choose the type of data as 'Create a map based on bibliographic data'
3	Choose data source as 'Read data from bibliographic database'
4	Select the tab scopus, retrieve file 'scopus.csv'
5	Set the type of analysis as 'Co-authorship', the unit of analysis as 'Organization' and the counting method as 'Full counting'
6	Set the minimum number of documents of organization to two and the minimum number of citations of organization to three.
7	Select the number of organization to be selected 23

Applying a minimum two-publication threshold, with a minimum of 3 citations, and at least one link from at least two entities, we systematically analyzed 23 entities forming nine distinct clusters with 37 collaborative linkages, among 1540 organizations (Figure 3).

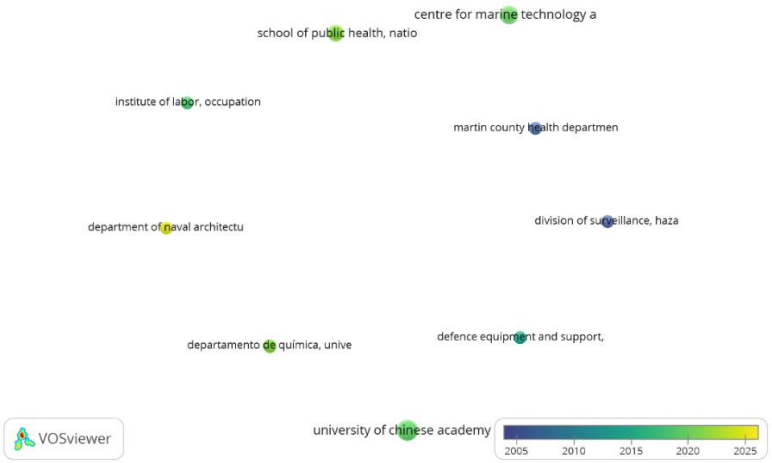

Figure 4. Overlay Visualization of Institution's Collaboration network

There are four distinctive clusters to be analyzed for institutional collaboration. The first cluster is developed cross-continently among Universidade Estadual de Londrina-Brazil, Universidade do Vale do Itajai-Brazil, University Lancaster-UK, and Universidade Federale Luminense-Brazil, working for shipyard environmental risk management.

The second one among National Medical Center-Taiwan, Institute of Labor, Occupational Safety and Health-Taiwan, National Institute of Environmental Health Sciences-Taiwan, and School of Public Health-Taiwan, collaborating for the research of health risk assessment for the Shipyard Welder.

The third collaboration is between defense equipment and support-UK, Exeter University-UK and Hoffman Engineering Corporation-USA, cooperating for safety risk assessment using ship motion prediction using simulation.

The last distinctive cooperation is between the Department of Naval Architecture and Shipbuilding, Institut Teknologi Sepuluh Nopember, Indonesia, and the Department of Naval Architecture, Ocean and Marine Engineering, University of Strathclyde, UK, mostly in the Integrated Value Engineering and Risk

Assessment (VENRA) approach applying multicriteria decision making (Baihaqi et al., 2023). These institutions are listed as the top and runner-up of the prolific organization in this shipyard risk management.

3.3.3. Analysis of National Collaboration

The top 10 nations, which account for 61.21% of the research, are out of the 63 countries where the research is done. With 117 publications, or 14.41%, the United States is the most prolific nation. China, with 91 publications (11.21%), comes in second, followed by South Korea in third position with 65 articles (8.00%). Indonesia, a third-world nation, comes in at number eight with 24 research (2.96%).

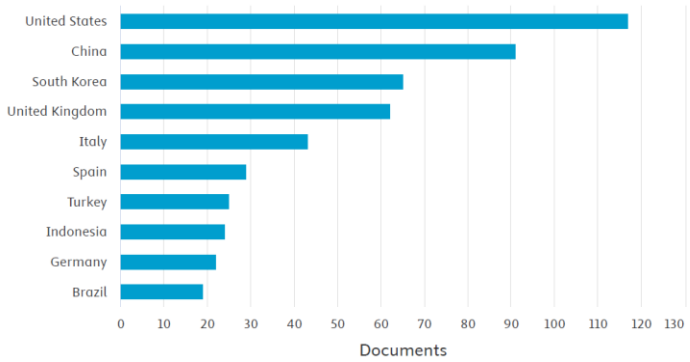

Figure 5. Documents by Country or Territory

Network topology is generated using VOSviewer 1.6.20 to map transnational research synergies (methodological procedure shown in Table 7. 46 countries that meet the minimum three publication and three citation standards are shown to collaborate in Figure 6, which shows 157 inter-nodal linkages with a total link strength of 243. Each vertex diameter represents the volume of national publications on shipyard risk management, while edge weight uses line thickness to measure the level of collaboration.

Table 7. Request for search based on the country's collaborative network.

Step	Search Request
1	Export the search result from Scopus database to csv file
2	Choose the type of data as 'Create a map based on bibliographic data'
3	Choose data source as 'Read data from bibliographic database'
4	Select the tab scopus, retrieve file 'scopus.csv'
5	Set the type of analysis as 'Co-authorship', the unit of analysis as 'Country' and the counting method as 'Full counting'
6	Set the minimum number of documents of a country to two and the minimum number of citations of a country to three.
7	Select number of organization to be selected 46 (all)

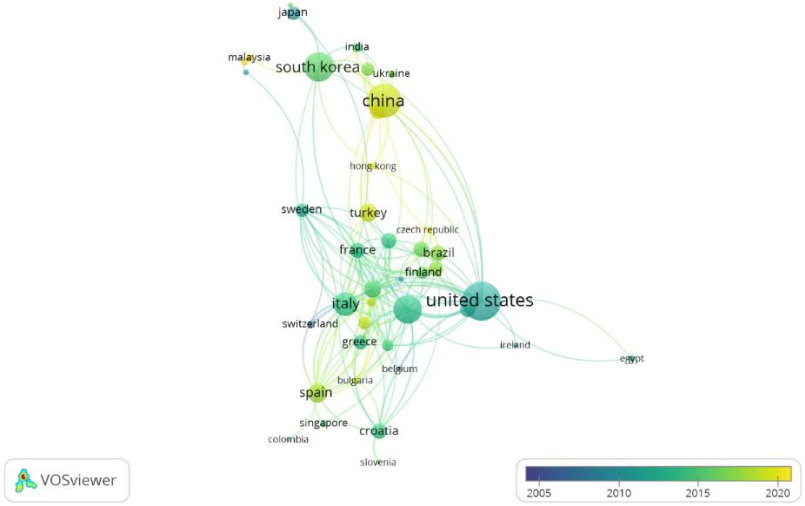

Figure 6. Overlay Visualization of the Country's Collaboration Network

Geospatial analysis identifies the United States as the network's nexus, maintaining strategic partnerships with multiple maritime researchers, mainly with China, South Korea, and the United Kingdom. It is also identifies that United Kingdom become the center hub of collaboration, that has strong cooperation with USA, South Korea, Italy and Indonesia.

It shown that China and Indonesia have the recent studies after year 2021, followed by Turkey and Portugal. In the other hand, United States and United Kingdom, event they are in the center of the networks, the median is in year 2015 or before.

3.3.4. Analysis of Keyword Co-Occurrence

Discipline boundaries in Shipyard Risk Management are identified using keyword co-occurrence analysis using scientometric mapping. The main conceptual framework and its semantic relationships are graphically represented in the web visualization produced by VOSviewer (Zou et al., 2025). The result of the search criteria shows 30 keyword items to be analyzed and divided into six main clusters.

Table 8. The most frequent keywords.

Keyword	Occurence	Link	Total Link Strenght	Average Publication Year
Risk Assessment	42	16	27	2016.60
Shipbuilding	38	10	26	2016.71
Shipyard	19	12	21	2016.79
Risk Analysis	18	7	12	2015.94
Safety	13	9	12	2019.46
Risk	13	7	9	2019.38
Sediment	11	6	9	2018.45
Heavy Metal	11	3	7	2020.82
Risk Management	10	5	5	2016.70
Project Management	9	5	6	2016.44
Pollution	8	5	5	2016.62
Sustainability	8	5	5	2020.25
Shipyards	8	4	5	2016.12
Occupational Exposure	8	4	4	2014.88

As quantified in Table 8, "Risk Assessment" dominates discourse with 42 occurrences, followed by "Shipbuilding" with 38 occurrences, followed by its semantics "Shipyard" with 19 occurrences. However, if "Shipyard" keyword is combined with "Shipyards" (plural), it still remains in third position with 27 occurrences. Subsequent prevalence metrics reveal key risk-related activities, including risk analysis, safety, and risk management. There are new keywords used in this shipyard risk management named "Heavy Metal" and "Sustainability" that are trending after the year 2020, while Occupational Exposure has become the oldest keyword with an average publication year before 2015.

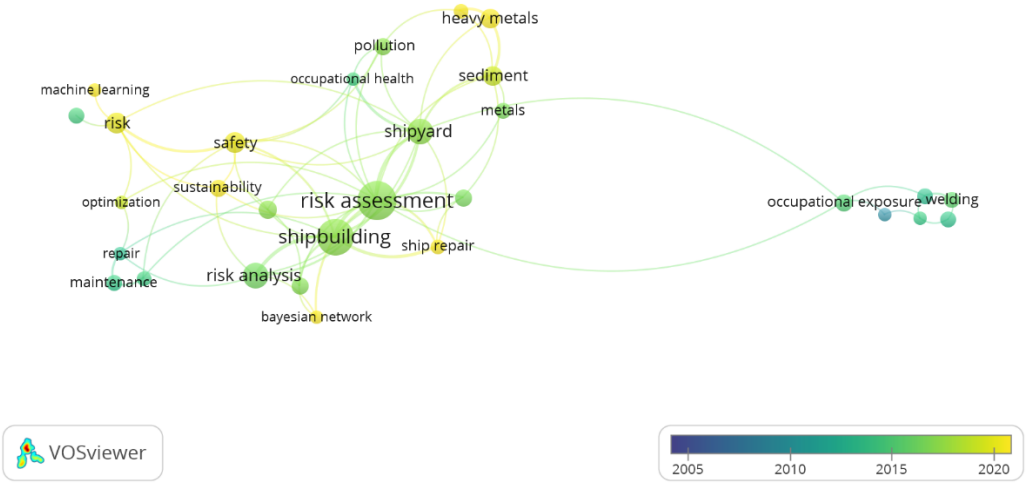

Figure 6. Overlay Visualization of the keyword co-occurrence network

The strong connections among these keywords indicate that the application of risk assessment in shipbuilding and shipyard is becoming increasingly important, particularly in mitigating risk to improve quality, safety, health and environmental condition in the area. In the Shipbuilding area, risk analysis and risk management is also significant subject area, in order to maintain business and environmental sustainability and safety.

4] Review and Analysis of Past and Current Research Areas

The trend in Shipyard Risk Management, can be analyzed by considering the keywords in this area, starting from oldest average year of publication such as Occupational Exposure, Environmental Risk, Financial and Technical Risk, Disaster Management Risk, Project Management and Supply Chain Risk, Human Centered Risk and Risk Assessment Model.

4.1. Occupational Exposure

A nested case-control study of lung cancer risk and ionizing radiation exposure at the Portsmouth Naval Shipyard (Yiin et al., 2007)and the research on the risk of chronic myeloid and acute leukemia mortality among workers at four U.S. nuclear weapons facilities and a nuclear Naval (Schubauer-Berigan et al., 2007)are among the publications that primarily feature Daniels R.D., a researcher from the National Institute for Occupational Safety and Health.

Due to the presence of numerous hazardous materials in the area, including welding fumes, fine organic solvents, and dye dust, many researchers continue to be interested in the health of shipyard workers. Exposure to organic paint solvents used in the Korean shipbuilding sector (Seo et al., 2024), genetic harm in Greek shipyards worker due to its harsh working area (Koutsoumplias et al., 2022), and the exposure to heavy metal vapors and chemicals, decline in serum adiponectin levels among Taiwanese shipyard workers (Wu et al., 2023) are a few of these studies.

Shipyards are prone to accidents, making occupational health and safety a prominent issue. Risk assessment methods like DEMATEL and Grey system theory help to prevent fatal occupational accidents in the shipbuilding industry, the processes of defining hazards, evaluating risks, taking action to eliminate or reduce risks are important issues in risk assessment(Seker et al., 2017).

4.2. Environmental Risk & Green Shipbuilding

Even though the average year of publication for this issue is 2016, there are several research that show that shipyard operations pose environmental risks, and these studies are still ongoing. To identify the sources, features, and level of pollution of heavy metals in the southern North Yellow Sea. The majority of Cu and Cr enrichments were discovered in coastal regions with a lot of muck (clay and silt). However, Weihai Bay and Dongpu Bay, which have more populations, estuaries, and shipyards, have higher concentrations of Zn, Cd, Pb, and Hg. However, because of sectors like shipbuilding and maritime traffic, the majority of locations showed Pb and Hg contamination (Shang et al., 2023). One of China's key mariculture zones is Xiangshan Bay. The findings demonstrated that the shipyard was responsible for a polycyclic aromatic

hydrocarbon (PAH) pollution plume. Phenanthrene and pyrene, which were primarily produced from diesel and lubricant, dominated the PAHs in water and SPM. According to the health risk assessment, the shipyard discharge posed a significant ecological danger of PAHs to the downstream and nearby water environment (Luo et al., 2023).

Tributyltin and/or biocide concentrations were found in almost 75% of the evaluated sites. based on values over safe limits that might have an impact on living things. In conclusion, antifouling paint residue contamination was pervasive over Brazil's coastline due to maritime activity (Abreu et al., 2025). High concentrations of Cu, Zn, Cd, Sn, Sb, and Pb were found in harbor sediments, particularly close to industrial complexes and shipyards, according to geochemical and grain size analyses of 282 samples collected from the Korean Peninsula's southeast coastal and offshore regions. These analyses included factor analysis and Cs-normalized element concentrations. Metal buildup in port sediments is still a persistent environmental issue (Um et al., 2025).

Analyzing environmental risks is essential to enhancing shipyard productivity and reducing pollution. Risks can be quantified and categorized with the aid of hazardous material and risk source identification. The implementation is guided by the UNE 150008:2008 standard (Durán, 2024). Due to the maritime industry's significant green transformation, there is an unprecedented need for green finance in the shipbuilding sector, which has drawn the attention of international investors (Chen et al., 2025).

4.3. Financial and Technical Risk

Financial risks, such as exchange rates and interest rates, and technical risks, among 26 other risks like design changes, are critical at various stages of shipbuilding. Using statistical techniques and a survey, the risk assessment is conducted in the Korean Shipbuilding Industry, and the financial risk is found (Lee et al., 2007). Further, using a Bayesian Belief Network, it is found that the internal and external factors, with the most external factor being the exchange rate (Lee et al., 2009).

Such a predictive assessment of the technical and economic effect allows for the quick and precise evaluation of the attractiveness of automating the risk management system from the standpoint of increasing the efficiency of working with risks, accelerating the process of their quantitative assessment, and forming corrective actions and management decisions. It has been noted that the creation and implementation of automated risk management systems in shipyards not only significantly expedites the process of managing industrial risks, allows for quick confirmation of the correctness of decisions made historically or currently regarding the occurrence of industrial risks, and concurrently saves a substantial amount of labor and time resources, but it is also a very profitable solution from an economic standpoint (Prokopenko et al., 2024).

Implications for green shipbuilding policy and practice

comprehensively extract single moment extreme market risk information and frequency domain risk information between the green bond market and the four major shipbuilding nations/regions: China, Japan, South Korea, and Europe. We further explore the joint risks spillover effects of return, variance, skewness, and kurtosis in extreme market conditions and across short and long terms.(Chen et al., 2025)

4.4. Disaster Management Risk

The meteorological disaster, even if it rarely occurs, can cause catastrophic damage. Since the shipyards are mostly located on the coastline and operate in open or semi-enclosed workspaces, they are vulnerable to the effects of natural disasters, such as tsunamis, gales, and thunderstorms. The daily maximum temperature, daily minimum temperature, daily sunshine hours, heat-wave days, and tropical nights are among the high temperature-related records that have hit all-time highs since South Korea's modern meteorological observation system was implemented in the summer of 2018. In 2018, heat waves killed 48 people in South Korea. The Gaussian process regression model (GPRM), a statistical technique, is used to forecast heatwaves that could harm shipyard workers (Yi & Yang, 2020).

In British Columbia, large-scale earthquakes have the potential to cause landslides in the Fraser River, therefore they are most likely to occur close to Sand Heads Lighthouse. For instance, the 1985 landslide occurred about 100 meters from the Lighthouse. Therefore, the destruction of the Sand Heads Lighthouse and the buoys from the outer delta is one of the scenario's primary outcomes. Furthermore, the intended scenario might demolish buildings along the coast, including quaysides, shipyards, and other structures. Thus, the disaster management is prepared (Islam et al., 2023).

The operations of the US shipbuilding and repair sector may be disrupted by climate change and related coastal hazards. The nation's total shipbuilding strength, ship upkeep and repairs, and military and commercial ship orders are all at risk from these disruptions. According to a survey of the US shipyard industry, the sector is not adequately equipped to handle future coastal hazard events, and urgent action is required to guarantee a robust environment for shipbuilding and repair (Hill et al., 2024).

4.5. Supply Chain and Project Management Risk

A successful shipbuilding project is mostly dependent on effective risk management and implementation. Through an application in a project at the Batam Island shipyard, the risk management framework is created with an enclosed risk culture and company risk culture in the risk management implementation in the shipyard industry. To be successful in the shipyard business, the company's risk management culture must be fully supported by senior management in order to be implemented in all employees and parties (Hariadi et al., 2024).

Shipyards can use Lean tools and digital technology, among other things, to improve business operations. However, producing extremely complex products in a company setting with intricate inter-process relationships among numerous stakeholders also suggests a very challenging Lean approach implementation effort. In order to help turn the shipbuilding system into a smart, sustainable, or climate-neutral one, research is being done in Croatia to reduce the chance of failure in completing the Lean implementation process (Kunkera et al., 2025).

Although it accounts for a significant portion of shipbuilding delays, the necessity of planning and risk assessment models for component availability in Indonesian new ship construction is rarely investigated. The creation of risk analysis techniques that combine quantitative evaluation techniques with Failure Mode and Effect Analysis (FMEA) and Bayesian Network (BN) approaches in the acquisition of component materials and shipbuilding installations is anticipated to address the issue of identifying the most important risks so that risk assessment measures can be implemented (Ariany et al., 2022).

4.6. Human-Centered Risks

Human-centered Significant risks in shipbuilding include miscommunication, technical faults, human error, and occupational dangers. By focusing on human-centered risk management during the shipbuilding process, the social sustainability is examined. In order to prevent accidents, it looks at the relationships between actors and risks, identifies human-centered hazards, reviews the key players in the shipbuilding process, and analyzes the relationships between risks to identify the underlying causes. A MACTOR (Matrix of Alliances and Conflicts: Tactics, Objectives and Recommendations) approach based on interval-valued spherical fuzzy (IVSF) is suggested for the shipbuilding process in order to accomplish this goal. The results show that the biggest risk is human error, which is followed by occupational dangers, technical faults, and misunderstandings. Collaboration between ship designers, engineers, and inspectors is necessary for effective risk management (H. Yilmaz & Karadayi-Usta, 2025).

4.7. Risk Assessment Methodology

The shipbuilding industry uses a variety of models to evaluate and manage risks, such as the Bayesian Network in the Korean Shipbuilding Industry (Lee et al., 2009), the spherical fuzzy sets in occupational health and safety in Turkiye (Gündoğdu & Seyfi-Shishavan, 2021), Failure Mode and Effect Analysis (FMEA), and the Bayesian Network (BN) for component availability in the construction of new ships in Indonesia (Ariany et al., 2022).

Decision Making Trial and Evaluation Laboratory (DEMATEL), sometimes known as Fuzzy DEMATEL, is a commonly used multi-criteria decision making (MCDM) method. In Turkiye, an occupational risk-assessment method that uses DEMATEL and the Grey System to study hazardous shipyard operations and work units and shipyard Critical Risk Factors can assist shipbuilding managers in developing appropriate accident prevention plans (Seker et al., 2017). The fuzzy DEcision-MAking Trial and Evaluation Laboratory (DEMATEL) and Weighted Evaluation Technique (WET) approaches are used in Indonesia Shipyard to develop and observe the new methodology known as integrated Value Engineering and Risk Assessment (VENRA) (Baihaqi et al., 2024).

Another MCDM technique is the Spherical Fuzzy Analytical Hierarchy Process (SF-AHP), which elaborates the Fine-Kinney and Hazard Rating Number System (HRNS) approaches as the risk assessment criteria by extending the Combined Compromise Solution (CoCoSo) method within the fuzzy framework to prioritize occupational hazards (Bayhun & Demirel, 2024). The primary actors in the shipbuilding process are investigated, human-centered risks are identified, the linkages between actors and risks are examined to prevent accidents, and the relationships between risks are analyzed to identify the underlying causes using a variation of other MCDM. For the shipbuilding process in Turkey, the MACTOR (Matrix of Alliances and Conflicts: Tactics, Objectives and Recommendations) technique based on interval-valued spherical fuzzy (IVSF) is suggested (H. Yilmaz & Karadayi-Usta, 2025).

The researcher in shipbuilding industry created the method known as automated risk management systems. It has been noted that the creation and implementation in shipyards not only significantly expedites the industrial risk management process, but also makes it possible to quickly confirm the correctness of judgments made in the past or present about the likelihood of industrial risks. This is a very advantageous

approach from an economic standpoint in addition to saving a substantial amount of time and work (Pautova & Burmistrov, 2022).

5] Future Research Areas

There is growing interest in the safety and reliability of Maritime Autonomous Surface Ships (MASS), with research focusing on mechanical reliability, software, hazard assessment, and collision avoidance. (Z. Li et al., 2023). This MASS will also pose a challenge to the shipbuilding process, creating risk, especially legal and financial risk, in the event that the vehicle is not functioning correctly.

Sustainability has become the emerging term in the shipyard Industry. Sustainable disaster management involves focusing on four key areas: legislation, internal coordination, technology that is responsive and sustainable, and knowledge of the latest disaster risk research. Sustainable safety protocols for floating dock operations in shipyards by identifying potential workplace risks in emergency situations has been developed (Bayhun & Demirel, 2024). Since sustainability is completely critical for industry, a study, which includes real-cases and theoretical work, proposes a systematic approach to create export model for a sustainable naval shipbuilding industry by providing a roadmap for companies together with the external necessities to pursue a to-the-point export strategy, using SWOT Analysis and AHP method, to prioritize the most important factor (B. Yilmaz & Yilmaz, 2024). However, the sustainable business, environmental, and health is an open area to be further explored. There is no Business Continuity Management or Plan in Shipyard or shipbuilding industry have been indexed in Scopus database in July 2025.

From this literature review, it is found no research applying integrated risk management in Shipyard or Shipbuilding Industry. Enterprise risk management serves as the foundation for integrated risk management, which is developing into a more complete approach. IRM's comprehensive approach to risk management integrates risk management practices across all areas of operations, including strategy, procedures, systems, and personnel. These principles are supported by the robustness of the decisions and risks managed within this integrated framework (Narang, 2025).

Integrated Management System (IMS) is currently a voluntary tool for effective process management in organizations, which is often associated with the integration of ISO 9001 (Quality), 14001 (Environmental), and 45001 (Occupational Safety and Health). It is proposed that Integrated Risk Mnaagement is integrated management system design based on risk management according to ISO 31000 and PAS 99, which includes specifications and requirements for an integrated management system, can serve as a suitable tool for risk management (Lahuta et al., 2021).

For the further research, this integrated risk management should cover all of the aspect of the shipyard Industry, either occupational safety and health, environmental, disaster, technical, quality (including human centered risk), financial, and legal. This integrated risk management should maintain the shipyard organization sustainability, and should be digitalized. The automated risk management is considered giving the business adavantage and efficiency at once (Pautova & Burmistrov, 2022). The approach of Business Continuity Management to manage the crisis can be elaborated to build the robust Integrated Shipyard Risk Management (Blyth et al., 2025).

6] Conclusion - Summarize the main outcomes and their significance**.**

This bibliometric analysis provides a comprehensive overview of global research trends in shipyard risk management, drawing on data extracted from the Scopus database. The study highlights a significant growth in academic interest over the past two decades, with United States and China emerging as the leading contributor in terms of publication volume and collaborative networks. This is aligned with the research in Construction Project, which includes shipbuilding, countries like China, the United States, and the United Kingdom, are leading in risk management research (Osei-Kyei et al., 2022).

The analysis reveals that current research predominantly addresses key risk categories including **occupational exposure**, **environmental risks**, **financial and technical uncertainties**, **project management risks**, **disaster management preparedness**, **human-centered risks**, and the development of **risk assessment models**. These themes reflect the complex and multidisciplinary nature of risk in shipbuilding and repair activities.

Moreover, cluster mapping and keyword co-occurrence analysis suggest that future research is likely to focus on emerging topics such as **risk management for autonomous vessels**, **climate change impacts**, **sustainable shipyard practices**, and the implementation of **integrated risk management frameworks** that encompass digital technologies and systems engineering approaches.

In conclusion, while traditional risks remain a dominant concern, the evolving landscape of maritime technologies and environmental regulation is reshaping the research agenda. To ensure resilience and competitiveness, shipyard stakeholders must adopt a forward-looking approach that integrates innovation, sustainability, and holistic risk governance.

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