Chapter 7
Instruments Utilized in Short Sea Shipping Research: A Review

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Abstract This study explores the instruments of short sea shipping (SSS) that has been utilized through an inclusive review of papers published in well-known journals over the 2002–2021 period. Systematic exploration shows that maritime policy and management plays a dominant role in publishing short sea shipping research. At the same time, classification and identification of important determinants and barriers for successful SSS has been found as the main research area, followed by attractiveness and competitiveness of SSS; policy and subsidisations in SSS and multimodal transportation network; energy efficiency, emission and environmental issue and protection; ports and transport system efficiency; cargo operations, inventory management, competitive SSS technology and ICT; potential demand, opportunity and competitive advantage; sustainable development and influence of meteorological and weather conditions on SSS operations as popular topics. Since 2002, the use of quantitative and qualitative analysis techniques has progressively increased in SSS in order to help researchers make decisions through selected scientific methods. With this work, present and prospective researchers can understand the contemporary development and popular research topics in SSS. By presenting a review on the common research instruments and techniques used in SSS research, this study is expected to fill the gap in the present literature through the collation of information on the research approaches in contemporary SSS studies.

Keywords Short sea shipping (SSS) · Information communication technology (ICT) · Sustainable development · Quantitative analysis · Qualitative analysis

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7.1 Introduction

This paper is organized as follows: Sect. 7.1 identifies the main research area topics in short sea shipping. Section 7.2 presents the collection of relevant papers and a review process. Next, Sect. 7.2 presents volume outline and analysed research methods and data analysis techniques, and Sect. 7.3 presents conclusions and discussion.

Basically, SSS defined as oceanic transport between the seaports of a nation-state as well as between a country's seaport and the seaports of neighbouring countries [13]. This definition includes the type of service, being cabotage or coastal within the ports of a country that may extend the geographic coverage to adjacent countries. In 1992, the European Commission presented its first SSS publication that describes SSS as a carriage of goods and passengers by ocean between ports situated on the mainland of one-member state without calling at islands or services between ports of one-member state where one or more ports are situated on islands and offshore supply services [25]. In 2005, the US Maritime Administration (MARAD) defined SSS as a commercial maritime transportation that does not passage an ocean. It is another method of commercial conveyance that employs coastal waterways and inland to transfer commercial freight from main domestic harbours to its destination [121]. Constant with the MARAD definition, [129] reveals the following basics to the above-mentioned definitions: feedering, intermodalism, inter-regional cargo, border crossing, transhipment, spoke and hub networks and a substitute to road transport for trailers or container [129]. In a more inclusive approach, [5] indicates that SSS generally involves the carriage of cargo, passengers and vehicles by vessels along the coasts, to and from nearby islands, within internal waters such as rivers and lakes but without passage crossing an ocean.

For a nation, SSS not only ensures the transportation of resources needed for production processes but also facilitates the transshipments of vehicles, which accumulates more advantages for the nation. It is argued by [109] that SSS has some advantages which are decreased environmental impact, better utilization of infrastructure, potential cost efficiencies and coastal economic development. Along similar line of argument, [3] reveals that a feasible SSS that alternately connected by road transport will minimize road congestion, reduce road construction and maintenance costs and improve the surrounding environment. On the other hand, since maritime transport offers higher fuel economy and lower emissions of harmful pollutants, SSS has been considered as one of the most sustainable and economically competitive modes of transport [72].

7.2 Research Area in Short Sea Shipping

The SSS sector has traditionally been regarded as an important component of a nation's economic system. Therefore, research on SSS has received a countless deal of attention from scholars worldwide. For instance, an impressive volume of studies

have been conducted for classification and identification of important determinants for its successful undertaking [2, 4, 6, 7, 10, 11, 14–18, 36, 54, 63, 65, 72, 73, 79, 84, 86, 88, 88, 89, 104, 106, 112, 113, 126, 138, 141, 143, 147, 151, 164, 166, 167, 169].

Subsequently, the next popular SSS research area is on the attractiveness and competitiveness of SSS in a multimodal transport chain [8, 9, 19–21, 27, 34, 35, 37, 39, 42, 62, 66, 68, 71, 77, 78, 87, 94, 102, 113, 120, 130, 145, 146, 151, 155, 161]. This is followed by research on policy, subsidization, funding and government assistance in SSS and multimodal transportation network as the third-most popular area [12, 44, 51, 59, 60, 81, 82, 92, 111, 113, 131, 136, 139, 148, 153, 156, 157, 164].

The fourth research area involves energy efficiency, emission and environmental issue and protection [23, 40, 47–49, 52, 53, 55, 58, 61, 67, 70, 105, 116, 120, 122, 124, 132, 143, 156, 160, 162, 165, 168].

This is followed by ports and transport system efficiency, cargo operations, inventory management, competitive SSS technology and ICT [1, 22, 26, 28, 31, 33, 41, 45, 56, 57, 63, 76, 83, 94, 97, 99, 103, 106, 107, 113, 128, 135].

The sixth research area covers potential demand, opportunity, competitive advantage and sustainable transport development [32, 38, 50, 58, 59, 69–71, 74, 75, 90, 92–94, 98, 100, 108–110, 119, 124, 125, 127]. Eventually, only few studies can be traced that focus on the influence of meteorological or weather conditions on SSS operations [29, 43].

Basically, such reviews are helpful to understand the contemporary development and popular research topics in SSS. By presenting a review of the major research instruments and techniques used in SSS studies, this study fills the gap in the present literature by collating information on the research approaches of contemporary SSS studies, whether through the qualitative or quantitative techniques.

Consequently, this study reviews the major data analysis techniques used in SSS research. Next, comparing the status of current research in SSS, it is found that excessive commitment has been given to shipping operations, port strategies and SSS developments, but few efforts have been made to research in meteorological or weather conditions, policy and government assistance. The next section will explain the most exciting instruments that have been employed and followed by rare instruments that can be traced employed in SSS study.

Based on thorough observation, there are numerous studies on SSS that have been conducted between 2002 and 2021. Obviously, the Maritime Policy and Management journal plays an important role in publishing SSS studies involving 50 journal articles, followed by Maritime Economics and Logistics with 30 papers, The International Journal of Shipping and Transport Logistics with 25 papers, Journal of Transport Geography with 15 papers, Transportation Research Part A with 11 papers, Marine Pollution Bulletin with 8 papers, Transport Reviews with 3 papers, The Asian Journal of Shipping and Logistics with 3 papers, Journal of Navigation with 3 papers, Transport Policy with 3 papers, Transportation Research Part D with 4 papers, Journal of Shipping and Trade with 2 papers, Journal of Maritime Research with 2 papers, Marine Policy with 2 papers, Journal of Shipping and Ocean Engineering with

2 papers, Transport and Telecommunication Journal with 2 papers, International Journal of e-Navigation and Maritime Economy with 2 papers and the last one is the Naval Architect with 2 papers. Impressively, the number of the articles and studies that has been published in SSS keeps increasing for the past 3 years until the present day.

The papers are identified using Scopus, Research Gate, and Google Scholar as research reference and carrying out queries with particular keywords. In order to ensure consistency and homogeneity, all non-indexed journals and dissertations are excluded from the selection due to their more subjective impact on academic literature. This study also presents an academic review on SSS and its significant techniques and method that are utilized by the respective areas. Lastly, a systematic summary of the significant techniques and the gap that this study expects to fill are offered. Apart from that, in order to comprehend the review on the selected instruments, the next section will be deliberated on the recognizable instruments that have been employed in SSS.

7.3 Results and Discussion

7.3.1 Algorithms

Based on Table 7.1, there are several approaches of algorithms that have been used in open literature. Different researcher utilized different levels depending on the area that he or she had explored. For instance, [50] employed the label-setting algorithm in a study to determine the optimal routes for mother and daughter ships, as well as the optimal size of the daughter ships. Authors of [41] employed the pathfinding

Table 7.1 Approaches of algorithms in SSS

Instruments	Scholar	Area
Label-setting algorithm	[50]	Optimal routes optimal size of ships
Pathfinding algorithm	[41]	Ship routing
Algorithm and meteo-oceanographic predications	[40]	Ship routing
Guided algorithm	[22]	Schedules of ships
Multi-objective evolutionary algorithm	[70, 71]	Fleets for the sea motorways
NSGA-ii algorithm	[70]	Optimization of container fleets
Frank–Wolfe hybrid algorithm	[96]	Carbon emission reduction
Algorithms	[52]	Energy efficiency
L-shaped algorithm	[1]	Inventory routing
Label-setting algorithm and path-flow-based formulation	[157]	Short sea shipping cost efficient

algorithm in ship routing and revealed the economic benefits of using ship routing in SSS during energetic wave episodes. Contrarily, authors of [40] employed the algorithm and Meteo-Oceanographic technique to come out with the predictions of ship routing from a European perspective. Within similar research area, [22] employed the guided algorithm and come out with the optimal dynamic rearrangement of schedules of other ships to meet the demand after a vessel's immobilization. From a Spanish and French perspective, [70, 71] employed the multi-objective evolutionary algorithm and revealed that the most suitable fleets for the Sea Motorways are Vigo-St.Nazaire and Gijón-St.Nazaire. Additionally, [70] employed the NSGA-II algorithm to investigate the influence of external costs on the optimization of container fleets and revealed that optimized vessels are able to provide 'greener' multimodal chains than the road. In a hybrid approach, [95] employed the Frank–Wolfe hybrid algorithm to investigate the design of coastal shipping services subject to carbon emission reduction targets and state subsidy levels and proposed a model that was applied to Bohai Bay in China.

In term of energy efficiency in SSS, [52] employed fuel consumption, operational and design specifications algorithms, and the results show that even a conservative estimate of one to four hours of reduced time per port call would lead to a reduction in energy use of 2–8%. Last but not least, from an African perspective, authors of [44] employed the L-shaped algorithm to investigate the inventory routing problem with stochastic sailing and port times. This study presented a computational study based on real-world instances. The following section will discuss the qualitative studies but no specific instruments that have been employed in SSS study.

7.3.2 Qualitative Research

Based on Table 7.2, numerous researchers employed a qualitative approach, and it is difficult to identify whether they employed a specific qualitative instrument or techniques to reveal their findings. Among others, [38] conducted a survey to investigate autonomous technologies in SSS and revealed that autonomous technologies are practical to the shipping industry that is facing the problems of crew costs and skill shortage. From the same perspective, [122] employed a survey to investigate an environmental friendliness of SSS towards road transport and presented a new tool to identify the geographical scope where each transport alternative is more environmentally friendly. Similarly, Hamilton [44] employed the same approach to investigate the SSS network and finance model and suggested that proper consultation with stakeholders and design of the implementation can mitigate constraints. [100] also employed the qualitative method when they investigated on slow steaming as part of SECA compliance strategies among Ro-Ro and Ro-Pax shipping companies and conclude that for Ro-Pax and Ro-Ro segment, bunker prices, rigorous competition and most importantly different service quality requirements have significantly restricted the potential implementation of slow steaming.

Table 7.2 Approaches of qualitative research in SSS

Instruments	Scholar	Area
Survey	[38]	Autonomous technologies
Survey	[122]	Environmental
Survey	[44]	SSS network and finance model
Qualitative methodology	[100]	Ro-Ro and Ro-Pax shipping
Qualitative methodology	[51]	Policy implications
Qualitative methodology	[57]	Barriers for SSS
Survey	[85, 89–91, 118]	Current practices of European, China, Japan and Korean SSS
Survey	[21]	Competitiveness of Turkish coaster merchant fleet
Survey	[109]	Food loss reduction in Northeast Asia
Qualitative and observations	[14]	Short sea shipping sustainable
Interviews	[165]	Safety in short sea seafaring
Interviews and triangulated analysis	[167]	Role of policy in supporting SSS

Form both American and European point of view, [94] employed this instrument to investigate the SSS and its prospects. This study concludes that SSS can improve technologically effectiveness for advanced solutions and customized that will more integrate it into the intermodal transportation chain and will advance its image among shippers. From the South American perspective, [51] employed a qualitative approach to investigate potential and policy implications in Brazil and revealed that the cabotage law restricts the coastal and inland water trade to vessels flying its national flag. Additionally, [57] employed the same approach to investigate the barriers and enablers for SSS in Southern Africa and revealed that SSS has the theoretical potential to work in the African continent. Lastly, some other scholars also employed the same approach to investigate SSS in Asia.

For both European and Northeast Asia, [85, 89–91, 118] conducted a survey to investigate the current practices of European, China, Japan and Korean SSS. Similarly, [21] conducted a survey and interview to investigate the competitiveness of the Turkish coaster merchant fleet, and this study revealed that Turkish needs to build low draft, river going and box-type vessels to gain a competitive advantage. In the Northeast Asia, [109] employed the same method to investigate the food loss reduction in emerging economies by exploiting SSS opportunities. This study facilitates the applicants in eliminating both unfruitful options with respect to business effectiveness and food loss reduction.

Table 7.3 Approaches of decision support systems (DSS), discrete event simulation and decision networks in SSS

Instruments	Scholar	Area
Decision networks	[134]	Sustainability of SSS
DDS	[76]	Cascading feeder vessels
Discrete event simulation	[125]	Sustainability of SSS
DSS	[124]	Ballast water risk

7.3.3 Decision Support Systems (DSS), Discrete Event Simulation and Decision Networks

Based on Table 7.3, there are four studies that were traced to have employed these instruments. All the studies are European based. Firstly, [134] employed decision networks to investigate the sustainability of SSS and revealed that the capacity of regasification terminals for LNG, which was under construction, and the modal distribution of inland water cargo transportation are the two most important variables for the decision to implement liquefied natural gas (LNG) as fuel. Second, [76] employed the DDS to investigate the cascading feeder vessels and the rationalization of small container ports. The results of this research show that by 15% of the sub-1000 TEU fleet presently laid up and very limited on order, bigger feeders with deeper drafts seem certain to assist at least nearly of these routes. On the other hand, [125] employed discrete event simulation to investigate sustainability development in SSS. Finally, [124] used DSS to investigate a ballast water risk indication for the North Sea, and they concluded that exemptions from BWM are not recommended for the North Sea area.

7.3.4 Multi-criteria Decision-Making (MCDM), AHP, Delphi, Fuzzy Dematel, Fuzzy Logic

Based on Table 7.4, from the European perspective, [71] employed multi-criteria decision-making to analyse the Motorways of the Sea for France and Spain and come out with the most suitable motorways of the sea options. Authors of [96] also employed the same instrument to explore the logistics network and externalities for short sea transport. This study discloses savings in intermodal transportation costs and a slight decrease in externalities with respect to land transportation. On the other hand, there are pretty numbers of academia that employed the same instruments under MCDM which are Delphi, Fuzzy Dematel and AHP (analytic hierarchy process).

From European perspectives, [63] employed the Delphi technique and presented a transport model using hierarchy process study on key performance indicators of island transport services. With the same perspectives, [88] also employed the same method to investigate the strengths and weaknesses of SSS and proposed a new approach to clarify some concepts in SSS. Using the same technique, [104] explored

Table 7.4 Approaches of multi-criteria decision-making (MCDM), AHP, Delphi, fuzzy Dematel and fuzzy logic in SSS

Instruments	Scholar	Area
Multi-criteria decision-making	[71]	Motorways of the sea
MCDM	[97, 153]	Logistics network and externalities for SSS
Delphi technique	[63]	Indicators of island transport services
Delphi technique	[88]	Strengths and weaknesses of SSS
Delphi technique	[105]	Potential for British coastal shipping
Delphi-fuzzy dematel	[126]	Barriers to coastal shipping
Fuzzy logic	[30]	Economic feasibility study of SSS
Delphi technique	[7]	SSS in Archipelagic Southeast Asia (ASEA)
Delphi-AHP	[6]	Interstate Ro-Ro SSS routes in ASEA sub-region
AHP	[2, 4]	Ro-Ro SSS operations in archipelagic southeast Asia
AHP	[98]	Sustainability on the feeder service improvement in Malaysia
AHP-Delphi	[138]	Ro-Ro operation

the potential for British coastal shipping in a multimodal chain and concluded that managers are in favour of multimodal developments, in particular cooperation between coastal shipping and road haulage. In addition, [126] employed the Delphi with Fuzzy DEMATEL to investigate the barriers to coastal shipping development in India and recommended relaxing cabotage rules to stimulate the inflow of foreign capital in order to grow coastal shipping, improving the current port system through joint efforts of the ports, Indian customs and government, and fostering supply chain collaboration. On the other hand, [30] employed the Fuzzy logic to investigate an economic feasibility study of SSS, and the results show that SSS has impressive prospective for further enlightening its environmental performance by depressing ship emissions at ports. In terms of multi-criteria decision method, [97, 153] employed this method to evaluate the performance of potential alternative ports as intermodal cargo consolidation centre.

In Asia, [7] employed this instrument to investigate the potential benefits and obstacles of interstate SSS in Archipelagic Southeast Asia (ASEA), and this study addresses the gap in the literature by focusing on SSS in ASEA, particularly those involving interstate Ro-Ro operations and extending the usage of the Delphi technique to the realm of interstate SSS. Subsequently, [6, 138] employed this study together with the AHP technique, and this study finalizes with the development of a decision-making model for interstate Ro-Ro SSS routes in ASEA sub-region.

For AHP, [2, 4] employed this instrument to develop a model of Ro-Ro short sea shipping operations in Archipelagic Southeast Asia and come out with the improvement of a decision-making model that was tested on three interstate Ro-Ro SSS routes within the ASEA sub-region. With the same region, [98] employed this instrument to investigate influences of the feeder service expansion in Malaysia concerning

its sustainability, and this study revealed that the service sub-criteria is the most important feature on the feeder service improvement in Malaysia.

7.3.5 Econometric Analysis, Cost Benefits Analysis (CBA), Economic Analysis, Cost Model and Monetary Cost, and Costs and Transit Time Model

Based on Table 7.5, in terms of financial analysis, [132] employed the cost benefit analysis (CBA) to investigate the role of regulation and fuel prices, and the results show that there are significant implications of the new sulphur limits to the payback period of emissions abatement investments, particularly following the unexpected drop in fuel prices. From a European perspective, [130] employed the same approach by using economic statistical analysis to investigate in the global logistics trend

Table 7.5 Econometric analysis, cost benefits analysis (CBA), economic analysis, cost model and monetary cost, and costs and transit time model in SSS

Instruments	Scholar	Area
CBA	[132]	Regulation and fuel prices
Economic analysis	[130]	Container and Ro-Ro shipping
Economic analysis	[68]	Analysis of SSS container
Cost and transit time model	[131]	Costs of averting modal shifts
Cost and transit time	[35]	Competitiveness of SSS
Cost model	[71]	Fleets for sea motorways
CBA	[111, 143]	Sustainable transportation
Costs and transit time	[74]	Container transport
Econometrics and spatial shift-share	[110]	SSS services
Costs and transit time	[108]	Demand in SSS
Approximate analysis and assessing external costs	[58–60]	Role of SSS in sustainable development
CBA with SWOT analysis	[80, 81]	Nigerian coastal and inland shipping cabotage policy
CBA	[133]	Ro-Ro SSS network
CBA	[148]	Integrated short sea shipping
Life-cycle cost assessment (LCCA)	[160]	CO_2 emissions and environmental
Life cycle assessment—LCA method	[168]	CO_2 emissions and environmental
Quality function deployment (QFD)	[151]	Quality of high-speed ferry
Visualization analysis	[153]	Short sea shipping
Configurational approach of the space syntax analysis	[159, 161]	Short sea shipping

spillover through container and Ro-Ro shipping in North Europe SSS. This study concludes that SSS in North Europe tends to divide into two different ways, participating in competition as a logistics provider or strengthening their own position as a pure carrier. With the same approach, [68] investigates the analysis of SSS container routes in the Mediterranean and the Black Sea. Their study revealed that the Italian foreign trade is becoming more oriented to high value goods.

From the same perspectives, [131] employed cost and time model to investigate the costs of averting modal shifts in the European SSS sector and come out with the proposed measures that can successfully reduce the negative effects of the regulation. Authors of [35] also employed the monetary cost and transit time to explore in the competitiveness of SSS, and the results show the road option is about 30 and 34% most costly than the best SSS option available for the exportations from Jaén and Southern Catalonia, respectively. Authors of [71] also employed the cost model instruments to explore the optimal fleets for sea motorways. This study concludes that the most suitable fleets for the sea motorways are Vigo-St.Nazaire and Gijón-St.Nazaire. Similarly, [111] also employed CBA to investigate the implementation of the 'ecobonus' project in the Republic of Croatia and contributes to the political initiatives of the European Union for the European maritime space without boundaries and promotes environmentally sustainable transportation. Next, [143] employed the same method to investigate the concept of VT (Vessel Train) to determine the effectiveness of associated cost towards the reduction of crew size. In terms of CO_2 emissions and environmental aspect, [160] revealed that the adoption of green technical and process improvements by Europe's SSS corporations is positively and significantly tied to environmental restrictions as an external institutional driver.

In North America, [74] employed the costs and transit time model to scrutinize the modal choice preferences in short-distance hinterland container transport. The outcomes of the research suggest that, to improve a further modal shift, operators should attempt to deliver daily services at a competitive price, with an emphasis on providing more consistent services than road transport. Authors of [110] furthermore employed the spatial econometrics and spatial shift-share to investigate SSS along the Atlantic Arc. The conclusion of this study shows that along the Atlantic facade of the Iberian Peninsula, there are growing nodes with great potential to enable the increase in their throughput, in terms of inner competitiveness or by establishing new SSS services between neighbouring positions. Authors of [108] also employed the costs and transit time model to investigate a modelled transportation demand in SSS. This model produces the amounts of cargo that could potentially be carried annually through each transport solution, for different freight rates and ship speeds.

On the other hand, [58–60] employed the approximate analysis and assessing external costs to investigate the role of SSS in sustainable development and came out with a model that can be applied to evaluate external benefits of infrastructure investment or a new shipping line. From an African point of view, [80, 81] employed the CBA with SWOT analysis to investigate the benefit of maximizing criteria from the Nigerian coastal and inland shipping cabotage policy. The study reviews government policies affecting investments in ship sizes operating in lakes, rivers canals, inland waters and coastal waters of the maritime state. Last but not least, [133] employed the

CBA to investigate the establishment of a Ro-Ro SSS network connecting Southeast Asian countries. In terms of space syntax analysis, [159, 161] employed this method to determine the relationship between the spaces of the urban grid.

7.3.6   Factor Analysis, Sensitivity Analysis, Statistical Techniques, OLS Regression, Concentration Analysis and Pearson Correlation Analysis

Based on Table 7.6, in terms of statistical technique, there are few studies that were traced to have employed factor analysis as an instrument in SSS. In North America, [127] employed factor analysis to investigate on customer segmentation of freight forwarders and impacts on the competitive positioning of ocean carriers in the Taiwan–Southern China trade lane. This study contributes to a managerial implications and directions for future research. From South America, [20] employed univariate and multivariate statistical techniques to investigate the domestic SSS services in Brazil. This study reveals that cabotage users aim to enhance the integration of logistics between transport modes and to adopt modal shift strategies if better services could be provided, including a real-time information system, shorter transit times and freight offered on a door-to-door basis. In the same research area, [82] employed a statistical technique focusing in regression analysis (OLS Regression)

Table 7.6 Factor analysis, sensitivity analysis, statistical techniques, OLS regression and concentration analysis in SSS

Instruments	Scholar	Area
Factor analysis	[127]	Customer segmentation
Factor-cluster analysis	[166]	The performance of SSS
Univariate and multivariate statistical techniques	[20]	Domestic SSS services in Brazil
Regression analysis (OLS regression)	[82]	Over-exertion in Swedish SSS
Pearson correlation analysis	[169]	Ro-Ro operation
Statistical techniques	[28, 123]	Ro-Ro connectivity
Employed the statistical techniques and secondary data	[103]	Cargoes in tramp shipping
Statistical method and used correlation analysis	[23]	Transportation, production and distribution on costs and environment
Statistical method and used correlation analysis	[36]	Ferry service in SSS
Sensitivity analysis	[24]	Transport mode
Concentration analysis	[117]	Port rationalization and port systems
A numerical method	[164]	Demand on alternative short sea shipping

to explore on administrative burdens and over-exertion in Swedish SSS and revealed that highest levels of exertion were reported by employees in the catering department, positions not generally associated with high administrative burden. Authors of [28] also employed the statistical techniques to explore on port connectivity indices and revealed that for Ro-Ro connectivity, neither the number of links nor the link quality strictly dominate the results of their proposed indicator. Authors of [103] employed the statistical techniques and secondary data to come out with a mixed method to explore in the viability of part cargoes in tramp shipping, and this study stretches a better understanding of potential risks and benefits related to utilization of part cargo operations. In Asia, [23] employed statistical method and used correlation analysis to investigate the impact of restructuring transportation, production and distribution on costs and environment. This study contributes to the Thai rubber industry as a whole.

Additionally, [36] employed these instruments to explore the critical success factor of the ferry transport service in SSS, and this study provides some corresponding reference suggestions about customized service for ferry providers. From Southeast Asia, [24] employed sensitivity analysis to investigate the shippers' choice behaviour in picking transport mode, and this study conclude that shippers potency shift to the SSS mode when the importance weights of CO_2 emission increase, and cost and to trucking mode when the weight of time declines. For concentration analysis, [117] employed this instrument to investigate a port rationalization and the evolution of regional port systems and revealed that constant discussion of reform in Norway concerning regional port governance, analogous to other European nations, may ultimately result in such rationalization. For the numerical method, [164] revealed that factor-cluster analysis can offer policymakers with a preliminary abundance of information that can aid in the development of focused policy for SSS-oriented projects.

7.3.7 Modal Choice Model, Discrete Choice Models and Preferences of Modal Choice Decision, Employed International Competition Model

Based on Table 7.7, in Europe, two studies have been traced to have employed these instruments. Authors of [37] employed modal choice model to investigate the European common transport policy and SSS. This study revealed how important the politico-economic evaluation is in a European perspective. Second, [114] employed international competition model to investigate the SSS as an intermodal competitor, and this study concludes that EU as a whole needs to emphasis on ports and transport system effectiveness in order to compete effectively in the freight transport market. Form a North American perspective, [19] employed the modal choice model to investigate the requirements of Atlantic Canadian shippers and proposed a new method of collecting data on how organizations split business in the decisions. In addition, [102]

Table 7.7 Modal choice model, discrete choice models and preferences of modal choice decision, employed international competition model in SSS

Instruments	Scholar	Area
Modal choice model	[37]	Transport policy and SSS
International competition model	[114]	SSS as an intermodal
Modal choice model	[19]	Atlantic Canadian shippers
Discrete choice models	[102]	Competition between Ro–Ro and Lo–Lo services in SSS
Mixed integer linear programming model	[147]	Optimal network configuration for the organization of transport services
Mathematical and calculation models	[156]	Sustainable sources
A mixed multinomial logit model and a latent class choice model	[151]	Inter-urban freight mode choice
Aggregate discrete choice model	[145]	Competitive and sustainable freight transport system
A path-flow model	[136]	Short sea liner shipping network
Transport demand modelling	[146]	Freight transport
Optimization model	[156]	Short sea feeder network

employed discrete choice models to investigate the competition between Ro–Ro and Lo–Lo services in SSS market in Mediterranean countries. This study revealed that the important element that emerges, in general terms, is the segmentation of the market in relation to the distances existing between each couple of countries. For mixed multinomial logit model and a latent class choice model, [151] revealed that freight mode choice is majorly influenced by transit time and frequency of service.

7.3.8 Comparison of Data Collected, Comparative Analysis, Destination (OD) Matrices

Under this category, Table 7.8 shows that [69] employed comparison of data collected instrument to investigate the SSS container routes in the Mediterranean and in the Black Sea. This study concludes that the most important Italian port cluster is the

Table 7.8 Comparison of data collected, comparative analysis, destination (OD) matrices in SSS

Instruments	Scholar	Area
Comparison of data collected	[69]	SSS container routes
Comparison and forecasting calculations	[43]	Vessel speed on bunker cost in SSS
Comparative analysis mixed with destination (OD) matrices	[116]	Emission control in SSS

Ligurian. On the other hand, [43] employed the comparison and forecasting calculations to investigate the impacts of vessel speed on bunker cost in SSS. Their study revealed that the negative economic impacts of the oil price variation can be mitigated to some extent by using lower vessel speeds. Additionally, [116] also employed the comparative analysis mixed with destination (OD) matrices to investigate the environmental effects of emission control area regulations on SSS in Northern Europe focusing on container feeder vessels. This study effectively illustrates how empirical data supports the necessity of stricter SO_x regulations in order for maritime operations to uphold a green image set up against competing transport modes. For Aggregate discrete choice model, [145] employed this method to determine the impacts of green collaboration in land-sea freight transport.

7.3.9 Energy Efficiency Design Index, Analysis of the Sea, Advanced Modelling Approach, SO_2 Emission Calculations

In terms of environmental, Table 7.9 shows that [61] employed the advanced modelling approach to investigate the methodology of power distribution system design for hybrid SSS, and this study presents a modelling methodology for dimensioning marine vessel ES and hybrid PDS components. On the other hand, [120] employed the energy efficiency design index to examine Ro-Pax and passenger ships in Greece and demonstrated that the 'EEDI baseline' calculation is highly influenced by vessel design and operational characteristics, dictating the need for close monitoring of the EEDI effectiveness in this sector. In terms of Port connectivity index, [155] employed this method to study foreland port connectivity disaggregated by destination market. This study revealed that the technique allows for a more specific identification of the major port rivals by destination market, resulting in more detailed data to aid port managers and policymakers in their decision-making.

Table 7.9 Energy efficiency design index, analysis of the Sea, advanced modelling approach, SO_2 emission calculations in SSS

Instruments	Scholar	Area
Advanced modelling approach	[61]	Hybrid SSS
Energy efficiency design index	[120]	Ro-Pax
Port connectivity index (FPCI)	[155]	Container short sea shipping (SSS) services

Table 7.10 Strength–weaknesses–threats–opportunities (SWOT) analysis in SSS

Instruments	Scholar	Area
SWOT analysis	[101]	The rewards of SSS
SWOT analysis	[81]	Benefit maximizing criteria

Table 7.11 Job Demands–resources (JD–R) model in SSS

Instruments	Scholar	Area
JD–R model	[93]	Shipping lines
JD–R model	[92]	Short sea cargo

7.3.10 Strength–Weaknesses–Threats–Opportunities (SWOT) Analysis

From a European perspective, Table 7.10 shows that [101] employed SWOT analysis to analyses the rewards of SSS in Croatia as well as the environmental anxieties related to shipping in universal and SSS particular. This study revealed that strengths and opportunities definitely reduce the implication of threats and weaknesses. From Africa, [81] employed (SWOT) analysis to investigate the benefit maximizing criteria from the Nigerian coastal and inland shipping. The study shows that in the valuation of marine policy, one tool that has been very helpful is the social costing technique.

7.3.11 Job Demands Resources (JD-R) Model

In general perspective, Table 7.11 shows [93] employed a JD-R model to examine the seafarers' perceptions of job demands of SSS shipping lines and their effects on work and life on board. Thus, this study concludes that a good working climate was pivotal in counteracting negative emotions and supporting motivation and collaboration. In another research, [92] investigated effects of job demands and social interactions on fatigue in short sea cargo shipping and highlight the importance of considering social interactions on board to advance our understanding of stressors and strain in seafaring.

7.3.12 Data Envelopment Analysis (DEA)

Based on Table 7.12, [47] employed a data envelopment analysis (DEA) to investigate the environmental demands and the future of the Helsinki − Tallinn freight route. This study revealed that current truck and semi-trailer-based transportation is challenged by containers, irrespective of how they are carried.

Table 7.12 Data envelopment analysis (DEA) in SSS

Instruments	Scholar	Area
DEA	[47]	Freight route

7.3.13 Data Mining Techniques

From the European perspectives, [39] employed the data mining techniques to evaluate liquid natural gas (LNG) utilization in SSS. This study found that the capacity of LNG regasification terminals under construction and modal distribution of cargo transport by inland waters are the two root nodes of the network.

7.3.14 Porte's Five Force Model

The author of [86] employed Porter's five force model to investigate the motorway of the sea port's requirements. The study revealed that the viewpoint of port authorities regarding this matter and suggested a list of 21 pre-requisites that ports can use to assess their potential.

7.3.15 Assessing External Costs

In Europe, [60] employed the assessing external costs instrument to explore the role of SSS in sustainable development of transport, and this study proposed a model that can be applied to evaluate external benefits of infrastructure investment or a new shipping line.

7.3.16 Impact Pathway and Top-Down Approaches

In Northeast Asia, [62] employed this instrument to explore in the management of empty container flows through SSS and regional port systems. This study found that SSS represents a viable tactic in the implementation of a regional port system development strategy.

7.3.17 Longitudinal Analysis

Through this instrument, [46] investigated the growing trade of unitised SSS for Finland and Germany, and this study discovered that growth of unitised maritime

cargo flow has faced difficulties after global financial crisis between Germany and Finland.

7.3.18 Formal Concept Analysis (FCA) Method

The authors of [64] employed this instrument to investigate the revitalization of SSS through simplified, slender and standardized designs and indicates that significant fuel and cost savings can be achieved by designing and building slender, simplified and standardized short sea ships. The savings might be of a similar magnitude as the traditional economies of scale benefits which are achievable by doubling the vessel size.

7.3.19 Novel Methodology

The authors of [107] employed novel methodology to examine the methodology for Ro-Ro ship and fleet sizing with application to SSS that allows the identification of the most suitable ship and fleet sizes for different market penetration levels.

7.3.20 Simulation Modelling Method

From the study of [83], the simulation modelling method was employed in an analysis of Ro-Ro terminals and shows that the variable that mostly affect the terminal capacity is the number of trucks arriving to terminals. It has also been utilized by [164] who focused on the Ro-Ro operation.

7.3.21 Two-Phase Hybrid Matheuristic

The authors of [45] employed a two-phase hybrid matheuristic to analyse the multi-product SSS inventory-routing problem and come out with an adaptive large neighbourhood search to solve the resulting ship routing and scheduling problem.

7.3.22 Bi-Objective Optimization, Mathematical Model, a Structural Equation Model, Discretization Method and Mathematical Formulation

In Europe, [99] employed bi-objective optimization and mathematical model in a study of container transport flow of goods and proposed a mathematical model that can minimize the transit time and transportation costs of container imports to Serbia. For the structural equation model, [162] revealed that there is a significant relationship between environmental regulations and the green technological among Europe's SSS companies. The other study by [140, 150] also employed the same method that focused on the cost reductions in ship and port operations.

7.3.23 Theoretical Intermodal Competition Model

Eventually, [115] employed the theoretical intermodal competition model in the topic of SSS as intermodal competitor, and the study concludes that the EU needs to focus on ports and transport system efficiency as a whole in order to compete effectively in the freight transport market. Thus, discussion on the papers that have been review and a conclusion will be simplified for the next section.

7.4 Conclusion

This study reviews a thorough literature review of data analysis techniques used in SSS between 2002 and the middle of 2021. It shows how SSS research has been undertaken to give researchers a superior understanding of the current state of research in the realm of SSS. Throughout the review period, there has been an increasing tendency in the utilization of both the quantitative and qualitative instruments for SSS research. More academic and research publications have also been consistently published throughout the period of consideration. The advance in SSS research is attributable to the fact that SSS has traditionally been regarded as an important element of a nation's economic system. During the review period, the MPM journal has maintained a dominant position in publishing research in the various areas involving SSS. Today, experience is greater than before by expert analysis and informed by research findings made using a variety of quantitative and qualitative instruments, and some of scholars pursued mix methods then become qualitative–quantitative approach to come out with the inspiring research contribution. As a whole, quantitative instruments have been used more often as compared to the qualitative approaches. The popularity of quantitative approaches is associated with the introduction and application of computer science, statistics and mathematics in social science research. Despite the comprehensive approach, this study retains

some limitations. For instance, this study considered only journal articles that visibly revealed their instruments because a clear understanding is essential to simplify the exact instruments that have been used by some scholars. Nonetheless, this study is suggestive and offers researchers a deep exploration of the present situation of SSS research.

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