Systematic review and meta-analysis

Labour force management in maritime ports: A comprehensive systematic literature review

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ARTICLE INFO

ABSTRACT

The COVID-19 pandemic led to a labour shortage crisis at maritime ports. Therefore, stakeholders of this industry must have robust tools to maintain good performance indicators of productivity and competitiveness. One of the most critical issues is the labour force related to allocation, performance evaluation, and foreseeing/adapting to new requirements. Many authors have studied the characteristics, elements, trends, and factors crucial in its management. However, there needs to be a comprehensive understanding of this concern. Therefore, this paper aims to develop a systematic literature review on labour force management in the maritime ports to (1) understand the elements and factors that strongly relate to human management and (2) identify future research directions to address the impact of labour shortages. Research questions and keywords were used to search academic databases for peer-reviewed papers, articles, or books. The search, selection and quality assessment processes were performed using the PRISMA methodology. This resulted in 32 documents for review and categorised based on their contributions to the research questions and content. The main findings include factors in labour force management, challenges in optimisation, technology and automation use, methods for evaluating performance, and the impact of the regulatory framework. In addition, potential future research streams were proposed to guide further studies into the needs of this industry.

1. Introduction

With the increasing demand for global trade, effective Labour Force Management (LFM) at maritime ports has become critical for ensuring efficient operations, high productivity levels, and optimal outcomes [1]. Before the COVID-19 pandemic, maritime ports grappled with challenges in labour force management. Issues such as allocating labour for enhanced efficiency, addressing workforce management challenges, anticipating industry changes, evaluating performance effectively, and adapting to evolving requirements were already critical focal points [2–4]. However, ports and terminals are the elements of the marine industry that experienced higher disruption due to the pandemic. In addition, they are suffering a labour shortage crisis aggravated by the pandemic and the subsequent backlog of cargo at sea [5,6].

According to Yildirim [7], the "crew change" crisis is one of the most critical challenges to complying with international health, welfare, and safety regulations. The shortage of workers in ports presents distinct challenges compared to shortages in other logistics sectors within the maritime industry. While the shipping side faces its own set of issues, such as the shortage of seafarers, the

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situation in ports is uniquely complex. Ports serve as crucial hubs for the handling, storing, and transferring of goods, connecting various modes of transportation and facilitating the smooth flow of international trade. Unlike onboard vessels, where crew members operate within a contained environment, port operations involve a broader range of tasks requiring diverse skill sets. From crane operators and dockworkers to customs officials and logistics coordinators, ports rely on a diverse workforce to handle the complexities of cargo handling, storage, and distribution.

Ports often operate under stringent regulatory frameworks, facing pressure to enhance efficiency while adhering to safety and environmental standards. The shortage of workers in ports can lead to bottlenecks, delays in cargo handling, backlog of orders, distress among crew, and increased operational costs, ultimately impacting the entire supply chain. Therefore, this results in operational disruptions, safety concerns, impact on efficiency, recruitment and retention challenges, and industry-wide repercussions [8,9]. In addition, the shortage of workers and ground transportation has pushed warehousing to limits that it may not have anticipated, which continues to exacerbate supply chain impacts beyond ports [10]. Moreover, ports must contend with competition for labour from other industries and face challenges in recruiting and retaining skilled workers due to the demanding nature of the work, irregular schedules, and potential automation threats. Hence, while shortages in the shipping sector are significant, the unique operational dynamics and multifaceted roles within ports present a distinct and potentially more challenging scenario.

Different studies have been developed to analyse LFM in maritime ports. They include labour force modelling, characterisation, trends and factors that impact its management [11–14]. However, there is a lack of comprehensive and up-to-date research in this area. Therefore, the scope of this paper is focused on developing a systematic review that synthesises and analyses the existing literature, providing a better understanding of the issues related to LFM in maritime ports. Moreover, this study aims to offer valuable insights that will guide the development of effective strategies, enhancing the efficiency and effectiveness of LFM at maritime ports.

This review provides a novel and comprehensive overview of the current research on LFM in maritime ports based on systematic and bibliometric analysis. Furthermore, the study identifies trends, gaps, and future directions regarding the factors on labour force assignment, the main challenges associated with labour force management, and methods for evaluating labour force performance and productivity in maritime ports. In addition, the study's findings supply valuable information for port authorities, policymakers, and researchers interested in improving workforce management and utilisation in maritime ports.

The paper is organised as follows. Section 2 outlines the methodology employed based on the PRISMA method. Section 3 provides an in-depth analysis and discussion of the results obtained from the systematic literature review on LFM in maritime ports. Section 4 presents the study's key findings. Section 5 delves into the details of potential future research lines. Finally, Section 6 briefly concludes the paper.

2. Methodology

A systematic review focused on the assignment, allocation, limitations, and management of the labour force in maritime ports is proposed based on the research developed by García-Peñalvo [15] and Systematic Reviews and Meta-Analyses (PRISMA) guidelines [16]. PRISMA methodology[1] is crucial as it provides a structured and transparent framework for conducting systematic reviews. It allows an unbiased recollection, assessment, analysis and documentation of studies related to a research area using an iterative process [17]. The PRISMA guidelines encompass a flow diagram of four distinct phases and a checklist featuring 27 essential items. The flow diagram delineates the sequential steps of identification, screening, eligibility assessment, and inclusion criteria for reports falling within the review's scope. The checklist provides 27 recommendations, including title, abstract, introduction, methods, results, discussion, and financing. Therefore, PRISMA items serve as a valuable guide and offer authors, reviewers, and editors a structured framework to ensure completeness and transparency in the systematic reviews. Fig. 1 presents the PRISMA flowchart and the selection process.

The following subsections describe the steps of the review process to identify the documents on the labour force in maritime ports, the most commonly used evaluation methods and future research lines.

2.1. Research questions

The research questions help to narrow down the problem of interest and to point out the research needs. Moreover, they describe the rationale for the review and provide an explicit statement of the research objective(s). The literature search, analysis and review revolves around the research questions, so they should be as specific as possible and of interest to other researchers and practitioners. The questions are the following:

- RQ1: What are the key factors influencing labour force assignment in maritime ports, and how do these factors vary across different regions and industries?
- RQ2: What are the main challenges associated with labour force management in maritime ports, and how have these been addressed in previous research?
- RQ3: How have advances in technology and automation affected the demand for labour in maritime ports, and what are the implications for labour force assignment and management?

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[1] The explanation, checklist, and flow diagram of PRISMA methodology can be found on http://www.prisma-statement.org.
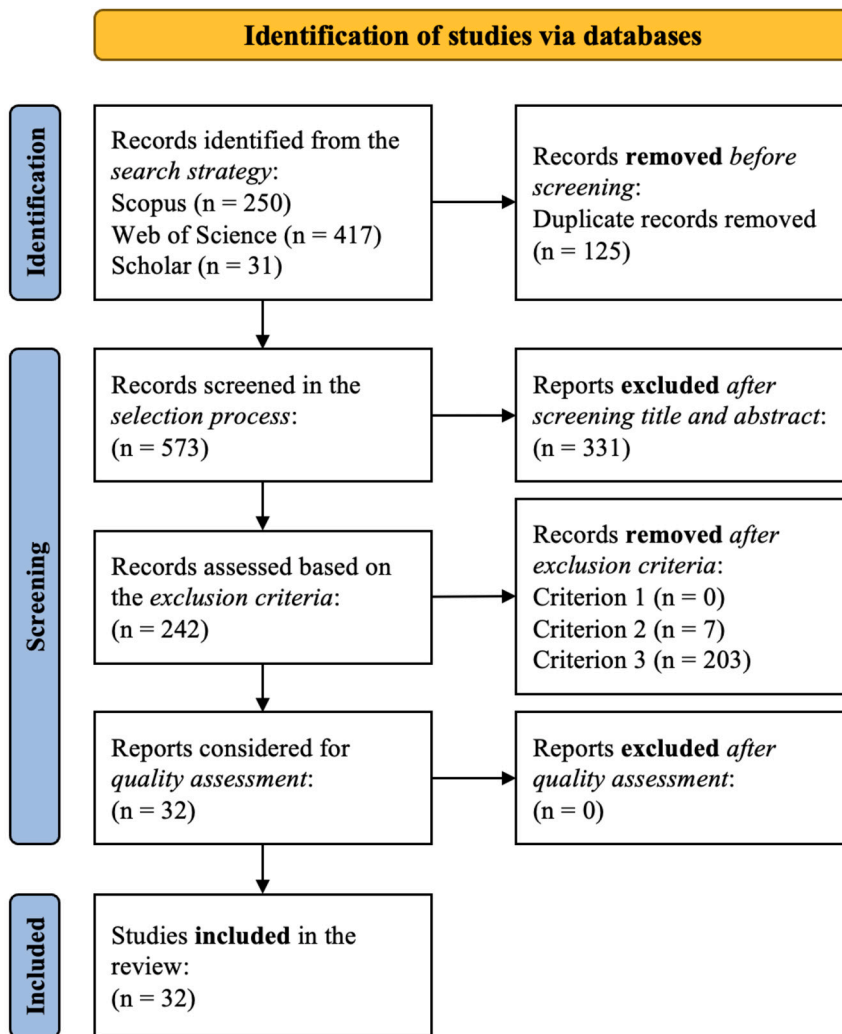
Identification of studies via databases

Fig. 1. PRISMA flowchart.

- RQ4: What are the most effective methods for evaluating labour force performance and productivity in maritime ports, and how can these be used to improve workforce management?
- RQ5: How do regulatory frameworks and government policies around the world impact labour force assignment and management in maritime ports, and what are the implications for stakeholders such as employers, employees, and local communities?

Adopting the PRISMA methodology facilitated a meticulous and systematic literature review process, allowing for rigorous analysis and synthesis of findings to effectively address the research questions. PRISMA ensured comprehensive coverage of relevant literature through its structured framework, enabling researchers to identify, screen, and select pertinent papers precisely. This methodological approach thoroughly examined vital factors, challenges, and implications of labour force management in maritime ports. By adhering to PRISMA guidelines, researchers could systematically extract, analyse, and interpret data from selected papers, thereby enhancing the reliability and validity of the study's findings. Thus, PRISMA played a crucial role in ensuring the methodological robustness and integrity of the research endeavour.

Table 1 provides a concise overview of the motivations behind each research question. It highlights the objectives, such as understanding labour allocation, identifying workforce management challenges, exploring industry changes, identifying performance evaluation best practices, and assessing the overall impact on stakeholders in the maritime labour force.

2.2. Search strategy

The first stage of the PRISMA methodology requests specifying the databases, registers, and sources consulted to identify the documents (including the filters, queries, and limits). Literature on workforce management at maritime ports was searched using Google Scholar, Web of Science, and Scopus. The keywords were identified from the research questions and used to construct several

Table 1
Motivation of research questions.

RQ#	Motivation
RQ1	Enhance understanding of labour allocation for tailored strategies, boosting efficiency at seaports for researchers, employers, and policymakers
RQ2	Identify and address challenges in workforce management for improved overall performance
RQ3	Study the impact of changes on workforce management to aid stakeholders in anticipating and preparing a sustainable workforce
RQ4	Identify best practices for evaluating performance, enhancing workforce management based on informed decisions and robust tools
RQ5	Understand industry shaping, aiding stakeholders in adapting to changes, and informing policymakers for social welfare decisions

Table 2
Boolean technique for search results.

Database	Search string	Number of records
Web of Science	("human resource management" or "workforce management" or "labour force management" or "resource management" and "maritime port")	417
SCOPUS	("human resource management" or "labour force management" or "resource management" and "maritime port")	250
Google Scholar	("human resource management" or "workforce management" or "labour force management" and "maritime port" and "assignment" or "allocation")	31

strings based on a Boolean technique. Synonyms and plural forms of the keywords were included to broaden the results. The results of the search, including the search strings used and the number of outcomes achieved, are listed in Table 2.

The initial search resulted in 698 papers. The duplicated records were removed, leaving 573 documents to be screened using the selection criteria. It is suitable to mention that the term "maritime ports" encompasses both seaports and maritime terminals. Seaports typically refer to harbour facilities where ships dock to load and unload cargo. At the same time, maritime terminals are specialised facilities within seaports dedicated to specific types of cargo handling, such as container terminals or bulk cargo terminals. Including seaports and maritime terminals under the umbrella of maritime ports is justified by their interconnectedness and shared functions within the broader maritime transportation network. Seaports serve as vessel entry and exit points, while maritime terminals facilitate the efficient movement and storage of goods within the port complex. Therefore, analysing the impact of the human labour force in maritime ports entails examining disruptions or challenges that occur at both terminal and seaport levels.

This notion is reinforced by the abstracts and keywords of each selected paper for analysis. The abstracts often mention the broader context of maritime ports, focusing on port operations and management that encompasses seaports and maritime terminals. Keywords associated with the papers frequently include terms such as "port operations," "terminal management," and "maritime logistics," highlighting the comprehensive scope of the research. By considering seaports and maritime terminals, researchers can understand the labour force dynamics and operational challenges within maritime ports, enabling more effective workforce management strategies and port optimisation strategies.

2.3. Selection process

The second stage of the PRISMA methodology consists of a selection process to narrow down the number of documents to be reviewed based on the scope of the research topic. The documents that resulted from the search strategy were reviewed based on inclusion and exclusion criteria to determine the ones that fit the scope of this paper. The title and abstract were screened to remove those papers that do not focus on the maritime port industry and human resource management. This process resulted in 242 documents, and they were assessed using the following exclusion criteria:

- Exclusion criterion 1: The document is not written in English or Spanish.
- Exclusion criterion 2: The document does not come from indexed sources.
- Exclusion criterion 3: The document does not consider human resources or labour force as a subtopic.

The documents that met the exclusion criteria were removed from the research, and 32 manuscripts were considered for the quality assessment.

2.4. Quality assessment

The third and last stage of the PRISMA methodology is to assess the bias/quality of the included documents to determine which ones are eligible. Evaluating the quality of each document is one of the most critical stages of any systematic review because it validates their methodology and results [18,19]. The seven questions proposed by Yousuf et al. [19] were used to evaluate the quality of the chosen documents, as presented in Table 3.

Question Q1 is inquiring about the clarity and precision of the research goals outlined in the document. It assesses if the purpose of the research is explicit and understandable. Question Q2 evaluates whether the article's content is coherent without unnecessary elaboration to engage the readers. Question Q3 assesses whether the methodology section is sufficiently transparent and detailed for readers to understand how the research was designed, data collected, and analysis conducted. This question evaluates the rigour

Table 3

Quality assurance questions.

Q#	Quality assurance question
Q1	Are the research aims specified clearly?
Q2	Is the information presented clear and concise?
Q3	Does the research provide enough explanation of its methodology?
Q4	Do the findings of the research contribute to the understanding of LFM in maritime ports?
Q5	Are the conclusions clearly identified?
Q6	Are the conclusions logical and concise with the structure of the paper?
Q7	Do the results contribute to the literature?

Table 4

Quality assessment results.

Author(s)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Total	%
Schuler and Jackson [20]	1	1	0.5	1	0.5	1	1	6	86%
Silberholz et al. [21]	1	1	1	1	1	1	1	7	100%
Couper [22]	1	1	0.5	1	1	1	1	6.5	93%
Sudarmaji [23]	1	1	1	1	1	1	1	7	100%
Choi et al. [24]	1	1	0.5	1	1	1	1	6.5	93%
Legato and Monaco [11]	1	1	1	1	1	1	1	7	100%
Meletiou and Law [25]	1	1	1	1	1	1	1	7	100%
De Martino and Morvillo [26]	1	1	1	1	1	0.5	1	6.5	93%
Han and Kim [27]	1	1	0.5	1	1	1	1	6.5	93%
Progoulaki and Theotokas [28]	1	1	1	1	1	1	1	7	100%
Fancello et al. [29]	1	1	1	1	1	1	1	7	100%
Di Francesco et al. [12]	1	1	1	1	1	1	1	7	100%
Bielić et al. [30]	1	1	0.5	1	1	1	1	6.5	93%
Huang et al. [31]	1	1	1	0.5	1	1	1	6.5	93%
Serra [32]	1	1	1	1	1	1	1	7	100%
Di Francesco et al. [13]	1	1	0.5	1	1	0,5	1	6	86%
Pak et al. [14]	1	1	1	1	1	1	1	7	100%
Di Francesco et al. [33]	1	1	1	1	1	0.5	1	6.5	93%
Koralova-Nozharova [34]	1	1	1	1	1	1	1	7	100%
Progoulaki and Theotokas [35]	1	1	1	1	1	1	1	7	100%
Fei [36]	1	1	0.5	0.5	1	1	1	6	86%
Petersson [37]	1	1	1	0.5	0.5	1	1	6	86%
Safa et al. [38]	1	1	1	1	1	1	1	7	100%
Chen et al. [39]	1	1	1	1	0.5	1	1	6.5	93%
[40]	1	1	1	1	1	1	1	7	100%
Ünsür [41]	1	1	0.5	1	1	0.5	1	6	86%
[42]	1	1	1	1	1	1	1	7	100%
Esser et al. [43]	1	1	1	1	1	1	1	7	100%
Andersen and Hansen [44]	1	1	1	0.5	1	1	1	6.5	93%
Bottalico [45]	1	1	1	1	0.5	1	1	6.5	93%
Walters and Wadsworth [46]	1	1	0.5	1	1	1	1	6.5	93%
Oluwagbenga et al. [47]	1	1	1	1	0.5	1	1	6.5	93%

and reliability of the research methods. Question Q4 determines if the results add meaningful insights to expand the existing understanding within the research field. Question Q5 evaluates if the document effectively presents its outcomes, key findings, and interpretations, allowing readers to grasp the conclusions from the article. Question Q6 examines the coherence of the manuscript's main findings with the overall structure of the research paper, i.e., the conclusions integrated with the rest of the document. Finally, question Q7 asks whether the results add valuable insights and knowledge to the existing literature of the research field. The method outlined by Yousuf et al. [19] was followed to score each question per document: a 'Yes' response receives a score of 1, 'Partially' gets a score of 0.5, and 'No' a score of 0. Table 4 shows the results of the selected papers.

It is essential to highlight that researchers and organisations involved in evidence synthesis often recommend aiming for at least 80% adherence to the PRISMA checklist items as a general guideline to ensure comprehensive reporting [48–50]. This recommendation stems from the principle that a higher adherence to reporting standards indicates a more thorough and transparent reporting of the systematic review process, which enhances the credibility and reliability of the study's findings. Additionally, achieving a higher PRISMA score facilitates the replication of the research and allows readers to assess better the risk of bias and the overall quality of the systematic review. Therefore, while not an absolute rule, striving for a PRISMA score of 80% or higher is considered good practice in systematic review research [50]. Based on the results presented in Table 4, all of the selected papers have passed the quality assessment with a percentage between 86% and 100%.

Table 5
Main information.

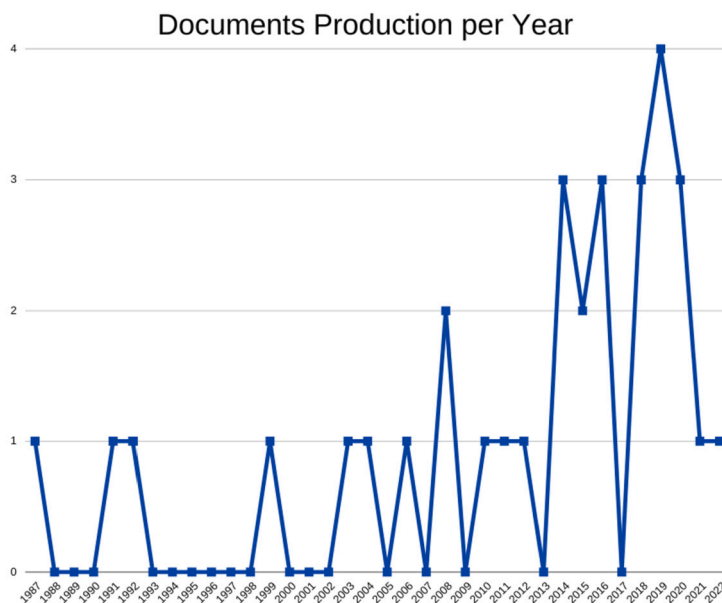| Type of information	Item	Results
General	Timespan	1987:2022
	Annual growth rate %	5.3
	Sources (journals, books, etc.)	10
Authors	Number of authors	31
Authors collaboration	Single-authored documents	20
	Co-authors per document	1.77
	International co-authorships	3.27%
Document types	Article	24
	Dissertation	2
	Proceeding paper	3
	Book	2
	Abstract	1

Fig. 2. Number of published documents per year.

3. Bibliometric analysis

As was mentioned, this review aims to comprehensively examine the key factors influencing labour force assignment in maritime ports, identify the main challenges associated with labour force management, assess the impact of technological advancements on labour demand, evaluate practical methods for determining labour force performance and productivity, and analyse how regulatory frameworks and government policies affect labour force assignment and management, considering the implications for stakeholders such as employers, employees, and local communities. Different methods have been implemented to analyse the literature of any research line, where one of the most prominent is the bibliometric analysis proposed by Pritchard [51]. It includes analysis of authorship, keywords, publication metrics, citation, co-citation, affiliations, etc. Therefore, this section presents the bibliometric analysis using the Bibliometrix R package of the 32 selected documents to identify the trends, gaps, and future directions in this field. Table 5 shows the main insights from the bibliometric analysis to better characterise the reviewed documents.

Table 5 reveals that analysed documents were published between 1987 and 2022, with a mean of 5.3% annual growth rate. This result indicates that research on LFM has been ongoing for at least three decades. In addition, the number of analysed publications has grown steadily in recent years. However, the sample shows that the most significant increase in publications has occurred in the last ten years, as shown in Fig. 2. In addition, the annual growth rate of 5.3% suggests that the field is still developing and that more research is likely to be published.

Table 5 also shows that 24 documents were articles, 2 were dissertations, 3 were proceedings papers, 2 were books, and 1 was an abstract. Articles were the most common type, suggesting that the research tends to be focused on specific topics and presented in a concise and accessible format. The 32 documents were mainly published in 10 sources, including journals, books, and proceedings papers. Journals were the most common, i.e., they are the leading dissemination platform for research in this field. Results of the analysed documents reveal that most of the research is concentrated in the journals "Maritime Policy & Management" (3 articles)

Table 6
Leading authors in the field.

Authors	Number of documents	References
P. Zuddas	4	Fancello et al. [29], Di Francesco et al. [12], Di Francesco et al. [13], Di Francesco et al. [33]
P. Serra	4	Fancello et al. [29], Di Francesco et al. [12], Serra [32], Di Francesco et al. [13]
G. Fancello	3	Fancello et al. [29], Di Francesco et al. [12], Di Francesco et al. [13]
M. Di Francesco	3	Di Francesco et al. [12], Di Francesco et al. [13], Di Francesco et al. [33]
I. Theotokas	2	Progoulaki and Theotokas [28], Progoulaki and Theotokas [35]
M. Progoulaki	2	Progoulaki and Theotokas [28], Progoulaki and Theotokas [35]
P. Fadda	2	Fancello et al. [29], Di Francesco et al. [12]

Table 7
Top 10 of articles based on citations.

Author	Total citations	Citation rate per year	Year	Type	Approach	Topic
Schuler and Jackson [20]	3945	109.6	1987	Article	Review	Characteristics
De Martino and Morvillo [26]	162	10.8	2008	Article	Qualitative	Efficiency
Choi et al. [24]	74	3.7	2003	Article	Qualitative	Planning
Pak et al. [14]	45	5.6	2015	Article	Quantitative	Efficiency
Silberholz et al. [21]	44	1.4	1991	Article	Quantitative	Efficiency
Legato and Monaco [11]	41	2.1	2004	Article	Quantitative	Efficiency and planning
Fancello et al. [29]	37	2.8	2011	Article	Quantitative	Allocation
Progoulaki and Theotokas [28]	32	2.3	2010	Article	Survey	Characteristics
Esser et al. [43]	24	8.0	2020	Article	Review	Characteristics
Safa et al. [38]	15	3.0	2018	Proceeding	Review	Characteristics

and "Marine Policy" (2 articles), sources related to policies in the maritime industry. The first focuses on business, organisational, economic, socio-legal and management topics at the port, community, shipping company and shipboard levels. On the other hand, the second one addresses international, regional and national marine policies, institutional arrangements for managing and regulating marine activities, conflict resolution, marine pollution and environment, and conservation and use of marine resources.

Table 6 identifies the leading authors of LFM in the maritime ports. The analysed documents suggest that Paola Zuddas and Patrizia Serra are the authors with the higher number of publications. However, these authors have published in recent years. This fact indicates that advanced developments in this industry have replaced the knowledge planted by early researchers. In addition, early contributions have not prevailed and influenced the latest advances in the subject.

Table 7 displays the top 10 cited articles with their respective citation counts, citation rate per year, publication year, publication type, approach, and addressed topic. Results show that some documents received citations only in specific years. The most cited one is a review developed by [20], published in the Academy of Management Review. This paper presents the relationship between the characteristics of human resource management practices and business strategy. The second most cited one is by De Martino and Morvillo [26], published in Maritime Policy & Management journal. The paper is a qualitative study that explores business processes' efficiency using performance indicators. The third most cited article is the one developed by [24], published in the Maritime Policy & Management journal. The authors analysed the planning and implementation of enterprise resource planning systems. The remaining seven manuscripts are divided into two main categories. The first group is focused on quantitative efficiency and management [14,21,11]. The second corresponds to surveys of organisations and addresses the characteristics or allocation of human resources at maritime ports [29,28,43,38].

Furthermore, the average number of co-authors per document was 1.77, i.e., most of the research has been developed by small teams. This is an important finding. Collaboration among researchers is prevalent because it is considered more innovative and rigorous than individual research. Only 3.27% of the documents have an international co-authorship. The low percentage suggests that research on LFM has been relatively localised, with limited international collaboration. One reason is the influence of local regulations and practices on managing the labour force at ports and its variation across different regions and countries. However, international collaboration can bring different perspectives and expertise to provide more innovative and novel findings.

Fig. 3 presents the word cloud of keywords about LFM in maritime ports. It visually represents the most commonly used terms in this field of study. The cloud is arranged by frequency, i.e., the most prominent words are the most used. The most relevant keywords are "manpower planning", "container", "human", and "shipping". These terms reflect the importance of effective planning and management of the workforce in the maritime industry, especially regarding the transportation of goods and cargo. Other important keywords are "leader participation", "heuristic", "decision making", and "model". They suggest the importance of strong leadership and decision-making skills and the role of data analysis and modelling in designing tailor-made strategies.

Fig. 4 shows a factorial analysis of the keywords, which supports the results from the word cloud (Fig. 3). Results from this analysis determine that keywords can be grouped into three clusters. The first one includes terms such as "manpower planning", "human resources", "container terminals", and "shipping". The efficient management of labour resources is critical to the smooth operation of container terminals and shipping industries. Human resources planning and allocation are essential for ensuring people have the necessary skills to improve productivity and efficiency. The second cluster highlights sustainable competitiveness. It indicates that environmentally friendly practices are becoming increasingly important in the maritime industry. In addition, companies with

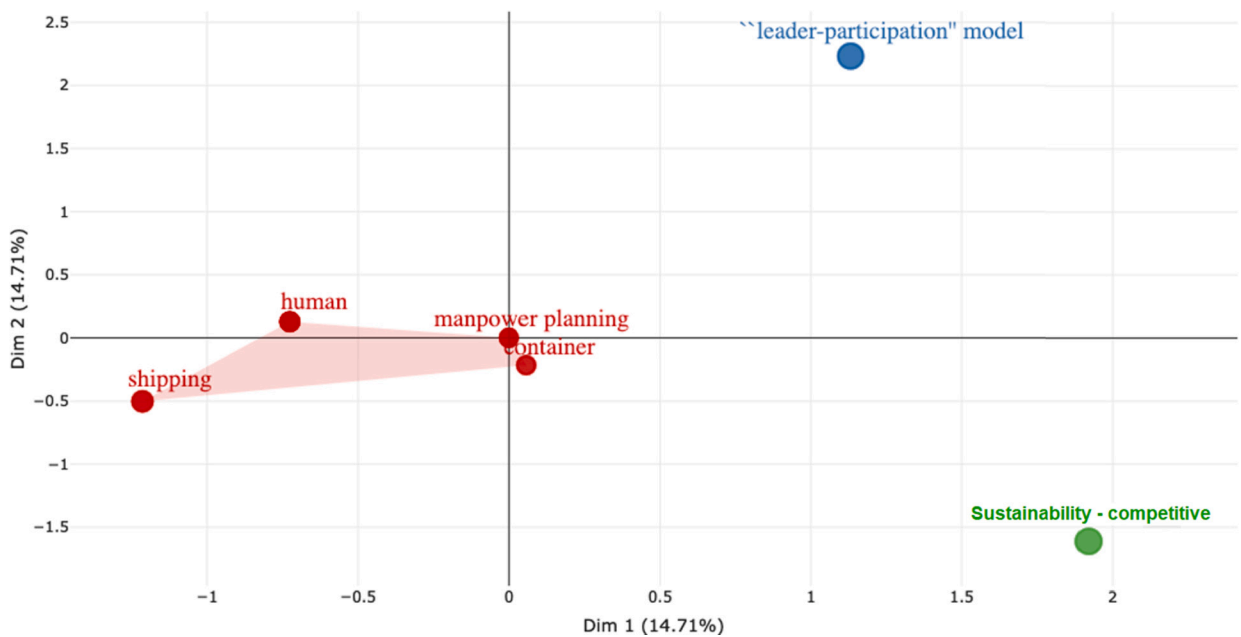**Fig. 3.** Keywords word cloud.

Fig. 4. Factorial analysis: correspondence analysis.

sustainable practices are more competitive, attract customers, and enhance their reputation. The third cluster focuses on "leader participation" models. Leadership and heuristic models are critical in leading organisations towards making effective decisions that positively impact the bottom line. The bottom line of a factorial analysis refers to the primary or overarching conclusion drawn from the study. It encapsulates the key insights or patterns identified by examining data using factorial techniques such as principal component analysis (PCA) or correspondence analysis. The bottom line typically highlights the main clusters, trends, or relationships uncovered in the data, concisely summarising the findings and their implications for the research or problem at hand. It is a high-level takeaway that guides interpreting and understanding the analysed variables or factors.

The results show that the factorial analysis identifies three distinct clusters of keywords related to labour force management in maritime ports. These clusters represent different thematic areas or concepts within the field. The first cluster focuses on terms such as "manpower planning," "human resources," "container terminals," and "shipping," highlighting the importance of efficient labour resource management for the smooth operation of ports and shipping industries. The second cluster revolves around sustainable competitiveness, emphasising the increasing significance of environmentally friendly practices in the maritime sector. Lastly, the third cluster centres on "leader participation" models, underscoring the critical role of effective leadership and heuristic models in driving organisational decision-making processes towards improved performance and profitability.

4. Findings and discussion

4.1. RQ1: key factors in LFM

Several factors influence labour force assignments in maritime ports, such as globalisation, technological advancements, and the size and complexity of the port [20,38,28]. These factors may vary across different regions and industries. The workforce may demand higher wages in developed countries, while developing countries may have a larger pool of unskilled workers, so hiring and assigning labour to specific tasks is simpler. Other key factors that affect LFM include the port size, the types of cargo handled, and the equipment used [33,11]. For example, ports that handle larger cargo volumes may require more workers to move goods, while those with automated equipment may require fewer workers. In addition, the type of cargo influences LFM. For example, ports that handle hazardous materials may require specialised labour. Furthermore, regional factors such as language barriers, cultural differences, and immigration policies can also impact labour force assignment [20,38,28]. Ports that require workers who speak multiple languages may face challenges in hiring and assigning workers if they are in regions with high immigration restrictions.

Partnerships among various stakeholders, including shipping liners, transhipment container terminals (TCTs), and other entities involved in freight transportation, emerge as critical factors influencing labour force dynamics in the maritime industry. These collaborations facilitate the efficient deployment of resources, such as deep-sea vessels and feeders, leading to streamlined operations and consolidated flows along critical routes [33]. Moreover, partnerships empower TCTs to offer high-performance, cost-effective services by leveraging collaborative efforts with shipping liners and strategic resource planning. They also enable TCTs to adapt to evolving industry demands and external changes, ensuring flexibility and responsiveness in service provision [34]. Additionally, partnerships play a pivotal role in workforce planning within TCTs. They allow external workers to supplement the internal workforce when necessary, thus influencing labour force dynamics and operational efficiency in the maritime sector.

Effective training and education programs represent another crucial key factor in labour force management within the maritime industry. These programs are pivotal in addressing personnel undermanning issues by equipping workers with the necessary skills and knowledge to carry out their duties efficiently. By providing comprehensive training on various aspects of port operations, safety protocols, and equipment handling, TCTs can ensure that their workforce is adequately prepared to meet operational demands [34]. Moreover, well-trained personnel are better equipped to prevent operation delays, which can harm TCTs and shipping companies, leading to additional costs and disruptions in service delivery. Therefore, investing in effective training and education initiatives is essential for enhancing workforce capabilities, minimising undermanning risks, and optimising operational efficiency in the maritime sector.

4.2. RQ2: main challenges in LFM

The challenges associated with LFM in maritime ports include needing more standardisation in job classifications, outdated technology, and inadequate training and development programs for workers. Previous research has addressed these challenges by implementing new technologies, such as automated equipment, which has increased efficiency and reduced the need for manual labour [29]. Additionally, some manuscripts have advocated using standardised job classifications and performance metrics to improve workforce management [11]. However, LFM can also create socio-economic challenges, such as job displacement, particularly in regions where port-related jobs are a significant source of employment. Therefore, previous research has also highlighted the need for policies and programs that address these issues, such as retraining and job placement programs for displaced workers [33,26,24,28,35,46,39].

The maritime industry faces several significant challenges related to partnerships and collaboration. One key challenge revolves around establishing and maintaining effective communication channels between shipping liners and transhipment container terminals (TCTs) [33,26]. Ensuring smooth coordination and information exchange is essential for optimising operational efficiency and enhancing service delivery. However, achieving this level of communication can be complex, requiring robust infrastructure and protocols to facilitate seamless interactions between stakeholders. Another formidable challenge is the industry's ability to adapt to external changes, such as service variations requested by shipping liners. Partnership arrangements must exhibit flexibility and agility to effectively accommodate evolving demands and market dynamics. Navigating these changes while maintaining operational integrity requires strategic foresight and proactive collaboration among industry players.

Training and education present another set of challenges for the maritime industry. Developing comprehensive training programs tailored to the specific work rules, operator skills, and operating environment of TCTs is essential but often challenging [34]. Ensuring the availability of skilled trainers and adequate resources for training programs poses logistical hurdles that must be addressed. Moreover, the need to regularly update and enhance training materials to align with industry advancements further complicates training initiatives. Despite these challenges, investing in robust training and education programs is crucial for addressing workforce shortages, preventing operation delays, and ensuring the continued competitiveness and sustainability of the maritime sector.

4.2.1. Impact of COVID-19 on maritime LFM

The COVID-19 pandemic has brought about significant challenges in the maritime labour force, particularly impacting crew changeovers [52]. National restrictions preventing seafarers from disembarking and undergoing crew changes have led to extended service periods, violating established standards and endangering seafarers' safety. International conventions emphasising seafarers' rights to annual leave, repatriation, and shore facilities have been compromised, with governments urged to facilitate effective crew

changes. Approximately 150000 seafarers monthly require changeovers, but by mid-2020, only 30% of governments permitted them, posing threats to seafarers' well-being and the safety of maritime trade [53].

Furthermore, the abandonment of seafarers has emerged as a concern during the pandemic. Instances of abandonment underscore the vulnerability of seafarers, prompting some governments, like India, to repatriate their seafarers [52]. The International Transport Workers' Federation (ITF) advocates protecting seafarers as frontline workers and raises concerns about embassy closures limiting seafarers' access to port assistance [54]. Urgent international cooperation is needed to address these issues and safeguard seafarers' well-being and rights amid the ongoing challenges of the pandemic.

4.3. RQ3: advanced technology and automation for labour demand

Advances in technology and automation have significantly impacted the demand for labour in maritime ports. Automated systems have increased efficiency and reduced the need for manual labour, such as container cranes and unmanned aerial vehicles [1,5,10]. These advancements have also increased safety and reduced the risk of accidents, leading to a better working environment. However, the implications of automation on LFM are complex [11]. While automation can reduce the demand for manual labour, it may also create new opportunities for skilled workers, such as maintenance and repair technicians [10,1,25]. Therefore, LFM must consider the changing demand and the skills needed to meet it [43].

4.4. RQ4: methods for evaluating labour force performance and productivity

Evaluating labour force performance and productivity is critical for improving workforce management. Therefore, several authors have proposed different methods to assess performance and productivity in maritime ports [13,14,33,39]. They can be categorised into mathematical modelling, heuristics, and discrete event simulation.

Mathematical modelling has been widely used to solve workforce management problems in maritime ports. A study by Legato and Monaco [11] proposed a mixed-integer linear programming model to optimise container terminal operations, including workforce management. The model considers labour demand, availability, and equipment allocation and scheduling. The results showed that the proposed model could optimise LFM and improve productivity. In addition, the study by Di Francesco et al. [12] addresses workforce management in maritime ports by modelling the allocation of human resources in transhipment container terminals using an integer linear programming formulation. The model assigns internal and external operators to shifts, tasks, and activities and returns shortages in shifts, tasks, and activities to contact overtime workers in time and serve vessels as scheduled. The paper shows that a 2-day planning horizon leads to better results than a standard daily one since the first provides a lower shortage of workers. The model also introduces a new cost formulation for internal operators that considers operators' productivity, activity priority, and complexity. This formulation helps to highlight resource undermanning timely, limiting delays in vessel operations, which can result in costs for both shipping companies and terminal operators. Therefore, timely knowledge of personnel undermanning is practical for convening overtime operators in good time and serving vessels as scheduled. The lower the workforce undermanning, the lower the costs generated by operation delays, and the more efficient and competitive the terminal in the port.

Another effective method is the fuzzy multiple criteria decision making (MCDM) approach [14]. It uses multiple criteria for decision-making to evaluate workforce performance, and it is functional when a qualitative evaluation has to be developed with data that are difficult to quantify. This study considers several factors, including worker experience, education, skill level, and efficiency, and assigns weights to each criterion based on their importance. Managers can use this approach to identify the best-performing workers and allocate them to the most critical tasks.

In addition, discrete event simulation is a powerful method for evaluating labour force performance and productivity in maritime ports. Simulation models can be used to test different scenarios and assess the impact of changes in the labour force on productivity. For example, a study by Silberholz et al. [21] proposed a discrete event simulation model to evaluate the impact of different labour force scenarios on productivity in a container terminal. The results showed that the proposed model could effectively evaluate labour force performance and productivity and help optimise workforce management.

It is suitable to mention that the studies on LFM, including those conducted by Di Francesco et al. [13] and Di Francesco et al. [33], exhibit several limitations warrant consideration. Firstly, a common limitation across these studies is the need for long-term planning in allocating workers. This oversight may lead to ineffective assignments and sub-optimal outcomes, potentially hindering port operations' efficiency. Secondly, the failure to account for uncertainty in problem parameters such as work demand and operating conditions undermines the accuracy of model predictions and decision-making processes, limiting their practical applicability.

Additionally, using a short planning horizon, as seen in the 2-day planning horizon adopted in Di Francesco et al. [33], introduces data uncertainty, impacting the model's ability to make accurate decisions. Furthermore, the studies often overlook specific costs associated with personnel undermanning, such as delays in berthing, penalties, and increased fuel costs. Neglecting these costs provides an incomplete economic analysis of labour management strategies' implications in maritime ports. Lastly, the scalability and performance of the models may be constrained when considering more significant problem instances and multiple scenarios, necessitating the development of specialised resolution techniques to address these limitations effectively.

4.5. RQ5: regulatory frameworks and government policies

The regulatory frameworks and government policies impact labour force assignment and stakeholders such as employers, employees, and local communities. One of the main effects is the requirement for standards in labour force assignments, which can

impact the recruitment and retention of employees [26,24,28,46]. For instance, regulations requiring specific training, certification, and experience can limit the pool of available workers, thereby increasing labour costs for employers. In contrast, relaxed policies may lead to less skilled or less qualified hired employees, resulting in lower productivity and safety concerns [28,35,46,39].

Government policies can also affect the allocation of labour forces within ports. For example, port authorities may require different staffing levels based on the type of cargo or vessel, leading to allocating more resources in one area than another. As a result, under or over-staffing of resources may occur in some areas. Furthermore, government policies impact the labour market in maritime ports by establishing restrictions or quotas on the number of foreign workers [35,39]. These policies may limit labour supply at the local market and, therefore, cause cost increases and port competitiveness in the local market to decrease.

The implications of regulatory frameworks and government policies on stakeholders in maritime ports are varied. Employers may experience increased labour costs due to compliance with policies and regulations, while employees may face limited employment opportunities due to strict certification and experience requirements. In addition, local communities face negative consequences because employment opportunities in maritime ports can be a significant source of income for the region.

5. Future research lines

The maritime industry has faced significant challenges recently, especially its labour force [5]. With an ageing workforce, a shortage of skilled workers, and competition from other industries, there is a pressing need for future research to explore innovative solutions to these issues [1]. This section outlines five potential future research directions that address challenges in the labour force at maritime ports, as follows:

- **Developing effective strategies for attracting and retaining young workers:** According to Ward [55], one of the significant challenges of the LFM is the ageing workforce and the need for newly trained candidates. In addition, human resource activities are expected to focus on identifying, developing and retaining skilled workforce [38,40]. Recently, Caesar [56] suggested that a comprehensive approach is required to address the contributing factors that result in sustainable qualified labour. Thus, future research should focus on developing effective strategies for attracting and retaining young workers in the industry. This could involve a range of initiatives, such as educational programs, internships, and apprenticeships. Also, studies on improving working conditions and wages should be developed.
- **Organisational support to work-family reconciliation measures:** There is a need to investigate the impact of work-family conflict on various employee outcomes, including well-being, commitment, absenteeism, and turnover rates within the maritime workforce. Research in this area could delve into the specific challenges port workers face in balancing work and family responsibilities and the role of organisational support in mitigating these challenges. Exploring the accessibility and effectiveness of work-family reconciliation measures provided by maritime organisations would shed light on potential strategies for improving employee satisfaction, retention, and overall organisational performance. By addressing these topics, future research can contribute to a more comprehensive understanding of labour force dynamics in the maritime industry and inform evidence-based strategies for optimising workforce management and well-being.
- **Exploring the potential of automation and robotics:** The use of automation and robotics in the maritime industry is on the rise, with many ports and shipping companies exploring the potential benefits of these technologies. Recent literature anticipates that automation will replace low-skilled jobs with high technical roles [56]. Future research should investigate the impact of automation and robotics on the labour force in maritime ports, including potential job losses, changes in skill requirements, and the effect on productivity and efficiency [43]. Moreover, some authors recommend concentrating knowledge transfer on digital skills, business knowledge, social skills, sustainability, and supply chain management [56]. Also, future research could explore the integration of information technologies for process automation, focusing specifically on business process automation and its implications for human resource management [57,45]. This line of inquiry would entail examining how automation technologies, coupled with knowledge of information systems, can be leveraged to enhance task coordination and operational efficiency within port environments. Investigating the factors influencing personnel adaptation and acceptance of these technologies would be crucial for understanding the challenges and opportunities associated with automation adoption in the maritime sector.
- **Developing innovative training and education programs:** One of the significant concerns of port stakeholders is whether current training is sufficient to prepare and develop the necessary competencies of future port workers [42,43]. Future research should focus on developing innovative and tailor-made training and education programs according to the needs of the industry. These robust programs should address technical and soft skills to equip future professionals to handle novel situations and challenges [45]. The abilities include business analysis, port operation/administration, maritime law, creativity, communication, teamwork, leadership, critical thinking, and problem-solving [58].
- **Impact of labour shortages on port operations:** The labour shortage in maritime ports can have significant implications for its operations, including delayed shipments, increased costs, poor quality, and reduced efficiency. Indeed, labour competence is essential for maintaining operations and reducing port disruptions [59]. Future research should investigate the consequences of labour shortages on port operations worldwide and identify strategies for mitigating them. An example is the recent study developed by Mthembu and Naude [59] in the Durban Port of Africa. In addition, future studies must consider long-term planning in allocating workers to ensure the effectiveness of assignments. This oversight could hinder the ability of port authorities to deploy labour resources. Also, research on LFM needs to account for the uncertainty inherent in problem parameters such as work demand and operating conditions. This lack of consideration for uncertainty may compromise the accuracy of model's predictions and decision-making processes, limiting its practical applicability in real-world port environments.

- **Analysing the role of partnerships in the maritime industry:** Labour coalitions have played a significant role in the maritime industry, advocating for the rights and interests of workers. Moreover, partnership is one of the Sustainable Development Goals, and innovative solutions for the supply chain can be derived from them [60]. Future research should analyse their impact on labour relations, working conditions, and wages. This research should also investigate the potential for new forms of collective bargaining and labour organisation in the industry for economic, environmental, and social purposes [60].

6. Conclusion

Labour force management is a critical aspect of efficient port operations, and it becomes even more important as global trade continues to increase. The COVID-19 pandemic and the subsequent backlog of cargo at sea have worsened the labour shortage crisis that the maritime industry was already experiencing. The shortage of workers and ground transportation has pushed warehousing to its limits, exacerbating supply chain impacts felt far beyond ports. Studies analysing LFM in maritime ports have been developed, including modelling, characterisation, and factors that impact its operation. However, a comprehensive and up-to-date research gap still exists in this area. Therefore, this paper aims to provide a systematic review of existing literature to facilitate effective strategies to enhance the efficiency and effectiveness of port operations.

The review was conducted based on five research questions and keywords related to them. The analysed documents were searched using the identified keywords and several databases such as Google Scholar, Science SCOPUS, and Web of Science. Initially, the search returned 689 papers and academic works. However, the PRISMA methodology reduced the number of records to 32 for further analysis. Each of these 32 papers was evaluated based on its contribution to the research questions and the validity of the proposed methodology. Finally, the quality of the selected papers was from 86% to 100%.

A bibliometric analysis was performed to provide an overview of the current state of the literature on LFM in maritime ports. The results shed light on several significant findings regarding LFM in maritime ports. Firstly, the study revealed a substantial increase in research output over the past decade, indicating a growing interest and recognition of the importance of LFM. This surge in publications suggests that researchers and practitioners are increasingly focusing on addressing the challenges and exploring opportunities to manage labour resources effectively within port environments. Moreover, the diverse range of publication types, including articles, dissertations, proceedings papers, and books, underscores the multidisciplinary nature of LFM research, drawing insights from various fields such as economics, management, and logistics.

The dominance of articles as the primary publication type reflects a preference for disseminating research findings in a concise and accessible format, aligning with the dynamic and practical nature of LFM research. This emphasis on articles highlights the need for actionable insights and evidence-based practices to address real-world challenges port operators and stakeholders face. Additionally, the concentration of research output in specific journals, notably "Maritime Policy & Management" and "Marine Policy," underscores the significance of policy-oriented research in shaping decision-making processes and regulatory frameworks within the maritime industry. This suggests a growing recognition of the pivotal role of policy interventions in addressing labour-related issues and fostering sustainable development in maritime ports.

The findings regarding international co-authorship patterns underscore the relatively localised nature of LFM research, with limited collaboration across international boundaries. While this may partly be attributed to the contextual differences and regulatory variations across regions, it also signifies untapped opportunities for fostering global collaborations and knowledge exchange. Encouraging international partnerships and interdisciplinary collaborations can enrich research endeavours, facilitate the transfer of best practices, and promote the development of holistic solutions to complex LFM challenges. These findings provide valuable insights for researchers, policymakers, and practitioners striving to enhance labour management practices and drive innovation in maritime ports worldwide.

The study identified trends, gaps, and future directions in this field. Also, it provides insights into the factors that influence labour force assignment, the main challenges associated with labour force optimisation, and methods for evaluating labour force performance and productivity in maritime ports. Results concluded that factors influencing LFM include globalisation, technological advancements, the size and complexity of the port, and regional factors such as language barriers, cultural differences, and immigration policies. On the other hand, the challenges are related to the need for more standardisation in job classifications, outdated technology, and inadequate training and development programs for workers. Previous research has addressed these challenges by implementing new technologies and standardising job classifications and performance metrics. However, LFM can also generate socio-economic challenges, such as job displacement, particularly in regions where port-related jobs are a significant source of employment. Therefore, policies and programs that address these issues, such as retraining and job placement programs for displaced workers, are essential. Finally, advances in technology and automation have significantly impacted the demand for labour in maritime ports, leading to the implementation of automated systems and reducing the need for manual labour. However, these advances also have socio-economic implications. Therefore, careful consideration of the social and economic impact of LFM is necessary.

This paper is fundamentally rooted in exploring the impact of the human labour force in maritime ports, focusing on understanding the complexities and challenges maritime ports face. By delving into the dynamics of workforce management, the study aims to uncover insights that can enhance operational efficiency, address labour shortages, and mitigate disruptions within these crucial nodes of the global supply chain. However, despite the comprehensive approach of considering both seaports and maritime terminals, this study has limitations. One limitation lies in the potential variability in labour force management practices and challenges between different types of maritime ports. Seaports and maritime terminals may have distinct operational characteristics, cargo handling requirements, and workforce dynamics, which could influence the effectiveness of labour force management strategies. Additionally, the study may need help generalising findings across diverse maritime ports worldwide, as regional factors, regulatory

frameworks, and infrastructure differences can significantly impact labour force dynamics. Moreover, while the study acknowledges the interconnectedness of seaports and maritime terminals, further research may be needed to delve deeper into specific challenges unique to each type of port facility. By addressing these limitations, future studies can provide more nuanced insights into labour force management within maritime ports, enabling more tailored and practical solutions to enhance port operations and productivity.

Funding

Not applicable.

CRediT authorship contribution statement

Adriana Moros-Daza: Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Maria Jubiz-Diaz:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Formal analysis, Conceptualization.

Declaration of competing interest

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

Data availability

Not applicable.

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