PERFORMANCE EVALUATION IN THE PORT SECTOR: A SYSTEMATIC LITERATURE REVIEW

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Abstract

This study aims to map characteristics of port performance evaluation articles that addressed port efficiency, to verify the types and functions of the metrics presented in the studies and presents evolution of performance evaluation in the port sector. Thus, a Bibliographic Portfolio was selected consisting of 149 scientific articles on the topic investigated. Data collection and analysis were carried out using the intervention instrument ProKnow-C. The results indicate that the majority of the portfolio presents port performance benchmarking (112 articles) and only 37 articles evaluate the performance of ports individually. It can be noted, although the control and communication functions of metrics are widely used in evaluation port performance, the improvement function is minimally explored. Likewise, it is noted that metrics that focus on predicting results are not widely used. However, despite the strong tendency to measure and compare port performance, it is possible to visualize that several studies in the area have presented concerns with management with regard to support for taking decision-making process, the importance of feedback from performance evaluation systems aimed at continuous improvement in the port sector, identifying bottlenecks and proposing improvements, forecasting productivity and costs, strategic management and evaluating performance from the perspective of stakeholders. The contribution of this study is made in a theoretical and practical way through the presentation of a thorough review of the discipline under study and addressing how to position the use of metrics to evaluate the ports performance, demonstrating their functions and types, and pointing out opportunities for future research.

1 INTRODUCTION

Maritime transport remains the backbone of international trade and the global economy, as over 80% of the volume of international merchandise trade is carried by sea and handled by ports, with an anticipated increase of 3% between 2024-2028 (UNCTAD, 2023). Considering that a country's growth is linked to its volume of imports and exports, maritime logistics becomes a critical issue that can impact, directly or indirectly, on the economy and the Gross Domestic Product of any country (Gok-kisa et al. 2021).

Considered a dynamic and complex system, the port sector continues to face multiple challenges, including increased trade policies, geopolitical tensions, and changes in globalization patterns (Gayathri et al., 2021; UNCTAD, 2023).

Although the literature on efficiency in the port industry is relatively new, with its first studies dating back

to the 1990s, in recent years there has been a significant advancement in research assessing efficiency and productivity in the port environment. Even though they are often treated as synonyms, particularly when the aim of the study is to compare the performance of ports, port efficiency and productivity are not equivalent terms. The idea behind using both concepts analogously is that efficiency reflects the productivity of ports, since it is related to the fact that inputs are being used intelligently for the production of a product, taking into account input price, time and production costs, and maximising profits and minimising time. Therefore, port performance improves as the port becomes more efficient and productive (Gonzalez & Trujillo, 2009).

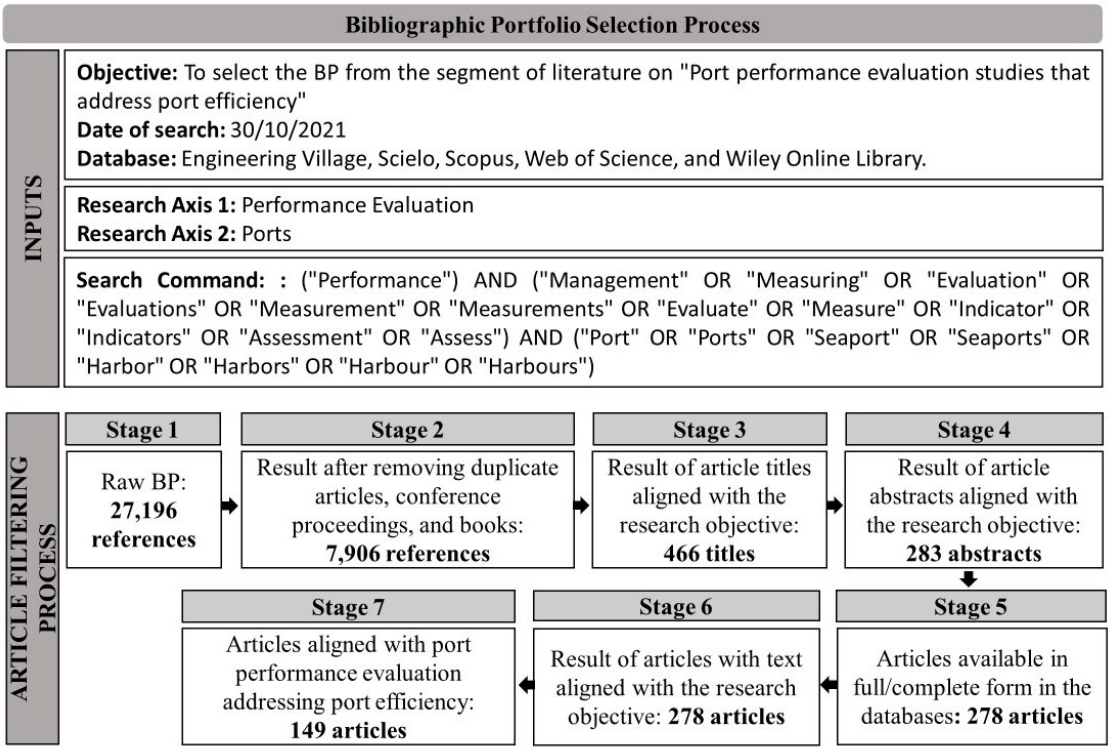
Considering the relevance of port services to the global economy and the fact that port efficiency affects international trade and is therefore under vast practical and academic evaluation (Mustafa; Khan; Mustafa, 2021), it becomes interesting to delve deeper and reflect upon the segment of literature that addresses the performance evaluation (PE) of ports in terms of port efficiency. In this sense, the aim of this study is to map and analyse the characteristics of PE in port studies that address port efficiency, to ascertain which types and functions of metrics the studies are using and to demonstrate the evolution of PE in the port sector.

2 METHODOLOGY

To achieve the study's objective, a systematic review of the scientific literature was conducted using the ProKnow-C (Dutra et al., 2015; Ensslin et al., 2022) to guide the selection and critical analysis of the Bibliographic Portfolio (BP).

The data were collected in October 2021, from databases: Engineering Village, Scielo; Scopus; Web of Science; and Wiley Online Library. The operationalisation of ProKnow-C facilitated the selection of 278 scientific articles on Port Performance Evaluation. However, due to the literature's emphasis on the importance of port efficiency, both in operational and financial terms, for the productivity of port terminals and consequently for the overall performance of ports (Gonzalez; Trujillo, 2009; Wang et al., 2021), the articles addressing port efficiency were analysed, totalling 149 scientific articles available for free from the databases and in portuguese, spanish, and english. The article selection process is presented in Figure 1.

Figura 1 Processo de seleção do Portfólio Bibliográfico-**Fig. 1** Bibliographic Portfolio Selection Process



The articles from BP are identified in the References section, by the numbering from 1 to 149, enclosed in

brackets "[]", at the end of each article's reference. This coding was adopted throughout the entire results development.

It should be noted that the BP is divided into two types of studies: those that conduct the PE individually (37 articles), presenting an internal view of the port; and those that perform benchmarking of various ports (112 articles), which compare their performance with an external perspective, using data and reports from port authorities. As a result, the illustrations in the results sections display two areas: benchmarking and individual performance evaluation, allowing for a better visualisation of similarities and differences between these two groups of studies.

For the analysis of the BP, two variables were selected (Basic functions of metrics; and Typologies of metrics), as presented in the study by Melnyk, Stewart and Swink (2004). In their study, the authors seek to better understand the functions of metrics that allow performance measurement, as well as the typologies of these metrics.

The metrics are qualitative and/or quantitative scales, based on the established unit of measure, that function as tools to aid in the decision-making process. In this sense, they serve three basic functions: Control (enables the measurement and monitoring of performance); Communication (highlights the possible performances and what is expected, both for company employees and external parties); and Improvement (highlights the gap between current and expected performance, allowing for recommendations for improvement) (Melnyk, Stewart; Swink, 2004).

In regard to typologies, metrics can be classified in two aspects: focus and time. The focus of the metric is related to the type of resource that will be measured and can be classified as financial, indicating monetary resources; or operational, defining other resources such as time, people, physical units, among others. On the other hand, the time aspect of the metric refers to how the metrics will be used, focusing on the performance of the outcome or being used predictively, to foresee future performance and even prevent the occurrence of problems (Melnyk, Stewart; Swink, 2004).

The evolution of PE in the port sector was presented based on the evolution of the PE area proposed by Bititci et al. (2012), which is divided into four stages: Productivity management; Budgetary control; Integrated performance measurement; and Integrated performance management. To interpret which of these stages each of the PB studies fits into, the variables proposed by Melnyk, Stewart, and Swink (2004) were used, presented in this study as criteria (Table 1).

Stage of evolution of the PE area (BITITCI et al., 2012)	Criteria (Melnyk, Stewart, Swink, 2004)
Productivity management	Functions of metric: control and communication; Focus of metric: operational; Time of metric: outcome.
Budgetary control	Functions of metric: control and communication; Focus of metric: financial; Time of metric: outcome.
Integrated performance measurement	Functions of metric: control and communication; Focus of metric: operational and financial; Time of metric: outcome.
Integrated performance management	Functions of metric: control, communication, and improvement; Focus of metric: operational and/or financial; Time of metric: outcome and predictive or just predictive. Note: To fall into this category, the article must have metrics with an improvement function and/or predictive time, not necessarily both.

Table 1 Criteria for the evolution of port performance evaluation.

Studies addressing productivity management focus on the outcome of operational efficiency, using metrics enabling the measurement and control of the performance analysed, promoting communication. Articles practising budgetary control measure the outcome of financial efficiency using clear metrics that also allow measurement and control of the measured performance. Meanwhile, studies engaging in integrated performance measurement use multidimensional metrics, reflecting the outcome of both operational and financial efficiency, comprehensible to internal as well as external stakeholders. Lastly, studies that address integrated performance

management also use clear and multidimensional metrics that reflect operational and financial efficiency, being able to measure the outcome of efficiency and also act predictively, in addition to enabling recommendations for improvement.

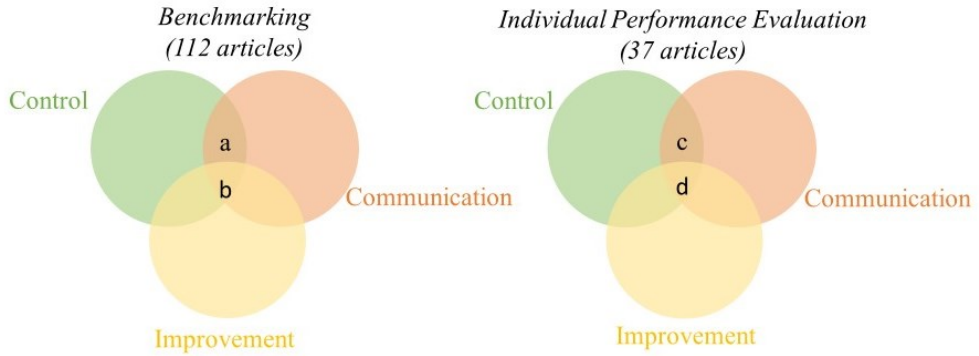
3 RESULTS

The results of this study are divided into three subsections. The first involves the analysis of the BP according to the basic functions of the metrics; the second discusses the types of metrics presented in the BP; and the third demonstrates how the evolution of port performance evaluation occurs based on what was presented in the studies that comprised the BP.

3.1 Variable 1 - Basic functions of metrics

In all the studies from the BP, port performance evaluation was carried out through the measurement of efficiency, using metrics that represented what the authors wished to measure and illustrating the control mentioned by Melnyk, Stewart and Swink (2004). Furthermore, the articles effectively communicated the metrics used, providing tables or a section of the article designated to explain what each of them represented and how they were measured, enabling their understanding and consequently the PE (Figure 2).

Fig. 2 Basic functions of metrics identified in the BP



Legend: article numbering
a:3,4,6,9,11,12,13,15,16,17,18,19,23,24,26,28,29,31,34,35,36,38,39,40,41,42,43,44,45,46,47,49,50,51,52,54,55,59,60,61,62,63,67,68,69,70,71,74,80,81,82,83,84,85,86,88,91,93,94,95,96,98,100,101,102,103,105,108,109,110,111,112,115,116,119,121,123,124,125,129,130,131,136,137,138,139,140,146 and 149.
b: 5,7,10,21,25,27,33,48,57,58,78,90,104,113,126,127,133,141,143,144,145,147 and 148.
c: 1,2,8,14,20,22,53,64,65,66,73,75,76,77,87,89,92,97,99,106,114,117,120,128,132 and 142.
d: 30,32,37,56,72,79,107,118,122,134 and 135.

However, when it comes to proposing improvements, the scenario changes, especially when it comes to articles that perform benchmarking, which, most of the time, aim only to measure performance, without making improvement recommendations when comparing the performance of ports. This scenario also occurs in studies focusing on the individual PE of the port, albeit to a lesser extent, as these studies are typically conducted through case studies, allowing for in-depth and tailored PE of the port, providing a deeper understanding of the environment being analysed and enabling the development of improvement recommendations for the evaluated performance.

Benchmarking is the process of identifying the standard of reference for products and services and pointing out the necessary steps to achieve these standards [101]. One of the conditions for benchmarking the efficiency of organizations is that they are homogeneous. In the case of ports, they provide the same services, use similar technologies, and operate under the same market conditions and business environment [100]. However, if the ports being compared operate in different regions, they may be subject to different technologies. Thus, this

comparison, in addition to becoming problematic, complicates the recommendation of improvements.

To exemplify some improvements proposed in the benchmarking studies within the BP, we mention the reduction of handling fees to increase efficiency[147]; enhancement of technological innovation in port operations[143]; efficient management of facilities concerning vessel entry and exit[141]; as well as the comparison between the performance of ports considered as benchmarks and those that are smaller and less busy, in order to provide insights for progress in performance[145].

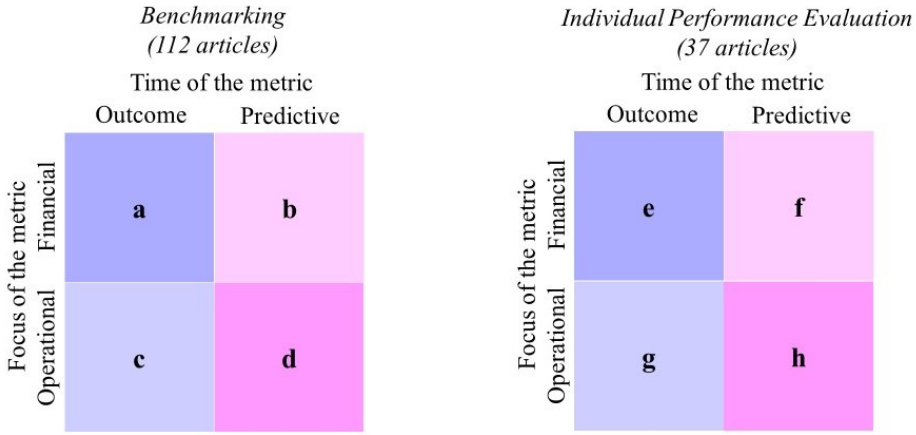
Regarding the studies that conducted individual port performance evaluation, it is noteworthy the development of a customised performance evaluation model which aided the manager of a fertilizer industry branch, located in a maritime port terminal, in identifying and promoting actions to improve the performance management process[107]; and even the use of simulation allowing the identification that for the studied bulk export terminal, measures such as reducing storage time and time between ship arrivals and increasing the load of each ship would help improve the production performance of the terminal[135].

It is clear that, despite the widespread use of control and communication functions of metrics, the improvement function is still used in a very limited way in the PE of ports. This is due to the fact that, in order to be able to recommend actions that will enhance the performance of a port, a profound knowledge of the specifics of the context being analysed is necessary, which is not often seen in benchmarking studies, where a set of ports operating in different geographical regions is evaluated under the same set of metrics.

3.2 Variable 2 – Typology of metrics

It is noticeable that operational metrics are widely used in both benchmarking studies of ports and in studies that conduct individual PE (Figure 3).

Figura 3 Tipologia das métricas utilizadas no PB-**Fig. 3** Typology of metrics identified in the BP



Legend: article numbering
a:3,4,5,6,8,11,12,13,15,17,19,24,25,28,31,39,48,57,58,59,60,61,62,70,71,74,78,80,83,88,90,91,95,96,98,100,101,102,104,109,110,111,113,121,123,124,125,127,130,137,138,139,143,144,146,147 and 149.
b: 7,8,105,143,146 and 147.
c:3,4,5,6,8,10,11,12,13,15,16,17,18,19,21,23,24,25,26,27,28,29,31,33,34,35,36,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,54,55,57,58,59,60,61,62,63,67,68,69,70,71,74,78,80,81,82,83,84,85,86,90,91,93,94,95,96,98,100,101,102,103,104,108,110,111,112,113,114,115,119,121,123,124,125,126,127,129,130,131, 133,136,137,138,139,140,141,143,144,145,146,147 and 148.
d: 7,8,33,44,45,84,105,126,143,146,147 and 148.
e: 2,14,20,30,37,64,87,88,89,97,99,107,117,118,120 and 132.
f: 8,37,64,75,87,89,97,135 and 142.
g:1,2,14,20,22,30,32,37,53,56,64,65,66,72,73,76,77,79,87,89,92,97,99,107,114,117,118,120,122,128,132 and 134.
h: 1,32,37,53,56,64,65,66,73,75,77,87,89,97,106,135 and 142.

Operational metrics are used when the purpose of the study is to measure the operational/technical efficiency of the port. These are usually metrics that impact productivity, such as quay length, number of gantry cranes, container capacity[141], cargo handled, port area[140], and delay time for loading and unloading[136]. Financial metrics, on the other hand, are associated with the profitability and costs of the port, such as operating expenses, revenue, net profit[149], total assets, cost of goods sold, and liabilities[109].

When it comes to the time of the metric, the outcome of performance is much more studied in articles conducting benchmarking of ports than in predicting their performance (Figure 3). This is due to the fact that these studies aim to compare the performance of a set of ports and highlight their strengths and weaknesses. Hardly do these studies aim to predict the future performance of these ports in order to prevent a compromised performance. However, this was the case in article[126], where the authors predicted the performance of Vietnamese ports to assist port administrators and investors in forming strategic policies and adjusting their investment portfolios.

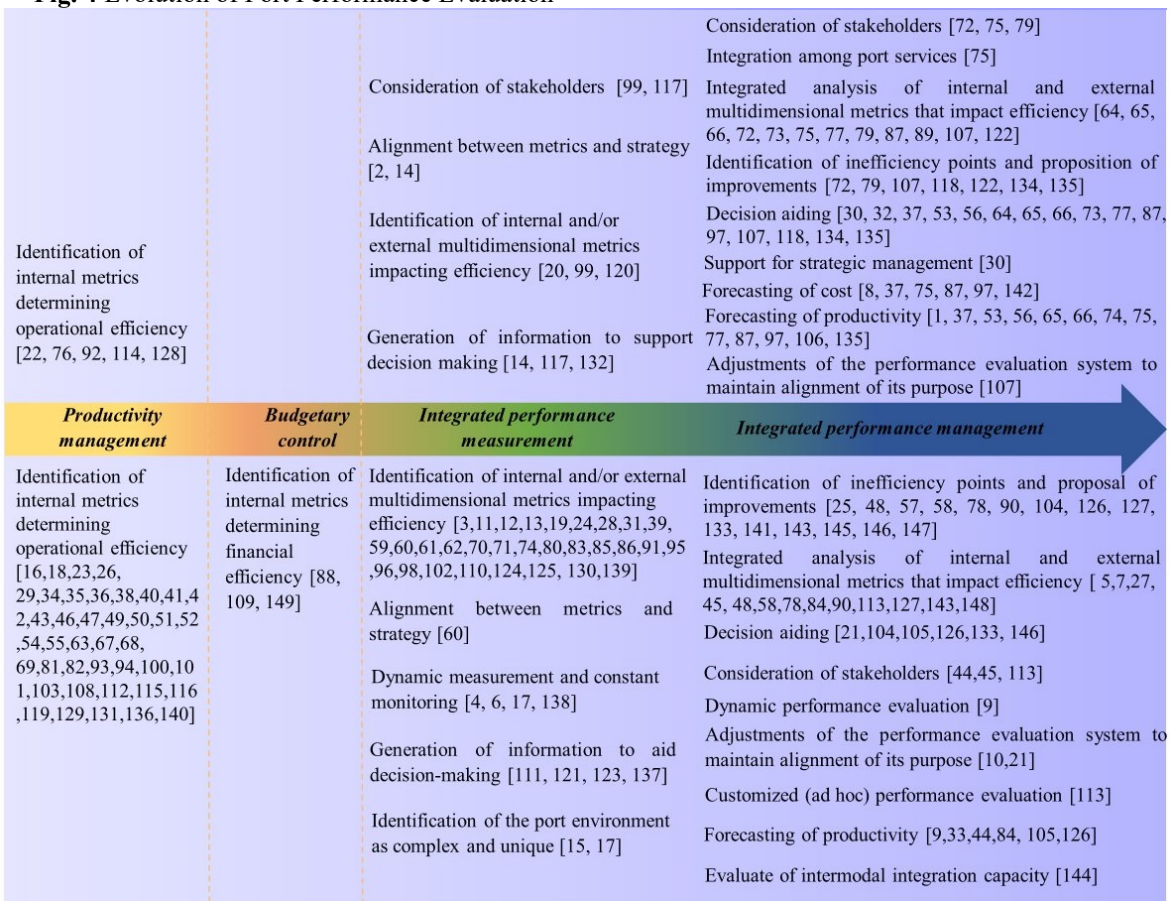
This reality changes when individual PE is undertaken in ports, where the use of metrics predictively in order to forecast the performance of the analysed ports is much more widespread. This prediction of results has been achieved through simulation[1,8,32,53,64,65,73,87,89,106,135,142], employing approaches such as queuing theory[56] and optimization models[75].

Thus, it is evident that studying their specificities is important for forecasting the performance of ports, as well as for proposing improvements. For this reason, predictive studies appear to be more appropriate and widespread when it comes to individual PE of a port than when benchmarking a group of ports, as predicting the performance of a specific port can be challenging, even more so when dealing with a set of ports.

3.3 Evolution of Port Performance Evaluation

The literature on organizational performance evaluation usually covers all levels of the organization: operational, managerial, and strategic. However, when it comes to the port sector, most of the literature focuses on the operational and financial level. Thus, it is noticeable that the port reform, carried out in 1990, led researchers to seek performance metrics focused on port efficiency[117] (Figure 4).

Fig. 4 Evolution of Port Performance Evaluation



In the individual PE of ports focusing on productivity management, there is the identification of internal and operational metrics reflecting operational efficiency and impacting port productivity[22,76,92,114,128], seeking to assess port operations[114], verifying how stowage plans influence quay performance[22], and enabling the identification of determinants of ship berthing safety at the quay[92].

In port benchmarking, productivity management is more explored. Studies that practice this comparison of port performance focus on the identification of internal metrics that configure operational efficiency associated with productivity (Figure 4). In the case of container terminals, performance is analysed with containerised loads as references[136], to understand how the operational capacity of a container terminal can be measured [129], and even to compare the time for ship entries and exits at ports[119].This comparison takes place among privatized ports [140] in developing countries[100,136], countries with different markets[67], and emerging nations[42,46,54]. For this purpose, the Data Envelopment Analysis (DEA) tool is most commonly used [94,101,103,109,115,124,126,127,129,130,136,145], but other tools are also used, even in a hybrid manner [18,52,59,95,112,147,148].

Contrary to productivity management, which is well disseminated in port PE literature, budgetary control appears somewhat modestly in research. However, some benchmarking studies identify internal financial metrics as profit, sales[88], total assets, cost of goods sold, liabilities, net income[109], equity, and operating expenses, to assess the financial efficiency of the port sector.

In integrated performance measurement, when it comes to the individual performance of ports, researchers

identify operational and financial metrics that impact efficiency[20,99,120]. As performance is measured, feedback from the generated information is necessary, as this process contributes to the development of a quality port management system capable of responding to market pressures[14], contributing to the strategic planning of the port[2], supporting port management decision-making regarding the need for changes in the port terminal[132], and also the decision to outsource services[14]. In addition to operational and economic dimensions, the importance of other dimensions related to politics, society, and business ethics is emphasized, including environmental aspects[117]. Confirming this, the relevance of external metrics, such as market information, competitors, customers[14], and stakeholders[99,117], is evident to make the right decision.

This context of integrated performance measurement occurs similarly in studies presenting port benchmarking, with the identification of internal operational and financial metrics within ports that impact efficiency (Figure 4). Considering the complexity of the port environment[15,17], as well as the differences between public and private administration in ports[12], it is noted that performance measurement is not static[4], and its result is one of the factors impacting port policies[12,13]. Therefore, constant measurement and monitoring of performance are recommended[4,6,17,138] to support the decision-making process [111,121,123,137], leading to improvement [6]. Additionally, this process allows for highlighting the metrics that are directly influenced by the context, enabling alignment between them and port strategy[60].

Integrated performance management is a more complex process, as it goes beyond measurement, since the information generated by efficiency metrics is used to manage the performance of ports, allowing for both performance prediction and the recommendation and implementation of improvements. In the individual performance of ports, there is the identification and integrated analysis of internal operational and financial metrics as well as external ones impacting efficiency[64,65,66,72,73,75,77,79,87,89,107,122], emphasizing the importance of stakeholder perspectives, such as users of port services[72,79] and service providers in the sector to facilitate the integration of the service chain in ports[75].

The result of this process of integrated identification and analysis is useful in supporting the decision-making process of port managers[30,32,37,53,56,64,65, 66,73,77,87,97,107,118,134,135] in optimizing scheduling and operations planning[134] and in port strategic management [30], as well as enabling the identification of inefficient activities for recommendations for improvement[72,79,107,118,122,134,135].

Individual port performance addressing management activities has been practiced through simulation[1,8,32,53,64,65,73,87,89,106,135,142] to identify productivity forecasts[1,37,53,56,65,66,73,75, 77,87,97,106,135] and of the costs [8,37,75,87,97,142]. However, the study [107] stood out for using a constructivist method of individual performance analysis that assisted in the management of the studied port, highlighting the importance of adjusting/revising the performance evaluation system to maintain its alignment with the purpose of port management.

Finally, integrated performance management is also present in benchmarking studies, indicating that individual analyses are not sufficient. Therefore, an integrated analysis of port services, the economic situation in which the port region is located, market trends [7], and the identification and evaluation of existing obstacles in the ports [7,25,48,57,58,78,90,104,126,127,133,141,143, 145,146,147] should be conducted. In this regard, it is important to identify and analyze internal and external multidimensional metrics [5,7,27,45,48,78,84,90,113,127,143,148], such as crane productivity and quay size, which impact the efficiency of port terminals and, consequently, port performance [5], highlighting the role of stakeholders, such as service users [44,45,113], to have a comprehensive view of the studied port context.

With the holistic view[113] provided by managing specific metrics within the analyzed context[21,113], dynamically generated information guarantees gains sustainability in the face of competition, fostering competitive advantage[10,21], allowing for agile responses to market pressures[21], supporting decisions regarding continuous efficiency improvement[21,104,105,126,133,146], predicting port productivity [9,33,44,84,105,126], and evaluating competitiveness in terms of ports' intermodal integration capacity[144].

Consequently, it is concluded that port performance analysis is being used not only for productivity and financial control but also as an interactive process allowing for measuring port performance, integrating multidimensional metrics, and acting in its management, enabling continuous improvement and consequently competitive advantage. Furthermore, in individual performance and benchmarking analyses, the importance of factors influencing port efficiency is noted, particularly in the operational aspect directly impacting productivity. It is also observed that there is a pursuit of continuous improvement in port efficiency, reflecting the overall sustainability of port performance.

4 CONCLUSION

The present study mapped the types and functions of metrics presented in 149 scientific articles on port performance evaluation addressing port efficiency and highlighted the evolution of the topic.

The results indicate that most of the literature conducts port performance analysis through benchmarking, with 112 articles featuring the comparison of a set of ports' performance. However, only 37 articles conduct individualized port performance analysis, allowing for a deeper understanding of the uniqueness of the context under study.

Regarding the functions of the metrics, it is noticeable that while control and communication functions of metrics are widely used in port performance evaluation, the function of improvement is still underexplored. Similarly, with respect to the typology of metrics, it is observed that metrics focusing on result prediction are not extensively used. This occurs because most studies aim to merely measure port performance and compare them through operationalizing benchmarking, rather than studying the specificities of each port analyzed, conducting personalized performance analysis considering the specific context.

However, despite this strong trend of measuring and comparing port performance, it is possible to see, through the presentation of the evolution of port performance evaluation, that various studies in the field have been expressing concerns about management regarding decision support, the importance of feedback from performance evaluation systems for continuous improvement in the port sector, identification of obstacles and proposing improvements, predicting productivity and costs, strategic management, and performance analysis from the stakeholders' perspective.

The contribution of this study is theoretical through the presentation of an extensive literature review on the studied topic, showcasing the evolution of performance analysis in the port sector, considering port efficiency, and providing a solid foundation for subsequent research. Additionally, this study makes a practical contribution by addressing the most appropriate use of metrics for port performance analysis, demonstrating their functions and types.

When it comes to research gaps, it was noted that studies focus on the analysis of historical data, seeking to measure and compare port performance; they rely on static methodologies that are inflexible to port changes; they use generic metrics that may not consider the specific characteristics of each port analyzed; and they do not encourage the participation of managers/stakeholders in the process of port efficiency performance analysis.

As such, opportunities for research are cited, such as studies that: focus on future scenario performance; develop action recommendations that will lead to performance improvement; contribute to port management in a way that enhances port efficiency beyond performance measurement; consider the particularities of the analyzed port context, using ad hoc metrics; use dynamic and flexible performance analysis methodologies to keep up with the constant changes in the port sector; and encourage the participation of managers/stakeholders in the construction of the port performance evaluation system.

An approach capable of conducting research that includes the full diversity of these aspects, in order to drive port efficiency and consequently port productivity, is the Constructivist Multicriteria Decision Aid (MCDA-C), which allows for knowledge generation for the actors involved in the performance evaluation process, is able to structure and evaluate aspects considered important for the manager/decision-maker, and assists the decision-making process in complex, conflicting, and uncertain contexts, such as the port sector (RAMBO et al., 2023).

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