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Seaport Performance Indicators and their Macroeconomic Spillovers: An SLR

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Abstract

Seaports function as critical nodes within global supply chains, yet the empirical literature linking port performance to macroeconomic spillovers remains conceptually fragmented. This study presents a systematic literature review (SLR) examining how port performance indicators have been empirically associated with macro-level outcomes, including trade, GDP growth, employment, welfare and spatial spillovers. Using a structured protocol across four major academic databases, 199 records were screened, resulting in 38 eligible empirical studies for detailed analysis. An inductive coding framework was developed to classify port performance indicators (operational efficiency, cost efficiency, infrastructure capacity, connectivity, governance, and port-industrial/sustainability models), macroeconomic spillover categories, and methodological families. The findings reveal a strongly trade-centric macroeconomic framing, with trade and export outcomes dominating the literature. Operational/time efficiency and infrastructure capacity emerge as the most frequently examined performance dimensions. In contrast, employment, welfare, governance, sustainability and distributional effects appear less systematically incorporated. Methodologically, gravity-based trade econometrics models dominate, while input–output and general equilibrium approaches remain comparatively limited. The review also highlights a bidirectional research divide, where macroeconomic variables are often modeled both as drivers and outcomes of port performance. Overall, the study maps dominant linkages, identifies underexplored domains, and provides a structured foundation for future port–economy research.

Keywords

Port Performance, Macroeconomic Spillovers, Trade Facilitation, Systematic Literature Review, Applied Thematic Analysis.

1. Introduction

Seaports play a central role in the functioning of modern economies. As critical nodes in global supply chains, they facilitate the movement of goods between regions, connect domestic industries to international markets, and enable participation in global trade networks. In contemporary logistics systems, ports no longer function merely as modal transfer points but constitute key nodes in door-to-door supply chains, where inefficiencies can undermine broader gains in shipping economies of scale and global production networks (Haralambides, 2017). As such, port performance has direct implications for national competitiveness and integration into international markets.

Efficient ports reduce transport costs, improve reliability, and enhance connectivity, thereby strengthening export competitiveness and supporting economic growth. Empirical research has demonstrated that port infrastructure quality and logistics performance contribute to economic development through their mediating effect on trade flows (Munim & Schramm, 2018). Similarly, port infrastructure endowment has been identified as a significant determinant of freight rates, with inefficiencies at the port level functioning as implicit trade barriers (Wilmsmeier & Hoffmann, 2008).

Beyond trade facilitation, ports can generate broader macroeconomic effects at local, regional, and national scales. Ports have been conceptualized as economic catalysts that generate wealth through backward and forward linkages with their hinterlands (Danielis & Gregori, 2013). Through agglomeration effects, proximity to seaports can stimulate industrial clustering, encourage information exchange, and expand labour market opportunities (Ayesu & Boateng, 2024). At the same time, contemporary debates highlight the evolving nature of port-related value creation, where efficiency gains and automation may reshape the spatial distribution of value added across regions (Haezendonck & Moeremans, 2020). In addition to growth and employment effects, port performance can influence spatial development patterns, price structures, and environmental externalities.

Despite the extensive body of research examining ports and economic performance, the literature remains conceptually fragmented. Studies employ a wide range of port performance indicators, ranging from throughput and infrastructure capacity to governance reforms, connectivity measures, and value-added metrics, and link them to diverse macro-level outcomes such as trade expansion, GDP growth, welfare, and regional spillovers. Moreover, methodological approaches vary substantially, spanning gravity models, input–output analysis, efficiency frontiers, optimization models, and qualitative case studies. As a result, there is limited clarity regarding which port performance dimensions are most frequently linked to specific macroeconomic spillovers, and which analytical tools dominate this research domain.

1.1 Problem statement and/or aim

This study systematically reviews the literature to classify and frequency-map which port performance indicators have been most commonly linked to specific macroeconomic spillovers, and to synthesize the empirical tools and methodological approaches used to examine these associations. Rather than estimating causal magnitudes, the review focuses on identifying patterns of thematic concentration and co-occurrence across studies.

The review is guided by the following research questions:

1. Which port performance indicators are most frequently examined in relation to macroeconomic outcomes, and how are they distributed across spillover categories?
2. Which types of macroeconomic spillovers are most commonly associated with different port performance indicators, and how do these associations cluster?
3. Which empirical methods and analytical tools are most frequently used to model or describe these performance–spillover relationships?

2. Methodology

To achieve the stated aim, a systematic literature review (SLR) was conducted to identify and classify relevant studies. Given the conceptual diversity of port performance indicators, macroeconomic spillover outcomes, and analytical approaches within the literature, the review adopted a scoping orientation. Rather than synthesising effect magnitudes or evaluating causal robustness, the objective was to systematically map, categorise, and quantify the linkages examined across studies. To facilitate this, an applied thematic analysis approach was employed to inductively identify recurring performance dimensions, spillover categories, and methodological families. This enabled the structured development of a classification framework and the identification of dominant indicator–spillover relationships and methodological patterns within the field.

The review followed the systematic literature review framework proposed by Albliwi et al. (2014), which provides a transparent and replicable structure for conducting and reporting SLRs. The methodology consists of a sequence of defined steps, outlined below:

- **Step 1: Develop a research purpose and/or objective** - Clearly define the central research aim and specify the focus of the review
- **Step 2: Develop research protocol** - Establish the review framework, including inclusion and exclusion criteria, search parameters, and screening procedures
- **Step 3: Establish relevance criteria** - Determine the conceptual boundaries of the study to ensure alignment with the research objective
- **Step 4: Search and retrieve the literature** - Conduct systematic searches across selected academic databases using predefined search strings
- **Step 5: Selection of studies** - Apply screening procedures to identify studies that meet the eligibility criteria

- **Step 6: Quality assessment for relevant studies** - Evaluate the methodological rigor and empirical relevance of the included studies
- **Step 7: Data extraction** - Systematically extract key variables, outcomes, and methodological information from each study
- **Step 8: Analysis and synthesis of findings** - Categorise and compare findings to identify dominant linkages, patterns, and gaps
- **Step 9: Report** - Present the findings in a structured and transparent manner
- **Step 10: Dissemination** - Share the outcomes of the review with the broader academic and practitioner community

2.1 Step 1 – Develop research purpose

The purpose of this systematic literature review is to examine how port performance indicators have been linked to macroeconomic spillovers in the existing empirical literature. Specifically, the review seeks to identify the types of port performance measures used, the macro-level outcomes to which they are connected, and the analytical tools applied to link these relationships.

2.2 Step 2 – Develop research protocol

The research protocol adopted for this review is summarized in Table 1. Four major academic databases were selected to capture multidisciplinary research at the intersection of ports, economics, and operations: **Scopus, Web of Science, IEEE Xplore** and **Springer Nature**. Searches were conducted within the Title, Abstract, and Keywords fields for Scopus, Web of Science, and IEEE Xplore. For Springer Nature, field-restricted searching was not available, and therefore, the search was conducted across the full text.

Table 1. Research Protocol

Databases	Scopus, Web of Science, IEEE Xplore, Springer Nature
Search Fields	Title, Abstract, and Keywords (Scopus, Web of Science, IEEE Xplore); Full-text search (Springer Nature)
Search String	(“container port*” OR “container terminal*” OR “bulk port*” OR “bulk terminal*” OR “seaport*”) AND (“port performance” OR “terminal performance” OR “port efficiency” OR “operational performance”) AND (macroeconomic* OR socioeconomic* OR “economic impact” OR “economic development” OR “regional development” OR “regional economy” OR “regional impact” OR “national development” OR “national economy” OR “national impact” OR spillover*)
Document Type	Peer-reviewed journal articles and conference papers
Inclusion Criterion	Study must explicitly analyse a relationship between a port performance indicator and a macroeconomic spillover outcome
Exclusion Criterion	Studies modelling macroeconomic variables as determinants of port performance (reverse causality); purely technical port engineering studies without macro-level outcomes; non-English publications
Quality Assurance	Minimum methodological sufficiency screening applied; inclusion required explicit operationalisation of port performance indicators, specification of macroeconomic spillovers, and identifiable analytical methods.

2.3 Step 3 – Establish relevance criteria

Relevance criteria were established to ensure alignment with the objective of examining the relationship between port performance indicators and macroeconomic spillovers. A study was considered eligible if it explicitly identified at least one measurable port performance indicator and linked it to a macro-level economic outcome at the regional,

national, or inter-regional scale. Only studies modelling port performance as an explanatory factor influencing macroeconomic outcomes were included, while studies primarily examining how macroeconomic conditions affect port performance were excluded to avoid reverse-causality bias. Furthermore, studies were required to provide empirical evidence or structured analytical reasoning supporting the linkage. Conceptual, descriptive, or purely technical studies that did not extend analysis beyond the port or terminal level were excluded. These criteria were applied during both abstract screening and full-text review stages.

2.4 Step 4 – Search and retrieve the literature

The search strategy described in the research protocol was implemented across the selected databases. The Boolean search string was applied consistently to ensure comparability of results across platforms. Searches were conducted without timeframe restrictions to capture the full evolution of research examining the relationship between port performance and macroeconomic outcomes.

The initial search yielded a total of 214 records across the four databases. Following the consolidation of results and removal of 15 duplicate records, 199 unique studies remained for screening.

All retrieved records were exported and compiled into a structured database to facilitate systematic screening and documentation of the selection process. The subsequent stages of screening and study selection are described in the following section.

2.5 Step 5 – Selection of studies

Following the retrieval stage, 199 unique records remained for screening. Title and abstract screening was conducted to assess alignment with the relevance criteria. Where ambiguity remained, full-text assessment was undertaken.
A total of 161 studies were excluded during the screening process. The dominant exclusion categories were as follows:

- **Reverse causality studies**, where macroeconomic variables (e.g., GDP, trade flows, institutional quality, economic reforms) were modelled as determinants of port performance rather than outcomes of port performance improvements.
- **Pure efficiency benchmarking studies**, primarily using DEA or SFA methods, which calculated and compared port efficiency scores without linking these metrics to macroeconomic spillovers.
- **Micro-level operational or optimisation studies**, focusing on crane scheduling, berth allocation, automation, waiting time reduction, or other internal terminal efficiency improvements without extending analysis beyond the port boundary.
- **Conceptual, policy-oriented, bibliometric, or editorial studies** that discussed governance, sustainability, or reform frameworks without presenting empirical macro-level impact analysis.

After applying the inclusion and exclusion criteria, a final sample of **38 empirical studies** was retained for detailed analysis.

2.6 Step 6 – Quality assessment for relevant studies

A formal quality scoring or risk-of-bias appraisal was not undertaken. Consistent with the scoping orientation of the review, the objective was not to rank studies according to methodological strength or estimate causal robustness, but rather to systematically map how port performance indicators have been linked to macroeconomic spillovers and to classify the analytical approaches employed.

Instead of formal quality grading, a minimum methodological sufficiency criterion was applied during screening. Included studies were required to: (i) clearly operationalise at least one port performance indicator; (ii) explicitly specify a macroeconomic spillover outcome; and (iii) provide sufficient methodological detail to allow the analytical approach to be identified and categorised. Only peer-reviewed journal articles and conference papers meeting these criteria were retained. Studies lacking these core elements were excluded.

Figure 1 below illustrates the study selection process, detailing the identification, screening, eligibility assessment, and final inclusion stages:

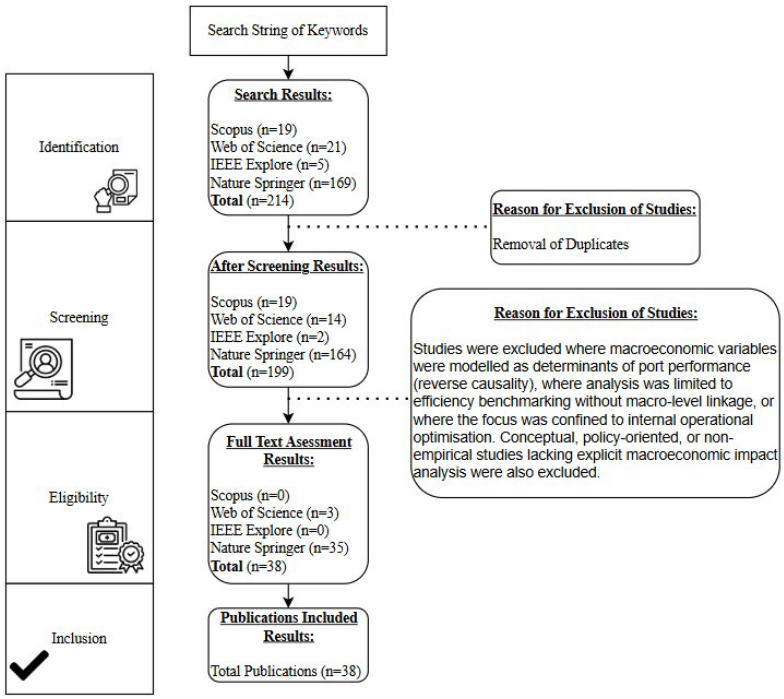

Figure 1. Study Selection Process Chart

3. Results (Findings) and Discussion

This section presents the empirical findings of the systematic literature review through a structured mapping of performance indicators, macroeconomic spillovers, and methodological approaches. The results provide a frequency-based synthesis that reveals dominant linkages, thematic concentrations, and methodological patterns within the reviewed body of literature.

3.1 Step 7 – Data extraction

Following study selection, a structured data extraction process was undertaken to enable systematic comparison across the 38 included studies. Given the conceptual and methodological diversity within the literature, a predefined data template was developed to ensure consistency in capturing key variables, analytical approaches, and contextual characteristics.

The heterogeneity of the reviewed studies necessitated the development of a custom coding framework. No unified taxonomy currently exists that systematically categorises port performance indicators alongside their associated macroeconomic spillovers. Therefore, an inductive thematic coding approach was adopted.

The thematic structure was developed in three stages. First, an initial screening of all included articles was conducted to extract the exact terminology used to describe (i) port-related explanatory variables and (ii) macroeconomic outcomes. Keywords and recurring constructs were recorded in a master extraction sheet. During this phase, high-frequency terms such as “turnaround time”, “dwell time”, “handling cost”, “connectivity”, “infrastructure capacity”, “trade flows”, “GDP growth”, “employment” and “spillover effects” repeatedly appeared across studies. Second, these recurring terms were clustered conceptually. Rather than coding each variable individually (which would have resulted in excessive fragmentation), semantically related variables were grouped into higher-order themes. For example, dwell time, turnaround time, vessel handling time, and labour productivity were grouped under a broader operational efficiency construct. Similarly, bilateral trade flows, export growth, and market access were grouped under a trade-related macroeconomic outcome category. Third, the framework was refined iteratively as extraction progressed. When new indicators emerged that did not fit cleanly within existing categories, thematic boundaries were reassessed and adjusted. This ensured that the coding scheme remained comprehensive while maintaining internal coherence.

Coding dimension 1: Port performance indicators (PP)
Port-related explanatory variables were coded into six standardised categories:

- **PP1 Operational/time efficiency**: indicators of operational speed and process efficiency (e.g., dwell time, turnaround time, handling time, labour/handling productivity).
- **PP2 Cost/tariff efficiency**: indicators reflecting port- and logistics-related costs (e.g., handling tariffs, freight-related costs, logistics costs).
- **PP3 Infrastructure/capacity**: physical and capacity-related indicators (e.g., berth capacity, cranes/equipment, terminal/berth infrastructure, expansion capacity).
- **PP4 Connectivity/network**: measures capturing network position and service connectivity (e.g., shipping connectivity, service frequency, hub status, hinterland/corridor connectivity).
- **PP5 Governance/institutions**: governance arrangements and institutional features shaping performance (e.g., reforms, regulatory structures, ownership/concession structures, institutional quality as it relates to port functioning).
- **PP6 Port-industrial/sustainability**: indicators capturing port–industry integration and/or sustainability-oriented port development (e.g., port-industrial complexes, development areas, sustainability-linked performance framing when treated as part of the port's development model).

Coding dimension 2: Macroeconomic spillovers (MO)
Macroeconomic outcomes were coded into seven categories aligned with what is explicitly measured or claimed in the study:

- **MO1 Trade/exports**: trade volumes, bilateral trade flows, export/import performance, market-access effects operationalised via trade.
- **MO2 GDP/output**: GDP/GRDP, economic output, value-added, growth proxies framed as economy-wide output effects.
- **MO3 Employment/demography**: employment levels, job creation, labour-market impacts, demographic-scale outcomes when explicitly modelled.
- **MO4 Prices/inflation/freight rates**: price-level outcomes, inflation, freight-rate outcomes, and related cost pass-through effects at macro scale.
- **MO5 Welfare/FDI/poverty**: welfare and development outcomes, including investment attraction (FDI), poverty reduction, or broad welfare metrics when explicitly stated.
- **MO6 Spatial spillovers/regional multipliers**: inter-regional effects, multiplier-type outcomes, spatial diffusion, or regional redistribution patterns beyond a single local impact.
- **MO7 Environmental/safety externalities**: quantified externalities such as accident damage, emissions exceedances, or explicitly modelled safety/environmental macro impacts.

Coding dimension 3: Method family (M)
Each study's primary analytical approach was coded into one (or more, if clearly multi-method) of the following method families:

- **M1 Gravity/Trade econometrics**: gravity-type trade models and related econometric approaches used to estimate trade/macroeconomic relationships.
- **M2 Input-output/MRIO**: input–output modelling and multi-regional input–output approaches used to estimate value-added and multiplier spillovers.
- **M3 Efficiency frontier (DEA/SFA)**: DEA/SFA and other frontier approaches used to estimate efficiency/productivity as a key performance construct.
- **M4 Game theory/institutional**: modelling rooted in institutional design and governance incentives (e.g., principal–agent or game-theoretic structures).
- **M5 Optimisation/simulation**: optimisation, simulation, and scenario models used to evaluate planning or performance impacts.
- **M6 Qualitative/case/grounded**: qualitative or case-based empirical designs, including grounded/interpretive approaches where the evidence is not primarily econometric.

3.2 Step 8 – Analysis and synthesis of findings

This section presents the results of the frequency-based mapping and classification analysis. First, the distribution of port performance categories and their linkages to macroeconomic spillovers is examined. Second, the analysis is inverted to assess the relative concentration of macroeconomic spillovers across performance dimensions. Finally, the distribution of methodological families employed across the included studies is summarized.

3.2.1 Mapping Port Performance Dimensions to Macroeconomic Spillovers

Figure 2 below shows the frequency with which each port performance (PP) category is examined across the 38 included studies, together with the number of times each PP category is empirically linked to specific macroeconomic spillovers (MO). The detailed study-level references underpinning these counts are provided in Appendix A.

Port Performance Indicator	Studies (n)	MO Code	Studies (n)	Port Performance Indicator	Studies (n)	MO Code	Studies (n)	Port Performance Indicator	Studies (n)	MO Code	Studies (n)
PP1 (Operational/time efficiency)	17	MO1	11	**PP3** (Infrastructure/capacity)	17	MO1	9	**PP4** (Connectivity/network)	9	MO1	4
		MO2	5			MO2	6			MO2	4
		MO4	3			MO4	5			MO4	3
		MO5	3			MO5	3			MO3	2
		MO6	3			MO6	3			MO5	2
		MO7	3			MO3	2			MO6	2
		MO3	2			MO7	2			MO7	1
PP5 (Governance/institutions)	8	MO1	5	**PP6** (Port-industrial/sustainability)	8	MO2	4	**PP2** (Cost/tariff efficiency)	6	MO1	3
		MO6	3			MO7	4			MO4	2
		MO2	2			MO1	2			MO2	1
		MO4	2			MO6	2			MO5	1
		MO5	2			MO3	1			MO6	1
		MO7	1			MO5	1			MO7	1

MO1: Trade/exports
MO2: GDP/output
MO3: Employment/demography
MO4: Prices/inflation/freight rates
MO5: Welfare/FDI/poverty
MO6: Spatial spillovers/regional multipliers
MO7: Environmental/safety externalities

Figure 2. Frequency of Port Performance Indicator Categories and their associated Macroeconomic Spillovers

Comparatively, the literature is most strongly concentrated around PP1 (Operational/time efficiency) and PP3 (Infrastructure/capacity), each appearing in 17 studies. This suggests that the dominant framing of port performance in macroeconomic literature remains grounded in tangible, measurable operational and physical performance dimensions, such as turnaround times, handling productivity, berth capacity and infrastructure provision. In other words, the empirical tradition appears to prioritise “hard” performance metrics that are directly observable and quantifiable. This reflects a technocratic orientation within the field, where operational efficiency and infrastructure capacity are treated as the primary channels through which ports influence broader economic systems.

In contrast, governance (PP5), port-industrial/sustainability models (PP6), and cost/tariff efficiency (PP2) appear less frequently, indicating that institutional and developmental dimensions of port performance remain comparatively underexplored in macroeconomic linkage studies.

From a spillover perspective, MO1 (Trade/exports) is the most consistently linked macroeconomic outcome, particularly in relation to PP1 (11 linkages) and PP3 (9 linkages). This concentration implies that improvements in operational efficiency and infrastructure are most commonly theorised and tested as mechanisms for enhancing trade performance.

3.2.2 Distribution of Macroeconomic Spillovers Across Port Performance Dimensions

Figure 3 below shows the frequency with which each macroeconomic spillover (MO) category is examined across the 38 included studies, together with the number of times each spillover is linked to specific port performance (PP) indicators. The detailed study-level references supporting these counts are provided in Appendix B.

Macroeconomic Spillover	Studies (n)	PP Code	Studies (n)	Performance Indicator	Studies (n)	PP Code	Studies (n)	Port Performance Indicator	Studies (n)	PP Code	Studies (n)
MO1 (Trade/exports)	20	PP1	11	**MO2** (GDP/output)	12	PP1	5	**MO6** (Spatial spillovers/regional multipliers)	7	PP1	4
		PP4	9			PP3	4			PP3	3
		PP3	6			PP4	4			PP4	3
		PP5	6			PP6	4			PP6	3
		PP2	4			PP5	2			PP5	2
		PP6	2							PP2	1
MO5 (Welfare/FDI/poverty)	6	PP1	3	**MO4** (Prices/inflation/freight rates)	5	PP1	3	**MO3** (Employment/demography)	4	PP1	2
		PP3	2			PP2	2			PP3	1
		PP4	2			PP4	2			PP5	1
		PP5	2			PP3	1				
		PP2	1								
		PP6	1								
MO7 (Environmental/safety externalities)	3	PP1	2								
		PP6	2								
		PP5	1								

PP1: **Operational/time efficiency** **PP4:** **Connectivity/network**
PP2: **Cost/tariff efficiency** **PP5:** **Governance/institutions**
PP3: **Infrastructure/capacity** **PP6:** **Port-industrial/sustainability**

Figure 3. Frequency of Macroeconomic Spillover Categories and their associated Port Performance Indicators

By a considerable margin, MO1 (Trade/exports) is the most frequently examined macroeconomic spillover, appearing in 20 studies. This clearly indicates that the dominant macroeconomic framing within the literature positions ports primarily as trade-enabling infrastructure. In other words, the majority of empirical work has focused on how port performance influences export volumes, bilateral trade flows, or trade competitiveness. GDP/output effects (MO2) follow at a noticeably lower frequency, while spatial spillovers (MO6), welfare/FDI (MO5), prices/freight rates (MO4), employment (MO3), and environmental/safety externalities (MO7) are progressively less represented.

Interestingly, when examining how spillovers link back to port performance indicators, the distribution across PP categories is relatively even. There are no extreme outliers in terms of one single PP dominating all macroeconomic outcomes, although operational/time efficiency (PP1) and connectivity (PP4) appear somewhat more frequently, particularly in relation to trade. This suggests that while trade is the most commonly analysed outcome, the performance channels through which it is studied are comparatively diversified.

It is important to emphasise that these frequency counts do not imply that trade-related spillovers are necessarily the most significant in economic terms. Rather, they indicate where the empirical focus of the literature has been concentrated. The table therefore provides insight into research patterns rather than definitive economic impact magnitudes.

Viewed in this way, the results can be interpreted from two complementary angles. On the one hand, a researcher interested in trade- or GDP-related impacts will find a substantial body of literature and established methodological approaches to draw upon. On the other hand, the comparatively lower frequency of spillovers such as employment (MO3), prices/freight rates (MO4), and environmental/safety externalities (MO7) may indicate potential gaps or opportunities for further investigation. The distribution thus serves as a map of the literature's emphasis and highlights both well-developed areas and domains where empirical exploration remains more limited.

3.2.3 Frequency of Methods Used across Studies

Figure 4 below illustrates the frequency distribution of method families applied across the 38 included studies. The detailed study-level references underlying these counts are provided in Appendix C. It should be noted that some studies employed more than one methodological approach; therefore, the total count across method families exceeds 38.

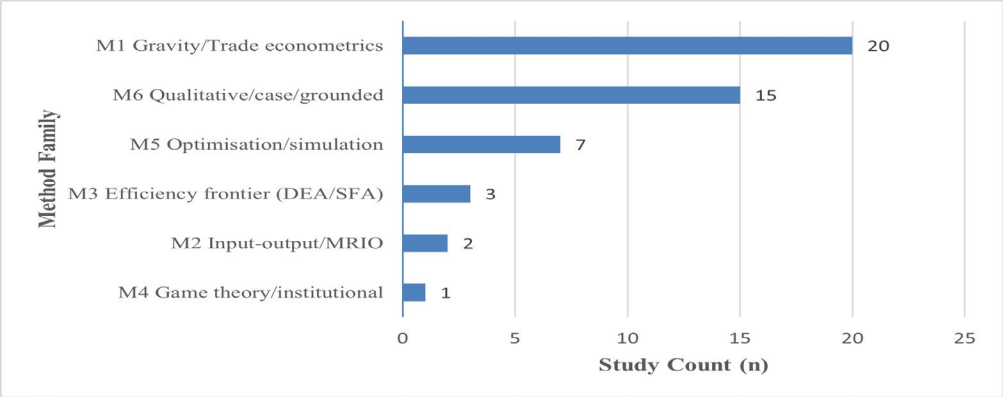

Figure 4. Distribution of Method Families applied across Final Studies

As shown in the figure, M1 (Gravity/Trade econometrics) is by far the most frequently applied method family. This indicates that a substantial portion of the literature relies on econometric modelling to quantify the relationship between port performance indicators and macroeconomic outcomes. The dominance of M1 aligns closely with the earlier finding that trade-related spillovers (MO1) are the most commonly examined macroeconomic outcome. The second most frequently used approach is M6 (Qualitative/case/grounded methods). These approaches tend to provide detailed contextual insights rather than purely statistical estimations and complements the econometric strand of the literature.

Overall, the distribution provides a useful indication of the methodological toolkit most commonly used to analyse how port performance indicators translate into macroeconomic spillovers. For researchers seeking to quantify such relationships, the prevalence of gravity-type econometrics suggests a well-established empirical pathway. Conversely, the presence of qualitative and simulation approaches demonstrates that explanatory and scenario-based analyses also play an important role.

5. Conclusion

This systematic literature review set out to examine how port performance indicators have been empirically linked to macroeconomic spillovers in the academic literature. Through the structured analysis of 38 eligible studies, the review identified dominant performance dimensions, spillover categories, and methodological tendencies shaping this field of inquiry.

The findings reveal that the macroeconomic framing of port performance remains strongly trade-centric. Trade and export-related outcomes constitute the most frequently examined spillover category, while broader development outcomes such as employment, welfare distribution, and environmental externalities appear less consistently across studies. In parallel, the literature exhibits a clear concentration on operational/time efficiency and infrastructure/capacity indicators, suggesting that tangible and quantifiable performance metrics remain the primary channels through which macroeconomic effects are theorized and tested. Governance and sustainability dimensions, although acknowledged in conceptual discussions, are seldom systematically embedded in macroeconomic analyses.

Methodologically, gravity-based trade econometrics techniques dominate the empirical landscape. While this provides robust evidence of trade facilitation effects, economy-wide approaches such as input–output models, computable general equilibrium frameworks, and spatial econometric models remain comparatively less prevalent. As a result, much of the empirical evidence emphasizes trade responsiveness rather than broader welfare or structural development outcomes.

Importantly, the broader body of port research appears directionally divided. A substantial proportion of studies examine macroeconomic variables as determinants of port performance, while an approximately comparable body of work investigates the macroeconomic consequences of port performance improvements. This bidirectional emphasis reflects a mature but fragmented field, in which the causal interplay between ports and economic systems is recognized but rarely integrated within unified analytical frameworks. Empirical evidence reinforces this dynamic relationship. Ayesu and Boateng (2024), for example, explicitly test for causality and identify a bi-directional causal relationship

between employment and port throughput, demonstrating that increased port throughput stimulates economic activity, while rising employment simultaneously increases demand for goods and thus port utilization. Similarly, Munim and Schramm (2018) acknowledge this circular causality in their theoretical framework, noting that trade gains generated through port improvements can trigger economic restructuring, which in turn further fuels trade expansion.

Future research can extend this review by engaging more deeply with the dimensions established in the classification framework. While the present study maps frequency patterns across performance indicators and macroeconomic spillovers, further work could interrogate these frequencies more granularly, examining which specific indicator–spillover combinations dominate and why. Beyond frequency counts, future studies may assess the relative magnitude and strength of these relationships, benchmarking different performance channels against one another to determine which dimensions generate the most substantive macroeconomic effects. The framework also provides a basis for identifying underexplored combinations and thematic gaps, thereby guiding more targeted empirical inquiry. Comparative research could cluster countries by structural or developmental characteristics to assess whether different contexts emphasize distinct performance dimensions or macroeconomic transmission pathways. Moreover, explicitly modelling dynamic and bidirectional relationships between macroeconomic conditions and port performance would advance understanding of the feedback loops identified in the literature. Importantly, this mapping exercise offers a structured lens for context-specific application. In particular, it provides a clear analytical foundation for a focused empirical case study in South Africa, where the classification framework can guide indicator selection and spillover measurement. Such work could quantify potential macroeconomic benefits or risks associated with performance improvements, thereby supporting evidence-based decision-making for policymakers and investors.

References

Abed, A., Babatunde, K., Azlina, A., Ghanem, O. and Onikosi-Alliyu, S. O., Assessing the impact of one belt and road (OBOR) initiative on trade potential and transportation efficiency using a gravity model analysis, *Discover Sustainability*, vol. 6, no. 693, 2025.

Adenigbo, A. J., Alumas, M. and Ayesu, E. K., Effect of shipping trade on economic growth in Nigeria: the Vector Error Correction Model (VECM) approach, *Journal of Shipping and Trade*, vol. 8, no. 15, 2023.

Alamoush, A. S., Ballini, F. and Ölçer, A. I., Revisiting port sustainability as a foundation for the implementation of the United Nations Sustainable Development Goals (UN SDGs), *Journal of Shipping and Trade*, vol. 6, no. 19, 2021.

Albliwi, S., Anthony, J., Lim, S.A.H. and van der Wiele, T., Critical failure factors of Lean Six Sigma: A systematic literature review, *International Journal of Quality & Reliability Management*, vol. 31, no. 9, pp. 1012-1030, 2014.

Amin, C., Mulyati, H., Anggraini, E. and Kusumastanto, T., Impact of maritime logistics on archipelagic economic development in eastern Indonesia, *The Asian Journal of Shipping and Logistics*, vol. 37, no. 2, pp. 157-164, 2021.

Ayesu, E. K. and Boateng, K. A. B., Estimating the impact of container port throughput on employment: an analysis for African countries with seaports, *Journal of Shipping and Trade*, vol. 9, no. 8, 2024.

Bhurtyal, S., Hernandez, S., Eksioglu, S. and Yves, M., A two-stage stochastic optimization model for port infrastructure planning, *Maritime Economics & Logistics*, vol. 26, pp. 185-211, 2024.

Bogataj, D., Campuzano-Bolarin, F., Moreno Nicolás, J. A. and Sethi, S. P., Gravity modelling of intercontinental supply chains considering a new port location, *Central European Journal of Operations Research*, vol. 33, pp. 1227-1250, 2025.

Boske, L. B. and Cuttino, J. C., Economic and transportation impacts of maritime-related trade, *Maritime Economics & Logistics*, vol. 5, no. 2, pp. 139-157, 2003.

Boussedjra, F. M., Talla, A. and Bouhali, M., Smart port strategy for sustainable development in Algerian ports: the case of the port of Skikda, *Environment Systems and Decisions*, 2022.

Chen, D. and Yang, Z., Investment in container ports along the Maritime Silk Road in the context of international industry transfer: the case of the port of Colombo, *Maritime Economics & Logistics*, vol. 20, no. 3, pp. 436-460, 2018.

Dadashpoor, H. and Taheri, B., Port-city interactions in the export-oriented region of Bandar-Abbas, Iran, *GeoJournal*, vol. 88, pp. 2423-2447, 2023.

Danielis, R. and Gregori, T., An input-output-based methodology to estimate the economic role of a port: The case of the port system of the Friuli Venezia Giulia Region, Italy, *Maritime Economics & Logistics*, vol. 15, no. 2, pp. 222-255, 2013.

Haezendonck, E. and Moeremans, B., Measuring value tonnes based on direct value added: a new weighted analysis for the port of Antwerp, *Maritime Economics & Logistics*, vol. 22, no. 4, pp. 656-676, 2020.

Haralambides, H., Globalization, public sector reform, and the role of ports in international supply chains, *Maritime Economics & Logistics*, vol. 19, no. 1, pp. 1-51, 2017.

Ircha, M. C., Maritime education and training: A global perspective, *WMU Journal of Maritime Affairs*, vol. 5, no. 2, pp. 195-204, 2006.

Kent, P. E., Leng, C. and Ayzanoa, G., Inside and outside the docks: exploring the costs, benefits, and impacts of port automation in the United States—a port of New York/New Jersey case study, *Maritime Economics & Logistics*, 2025.

Khan, Y., Hassan, T., Shukai, C., Oubaih, H., Khan, M. N., Kootwal, J. and Rehimi, U. U. R., The nexus between infrastructure development, economic growth, foreign direct investment, and trade: an empirical investigation from China's regional trade data, *SN Business & Economics*, vol. 2, no. 81, 2022.

Kornher, L., Sakyi, D. and Tannor, L. L., "When you need it quick, let us ship it right": on the importance of maritime transport for fruit and vegetable exports from Ghana, *Review of World Economics*, 2024.

Márquez-Ramos, L., Martínez-Zarzoso, I. and Pérez-García, E., Determinants of maritime transport costs. Importance of connectivity measures, *Networks and Spatial Economics*, vol. 11, no. 3, pp. 555-576, 2011.

Martínez-López, A., A multi-objective mathematical model to select fleets and maritime routes in short sea shipping: a case study in Chile, *Journal of Marine Science and Technology*, vol. 26, no. 2, pp. 673-692, 2021.

Matekenya, W. and Ncwadi, R., The impact of maritime transport financing on total trade in South Africa, *Journal of Shipping and Trade*, vol. 7, no. 5, 2022.

Merk, O., Manshanden, W. J. J. and Dröes, M. I., Interregional spillovers of seaports: The case of North-West Europe, *International Journal of Transport Economics*, 2013.

Mlambo, C., The Impact of Port Performance on Trade: The Case of Selected African States, *Economies*, vol. 9, no. 4, 135, 2021.

Mlimbila, J. and Mbamba, U. O. L., The role of information systems usage in enhancing port logistics performance: evidence from the Dar Es Salaam port, Tanzania, *Journal of Shipping and Trade*, vol. 3, no. 10, 2018.

Munim, Z. H. and Schramm, H.-J., The impacts of port infrastructure and logistics performance on economic growth: the mediating role of seaborne trade, *Journal of Shipping and Trade*, vol. 3, no. 1, 2018.

Neves, R. A. F., Lopes, A., Naveira, C., Rodrigues, N., Silveira, R. B., Guimarães, T., Filardi, F. and Santos, L. N., Socio-economic impacts of a maritime industrial development area in Brazil: The case of the Açu Port, *Maritime Studies*, vol. 20, no. 4, pp. 353-368, 2021.

Paul, J. A. and MacDonald, L., An empirical analysis of US vessel-related port accidents (2002–2012): Impact of union membership and port efficiency on accident incidence and economic damage, *Maritime Economics & Logistics*, vol. 19, no. 4, pp. 723-748, 2017.

Saha, R. C. and Khalil, K. B., The role of dry ports, intermodal, and synchromodal systems in reducing inland freight transport costs, time, and CO2 emissions for international shipping in Bangladesh and Malaysia, *Journal of Shipping and Trade*, vol. 10, no. 28, 2025.

Sahoo, A., Ferrari, E. and Nechifor, V., On the positive economic impacts of port infrastructure development and seaborne trade efficiencies in Sub-Saharan Africa: the case of Senegal, *Maritime Economics & Logistics*, 2025. [Source NS150]

Thill, J.-C. and Venkitasubramanian, K., Multi-layered hinterland classification of Indian ports of containerized cargoes using GIS visualization and decision tree analysis, *Maritime Economics & Logistics*, vol. 17, no. 3, pp. 265-291, 2015.

Tongzon, J., Determinants of competitiveness in logistics: Implications for the region, *Maritime Economics & Logistics*, vol. 9, no. 1, pp. 67-83, 2007.

Vukić, L. and Lai, K.-H., Acute port congestion and emissions exceedances as an impact of COVID-19 outcome: the case of San Pedro Bay ports, *Journal of Shipping and Trade*, vol. 7, no. 25, 2022.

Wahab, A. A., Impact of infrastructure on trade in Nigeria: a structural equation modelling approach, *Journal of Economic Structures*, vol. 13, no. 13, 2024.

Wang, C.-N., Nhieu, N.-L. and Chung, C.-M., Charting sustainable logistics on the 21st-Century Maritime Silk Road: a DEA-based approach enhanced by risk considerations through prospect theory, *Humanities and Social Sciences Communications*, vol. 11, 2024.

Wilmsmeier, G. and Hoffmann, J., Liner shipping connectivity and port infrastructure as determinants of freight rates in the Caribbean, *Maritime Economics & Logistics*, vol. 10, no. 1, pp. 130-151, 2008.

Xu, L., Fang, S.-C. and Zhang, X., Transport costs and China's exports: Some empirical evidences, *Journal of Systems Science and Complexity*, vol. 26, no. 3, pp. 365-382, 2013.

Xu, L., Lai, K. K., Qiao, H. and Wang, S., The impact of the port on the regional economy: Evidence from China's major container ports, *Journal of Systems Science and Complexity*, vol. 30, no. 6, pp. 1405-1426, 2017.
Zheng, S. and Negenborn, R. R., Centralization or decentralization: A comparative analysis of port regulation mechanisms, *Maritime Economics & Logistics*, vol. 19, no. 1, pp. 89-111, 2017.

Biographies

Jan-Louis Grundlingh is currently a Master's student in the Department of Industrial Engineering at Stellenbosch University. He previously completed both his undergraduate and Honours degrees in Logistics Management within the Faculty of Economic and Management Sciences. Jan-Louis is especially drawn to research that combines structured quantitative methods with broader systemic thinking. Beyond his academic pursuits, he maintains a strong commitment to personal development and discipline. He is passionate about fitness, particularly strength training and weightlifting. In addition, Jan-Louis has a deep interest in music production, where he explores atmospheric and rhythm-driven compositions, blending technical experimentation with creative expression.

Mia Mangaroo-Pillay is a Senior Lecturer in the Department of Industrial Engineering at Stellenbosch University, where she engages in teaching, research and supervision within the fields of industrial engineering. She holds a PhD in Industrial Engineering from North-West University, where she began her academic career and later held a lecturer position before moving to Stellenbosch University as a Senior Lecturer at the start of 2024. Her research focuses on operational excellence, human factors engineering, lean philosophy and Industry 4.0/5.0.

Leila Goedhals-Gerber is a Professor in the Department of Industrial Engineering at Stellenbosch University. She has been lecturing at the university for more than 20 years and has played a significant role in shaping teaching and research within the logistics and supply chain domain. She previously served as Subject Head for Logistics Management, where she contributed to the development and academic direction of the programme. In recent years, she has been instrumental in establishing a newly structured Master's degree within the Department of Industrial Engineering, with a specific focus on Logistics and Supply Chain Systems.

Appendix A: Frequency Counts of Port Performance Indicator Categories and their associated Macroeconomic Spillovers across Final Studies

PP Code	Studies (n)	MO Code	Studies (n)	Studies
PP1	17	MO1	11	Mlambo (2021); Ircha (2006); Tongzon (2007); Kornher et al. (2025); Márquez-Ramos et al. (2011); Xu et al. (2013); Xu et al. (2017); Mlimbila & Mbamba (2018); Adenigbo et al. (2023); Sahoo et al. (2025); Khan et al. (2022)
		MO2	5	Amin et al. (2021); Mlambo (2021); Neves et al. (2022); Adenigbo et al. (2023); Khan et al. (2022)
		MO4	3	Amin et al. (2021); Márquez-Ramos et al. (2011); Mlimbila & Mbamba (2018)
		MO5	3	Amin et al. (2021); Zheng & Negenborn (2018); Tongzon (2007)
		MO6	3	Amin et al. (2021); Tongzon (2007); Khan et al. (2022)
		MO7	3	Paul & MacDonald (2017); Neves et al. (2022); Vukić & Lai (2022)
		MO3	2	Neves et al. (2022); Ayesu & Boateng (2024)
PP3	17	MO1	9	Boske & Cuttino (2003); Bogataj et al. (2025); Márquez-Ramos et al. (2011); Xu et al. (2013); Xu et al. (2017); Munim & Schramm (2018); Matekenya & Ncwadi (2022); Wang et al. (2024); Abed et al. (2025)
		MO2	6	Amin et al. (2021); Bogataj et al. (2025); Dadashpoor & Taheri (2022); Munim & Schramm (2018); Chen & Yang (2017); Wang et al. (2024)
		MO4	5	Amin et al. (2021); Wilmsmeier & Hoffmann (2008); Martínez-López et al. (2021); Márquez-Ramos et al. (2011); Bhurtyal et al. (2024)
		MO5	3	Amin et al. (2021); Zheng & Negenborn (2018); Chen & Yang (2017)
		MO6	3	Amin et al. (2021); Dadashpoor & Taheri (2022); Wang et al. (2024)
		MO3	2	Dadashpoor & Taheri (2022); Chen & Yang (2017)
		MO7	2	Bhurtyal et al. (2024); Kent et al. (2025)
PP4	9	MO1	4	Boske & Cuttino (2003); Bogataj et al. (2025); Márquez-Ramos et al. (2011); Wahab (2024)
		MO2	4	Amin et al. (2021); Bogataj et al. (2025); Dadashpoor & Taheri (2022); Chen & Yang (2017)
		MO4	3	Amin et al. (2021); Wilmsmeier & Hoffmann (2008); Márquez-Ramos et al. (2011)
		MO3	2	Dadashpoor & Taheri (2022); Chen & Yang (2017)
		MO5	2	Amin et al. (2021); Chen & Yang (2017)
		MO6	2	Amin et al. (2021); Dadashpoor & Taheri (2022)
		MO7	1	Saha & Khalil (2025)

PP5	8	MO1	5	Ircha (2006); Thill & Venkitasubramanian (2015); Tongzon (2007); Mlimbila & Mbamba (2018); Wang et al. (2024)
		MO6	3	Thill & Venkitasubramanian (2015); Tongzon (2007); Wang et al. (2024)
		MO2	2	Haralambides (2017); Wang et al. (2024)
		MO4	2	Mlimbila & Mbamba (2018); Haralambides (2017)
		MO5	2	Zheng & Negenborn (2018); Tongzon (2007)
		MO7	1	Paul & MacDonald (2017)
PP6	8	MO2	4	Danielis & Gregori (2013); Neves et al. (2022); Haezendonck & Moeremans (2020); Wang et al. (2024)
		MO7	4	Ghennaï et al. (2023); Neves et al. (2022); Alamoush et al. (2021); Kent et al. (2025)
		MO1	2	Alamoush et al. (2021); Wang et al. (2024)
		MO6	2	Merk et al. (2013); Wang et al. (2024)
		MO3	1	Neves et al. (2022)
		MO5	1	Alamoush et al. (2021)
PP2	6	MO1	3	Xu et al. (2013); Xu et al. (2017); Sahoo et al. (2025)
		MO4	2	Amin et al. (2021); Martínez-López et al. (2021)
		MO2	1	Amin et al. (2021)
		MO5	1	Amin et al. (2021)
		MO6	1	Amin et al. (2021)
		MO7	1	Kent et al. (2025)

Appendix B: Frequency Counts of Macroeconomic Spillover Categories and their associated Port Performance Indicators across Final Studies

MO Code	Studies (n)	PP Code	Studies (n)	Studies
MO1	20	PP1	11	Mlambo (2021); Ircha (2006); Tongzon (2007); Kornher et al. (2025); Márquez-Ramos et al. (2011); Xu et al. (2013); Xu et al. (2017); Mlimbila & Mbamba (2018); Adenigbo et al. (2023); Sahoo et al. (2025); Khan et al. (2022)
		PP4	9	Boske & Cuttino (2003); Tongzon (2007); Wilmsmeier & Hoffmann (2008); Wahab (2024); Munim & Schramm (2018); Xu et al. (2013); Xu et al. (2017); Khan et al. (2022)
		PP3	6	Boske & Cuttino (2003); Tongzon (2007); Wahab (2024); Munim & Schramm (2018); Matekenya & Ncwadi (2022); Abed et al. (2025)
		PP5	6	Ircha (2006); Thill & Venkitasubramanian (2015); Paul & MacDonald (2017); Tongzon (2007); Haralambides (2017); Kent et al. (2025)
		PP2	4	Amin et al. (2021); Boske & Cuttino (2003); Tongzon (2007); Matekenya & Ncwadi (2022)
		PP6	2	Neves et al. (2022); Sahoo et al. (2025)
MO2	12	PP1	5	Amin et al. (2021); Mlambo (2021); Neves et al. (2022); Adenigbo et al. (2023); Khan et al. (2022)
		PP3	4	Amin et al. (2021); Munim & Schramm (2018); Adenigbo et al. (2023); Khan et al. (2022)
		PP4	4	Munim & Schramm (2018); Matekenya & Ncwadi (2022); Adenigbo et al. (2023); Khan et al. (2022)
		PP6	4	Danielis & Gregori (2013); Neves et al. (2022); Haezendonck & Moeremans (2020); Wang et al. (2024)
		PP5	2	Neves et al. (2022); Khan et al. (2022)
MO6	7	PP1	4	Amin et al. (2021); Tongzon (2007); Merk et al. (2013); Abed et al. (2025)
		PP3	3	Merk et al. (2013); Abed et al. (2025); Saha & Khalil (2025)
		PP4	3	Merk et al. (2013); Abed et al. (2025); Thill & Venkitasubramanian (2015)
		PP6	3	Merk et al. (2013); Ircha (2006); Boske & Cuttino (2003)
		PP5	2	Merk et al. (2013); Thill & Venkitasubramanian (2015)
		PP2	1	Merk et al. (2013)
MO5	6	PP1	3	Amin et al. (2021); Tongzon (2007); Zheng & Negenborn (2018)
		PP3	2	Zheng & Negenborn (2018); Tongzon (2007)
		PP4	2	Tongzon (2007); Zheng & Negenborn (2018)
		PP5	2	Tongzon (2007); Zheng & Negenborn (2018)
		PP2	1	Tongzon (2007)
		PP6	1	Ghennaï et al. (2023)
MO4	5	PP1	3	Amin et al. (2021); Márquez-Ramos et al. (2011); Wilmsmeier & Hoffmann (2008)
		PP2	2	Amin et al. (2021); Wilmsmeier & Hoffmann (2008)
		PP4	2	Wilmsmeier & Hoffmann (2008); Márquez-Ramos et al. (2011)
		PP3	1	Wilmsmeier & Hoffmann (2008)
MO3	4	PP1	2	Neves et al. (2022); Ayesu & Boateng (2024)
		PP3	1	Ayesu & Boateng (2024)
		PP5	1	Kent et al. (2025)
MO7	3	PP1	2	Paul & MacDonald (2017); Vukić & Lai (2022)
		PP6	2	Vukić & Lai (2022); Paul & MacDonald (2017)

		PP5	1	Paul & MacDonald (2017)

Appendix C: Distribution Count of Method Families applied across Final Studies

M Code	Study Count (n)	Studies
M1	20	Mlambo (2021); Ircha (2006); Zheng & Negenborn (2018); Paul & MacDonald (2017); Tongzon (2007); Wilmsmeier & Hoffmann (2008); Martínez-López et al. (2021); Bogataj et al. (2025); Dadashpoor & Taheri (2022); Márquez-Ramos et al. (2011); Xu et al. (2013); Xu et al. (2017); Neves et al. (2022); Wahab (2024); Matekenya & Ncwadi (2022); Adenigbo et al. (2023); Ayesu & Boateng (2024); Sahoo et al. (2025); Khan et al. (2022); Abed et al. (2025)
M2	2	Merk et al. (2013); Danielis & Gregori (2013)
M3	3	Amin et al. (2021); Paul & MacDonald (2017); Wang et al. (2024)
M4	1	Zheng & Negenborn (2018)
M5	7	Zheng & Negenborn (2018); Martínez-López et al. (2021); Bogataj et al. (2025); Vukić & Lai (2022); Chen & Yang (2017); Bhurtyal et al. (2024); Wang et al. (2024)
M6	15	Amin et al. (2021); Ircha (2006); Thill & Venkitasubramanian (2015); Boske & Cuttino (2003); Tongzon (2007); Kornher et al. (2025); Ghennaï et al. (2023); Dadashpoor & Taheri (2022); Munim & Schramm (2018); Mlimbila & Mbamba (2018); Alamoush et al. (2021); Saha & Khalil (2025); Haralambides (2017); Haezendonck & Moeremans (2020); Kent et al. (2025)