

Chapter 9

A Review of the Literature of Green Ports and Maritime Logistics

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Abstract Port operations and maritime logistics represent major sources of air pollution. Given the recent greening initiatives and developments in this area and correspondingly a geometric growth in the number of academic publications, this chapter aims to (a) provide some statistics of the key journals, authors and institutions that have contributed to the field, and (b) identify the primary research topics investigated. The proposed literature classification and analysis can help interested researchers and students establish their research agendas in this emerging area of study and investigation.

Keywords Green · Port · Maritime logistics · Environmental sustainability · Literature review · Bibliometric analysis

9.1 Introduction

Emissions from ships and port equipment have long remained out of sight and out of mind, until recently. Concern about the impact of burning high sulphur fuel at sea on adjacent populated areas has led to the introduction of Emission Control Areas (ECAs) where ships are required to switch to low sulphur fuel. Slow

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steaming in the vicinity of coasts and ports, and the use of scrubbers or switching to cleaner fuels like diesel and liquefied natural gas are the alternative greening approaches for maritime transportation (see Chap. 10). Technologies and practices for reducing the environmental footprint of ports may include cold ironing (where ships switch off their generators and plug into landside power supplies), hybrid ferries and hybrid cranes, the electrification of cranes and other equipment, a requirement for slow steaming and/or low sulphur fuel use in the vicinity of ports, vehicle booking systems, and automation (to allow yard operation during the night without lighting). In the context of ship construction, some ships are more environmentally friendly than others by design. Newer ships tend to be more energy efficient than older ones as hull and engine designs improve with time, and engines lose efficiency with age and use.

Given the recent developments in ports and shipping aimed at reducing emissions and improving energy efficiency, it is timely to look at how the corresponding academic research is evolving. This chapter reviews the literature of green ports and maritime logistics to provide some initial statistics of the key journals, authors and institutions contributed to the field, and identify the established research areas/topics with potential for making additional contributions (i.e. literature classification and data clustering).

The first step is to define the appropriate search terms. This is completed through several trial and error attempts to (1) defining an initial set of keywords and search structure, (2) checking the resulting papers and journals to ensure the appropriate coverage, and updating the keywords accordingly, (3) looking for irrelevant papers and research areas, identifying the ‘exclusion keywords’, and updating the keyword structure accordingly, and (4) looking for irrelevant subject areas to narrow down the search space, updating the keyword structure accordingly. Through this process, a sophisticated keyword structure was designed combining a three-level search structure and a four-level search structure (see Table 9.1).

Using the “title, abstract, keywords” search in Scopus database, we collected and stored articles for the keywords identified in Table 9.1. We limited our search space to English ‘journal’ papers published and excluded conference papers, book series, commercial publications and magazine papers. The initial search attempts resulted in *11,279 articles*. Excluding papers from the irrelevant subject areas reduces the number of papers to *2,180 articles* (also shown in Table 9.1). From 2,180 papers in Table 9.1, some papers appear in both three-level and four-level search results. Also amongst these are short non-refereed papers and those published in commercial magazines which are not regarded as scientific contributions. Further refinement of the search results to eliminate duplications, non-refereed articles, commercial magazine papers, and papers with unknown author names results in *338 journal articles* published between 1975 and 2014.

Table 9.1 The proposed search terms and the initial search results

Search keywords	Search results (No. of papers before/after removing unrelated subject areas)	
	Before	After
<p>(a) <i>A four-level search structure</i> Maritime OR port OR harbor OR Harbour OR waterway OR container OR cargo OR bulk Or breakbulk OR deepsea OR shortsea OR sea OR ocean AND Logistics OR supply OR transport OR transportation OR shipping AND Green OR (sustainability environmental) OR (sustainable environmental) OR (sustainability environmentally) OR (sustainable environmentally) OR emission OR (“environmental performance”) OR (“environmental management”) OR emission OR (carbon footprint) OR pollution AND NOT Fisheries OR fishery OR sediment OR algae OR trout OR salmon OR fisherman OR fishermen OR mussel OR molecular OR herring OR larva OR oyster OR (“sea bass”) OR aerosol OR (atmospheric chemistry) OR (atmospheric deposition) OR troposphere OR sewage OR ozone OR microbe OR microbial OR biology OR organism OR animal OR electron OR species OR eutrophication OR odor</p>	10,581	1,711
<p>(b) <i>A three-level search structure</i> (port operation) OR (naval architecture) OR (ship design) OR (ship build) OR (ship construction) OR (harbor operation) OR (harbour operation) AND Green OR (sustainability environmental) OR (sustainable environmental) OR (sustainability environmentally) OR (sustainable environmentally) OR emission OR (“environmental performance”) OR (“environmental management”) OR emission OR (carbon footprint) OR pollution AND NOT Fisheries OR fishery OR sediment OR algae OR trout OR salmon OR fisherman OR fishermen OR mussel OR molecular OR herring OR larva OR oyster OR (“sea bass”) OR aerosol OR (atmospheric chemistry) OR (atmospheric deposition) OR troposphere OR sewage OR ozone OR microbe OR microbial OR biology OR organism OR animal OR electron OR species OR eutrophication OR odor</p>	698	469
Sum	11,279	2,180

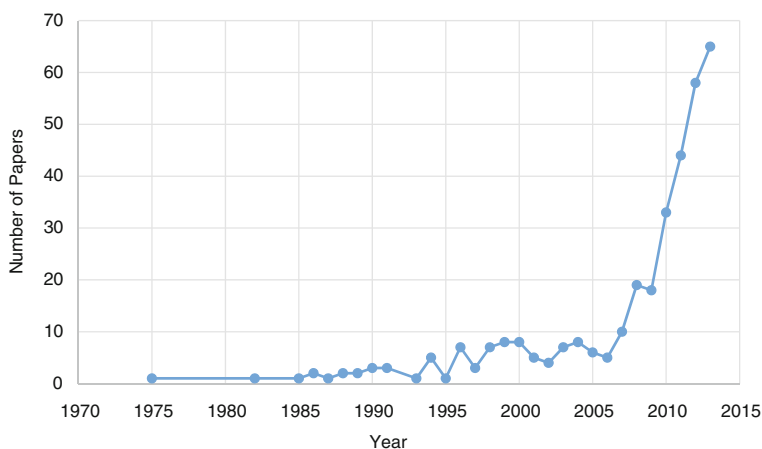
9.2 Initial Data Statistics

The initial statistics shows that 168 journals have contributed to the publication of 338 papers. It was found that ten journals have published 105 of these identified articles, representing approximately 32 % of all the published papers. Table 9.2 shows the top publishing journals and their number of contributing articles. Sustainability and green operations are the primary focus area for many of the key

Table 9.2 The top publishing journals and the quantity of contributed articles

Journal	No. of articles
Transportation Research Part D: Transport and Environment	29
Maritime Policy and Management	14
Environmental Science and Technology	13
Energy Policy	12
Ocean Engineering	10
Marine Technology	7
Transportation Research Part E: Logistics and Transportation Review	7
Science of the Total Environment	6
Transactions of the Royal Institution of Naval Architects Part A: International Journal of Maritime Engineering	5
Journal of Cleaner Production	4
Total	107

journals identified in Table 9.2. However, journals like *Maritime Policy and Management* and *Transportation Research Part E* appearing amongst the top contributing journals may be a good proof of the significance of this research area within the general context of logistics and supply chain management. Figure 9.1 shows the publishing trend using the quantity of publications in a given year. While still in its early growth and expansion period, the area of green ports and maritime logistics is attracting a geometric growth in the number of academic publications. This significant growth is more noticeable after 2006.

**Fig. 9.1** Publication trend in the area of green ports and maritime logistics

9.3 Bibliometric Analysis

We use BibExcel to perform some initial bibliometric and statistical analysis. BibExcel is a tool for analyzing bibliographic data or any data of a textual nature formatted in a similar manner (Persson et al. 2009). BibExcel allows modifying and/or adjusting the input data that can be imported from various databases including Scopus and Web of Science. The data output can be exported to Excel or any program that takes tabbed data records. This high degree of flexibility makes BibExcel a powerful tool, yet relatively difficult to work with especially in performing the initial setups.

BibExcel can be used to analyze the frequency of occurrence of a text in different fields of the bibliographic data. The author field was extracted from the data file and frequency of appearance of all authors was recorded. It was found that only 11 % of 757 contributing authors have contributed to more than one paper, leaving 675 authors appearing in only one paper. Table 9.3 shows the top contributing authors based on the number of published articles. We also completed an analysis to identify the top paired authors (i.e. those appearing on multiple joint papers). Table 9.4 shows the results. Interestingly, seven of the ten top contributing authors (Table 9.3) are also appearing in the list of top contributing paired authors (i.e. Corbett J., Wang C., Kontovas C., Winebrake J., Psaraftis H., Eide M., Lindstad H.).

The affiliations of the authors can also be extracted using BibExcel to provide some statistics on the contributing organizations. The top performing organizations, their geographical locations and the quantity of the contributing papers are shown in Table 9.5. The geographical dispersion of these organizations demonstrates that green ports and maritime logistics has attracted organizations and research centers from around the globe.

A similar analysis is conducted to identify the most frequently used words/phrases in the paper title and the list of keywords. The top 20 words used in paper titles and the top 20 keywords are outlined in Tables 9.6 and 9.7 respectively. From these tables, we find that many of the most frequently used keywords are those related to greenhouse carbon emissions (e.g. greenhouse gas, emission control, carbon dioxide, carbon emission, carbon monoxide, CO₂ emissions, gas emission,

Table 9.3 The top contributing authors

Author	No. of published articles	Author	No. of published articles
Corbett J.	11	Kontovas C.	4
Wang C.	5	Winebrake J.	4
Psaraftis H.	4	Deniz C.	4
Eide M.	4	Chen G.	3
Lindstad H.	4	Yang Y.	3

Table 9.4 The top contributing paired authors

Author 1	Author 2	Number of joint publications
Corbett J.	Winebrake J.	4
Corbett J.	Wang C.	4
Cheng T.	Lai K.	3
Kontovas C.	Psaraftis H.	3
Eide M.	Longva T.	3
Lai K.	Wong C.	3
Asbjørnslett B.	Lindstad H.	3
Cheng T.	Wong C.	3

Table 9.5 The top performing organizations

Organization	Country	No. of papers
Department of Marine Engineering, Istanbul Technical University	Turkey	4
Centre for Maritime Studies, University of Turku	Finland	3
Department of Shipping and Transportation Management, National Kaohsiung Marine University	Taiwan	3
Federal Institute for Health Protection of Consumers and Veterinary Medicine	Germany	3
Department of Biological and Environmental Sciences, University of Helsinki	Finland	3
Department of Civil and Environmental Engineering, University of California	United States	3
College of Marine and Earth Studies, University of Delaware	United States	3
Department of Logistics and Maritime Studies, Hong Kong Polytechnic University	Hong Kong	3
Graduate School of Logistics, Inha University	South Korea	3

Table 9.6 The top 20 words/phrases used in the list of keywords

Frequency	Keyword phrase	Frequency	Keyword phrase
91	Ships	34	Gas emissions
70	Shipping	30	Marine pollution
65	Greenhouse gas	28	Energy efficiency
58	Emission control	27	Environmental protection
57	Carbon dioxide	27	Maritime transportation
50	Air pollution	27	United States
45	Article	25	Environmental impact
35	Nitrogen oxides	24	Cost-benefit analysis
35	Oil spill	24	Port operation
34	Carbon emission	23	Exhaust emission

Table 9.7 The most frequently used words in paper titles

Frequency	Word	Frequency	Word
102	Emission	27	Energy
51	Ship	26	Green
48	Shipping	24	Vessel
35	Environment	24	Oil
35	Port	23	Transportation
35	System	23	Analysis
35	Marine	22	Design
29	Container	22	CO ₂
29	Case	22	Study
28	Maritime	21	Gas

carbon footprint, carbon dioxide emissions, carbon, carbon oxide, CO emissions, and CO₂). Nitrogen oxide, oil spill and sulfur dioxide are the next popular keywords after carbon-related keywords.

9.4 Literature Mapping

A network analysis (including a citation analysis and a co-citation analysis) of the published papers is now completed using Gephi, an open source software package that uses a 3D render engine to develop illustrations of large networks in real-time and assist in speeding up the exploration process (Gephi 2013). Gephi provides easy and broad access to network data and assist in specializing, filtering, navigating, manipulating and clustering of data (Bastian et al. 2009).

Different methods have been used in the past to measure the significance of a paper. The most common method is a citation analysis which aims to determine the ‘popularity’ of a paper by counting the number of times a paper is cited by others in a given network (Cronin and Ding 2011). Ding et al. (2009) argue that in addition to ‘popularity’ of a paper measured by the number of citations, the ‘prestige’ is another important indicator which is the number of times a paper is cited by highly cited papers. In other words, a popular paper (a highly-cited paper) may not necessarily be a prestigious paper although in some cases there might be a strong positive correlation between the two measures. PageRank is therefore used as a measure for both popularity and prestige.

Gephi is able to evaluate the importance of articles based on their PageRank. A total of 80 papers out of 338 cite each other which are used for PageRank analysis. Table 9.8 shows the top ten papers based on a PageRank measure. For these papers, the table also shows the number of citations (both local citation and global citation), the pure ‘popularity’ measures. Clearly, a higher number of local and global citations cannot guarantee a higher PageRank value (e.g. Corbett and Fischbeck (2000) vs. Corbett et al. (2009), and Tzannatos (2010)).

Table 9.8 Top 10 papers using a PageRank citation measure

Paper	PageRank	Local citation ^a	Global citation ^b
Bailey and Solomon (2004)	0.0348	7	46
Corbett and Fischbeck (2000)	0.0308	5	34
Corbett et al. (2009)	0.0298	7	80
Wang et al. (2007)	0.0209	3	37
Eide et al. (2009)	0.0190	2	35
Corbett (2002)	0.0185	3	14
Corbett and Robinson (2001)	0.0185	2	7
Tzannatos (2010)	0.0185	2	28
Höfer (1998)	0.0185	2	4
Gallagher (2005)	0.0183	2	12

^a*Local citation*: the number of citations within the pool of 338 papers

^b*Global citation*: the number of total citations based on Scopus

A co-citation network consists of a set of nodes representing journal articles and a set of edges/links representing the co-occurrence of the nodes/articles in other papers (Leydesdorff 2011). Therefore, two publications are called to be co-cited if they appear together in the reference lists of other documents. That is if both document A and B are included in reference list of paper C, then A and B are co-cited. It is proven that papers which are more often cited together are more likely to present similar subject areas or be related (Hjørland 2013). The initial co-citation mapping with Gephi revealed that there are only 30 articles out of a total of 338 that have been co-cited by other papers within this sample.

The nodes of a network can be divided into clusters or modules where the density of edges is greater between the nodes of the same cluster compared to those of different clusters (Radicchi et al. 2004; Clauset et al. 2004; Leydesdorff 2011). Where nodes represent articles in a literature network, a cluster can be seen as a group of well-connected articles in a research area with limited connection to papers in another cluster or research area. Data clustering can be used as a classification tool for grouping of a set of given articles (Radicchi et al. 2004). Clustering allows for the topological analysis of networks, identifying topics, interrelations, and collaboration patterns. Modularity has received increasing attention from scholars turning it into a critical research field in social network analysis (Blondel et al. 2008).

The default modularity tool in Gephi is based on the Louvain algorithm, an iterative optimization model that aims to determine the optimal number of partitions that maximize the modularity index (Blondel et al. 2008). Applying this algorithm to the proposed 30-node citation network resulted in the creation of seven clusters. Papers of each cluster are cited together more often and these papers are more likely to present similar subject areas (Hjørland 2013). To identify the area of research focus for each cluster (i.e. characterizing/labeling of clusters), we carefully evaluated the contents and research areas of all papers. Table 9.9 summarizes the areas of research focus for each of the seven clusters. We recognize these seven clusters as

Table 9.9 Data clustering results

Cluster	Research area
1	Emissions (e.g. evaluation of emissions from vehicles, emissions mitigation strategies: their costs and benefits)
2	Eco-efficiency (e.g. berth allocation strategies, bunker consumption optimization, bunker levies, low carbon shipping)
3	Energy eco-efficiency (e.g. energy intensity and economic costs)
4	Climate change policy, regulation and carbon tax
5	Carbon footprint case studies
6	Ship mobility emissions (e.g. emissions from maneuvering ships, direct and feeder services)
7	Ship design (e.g. energy efficiency and cost effectiveness)

the primary areas of research focus within the context of green ports and maritime logistics. It is expected that research in all clusters as well an interdisciplinary multi-cluster research continue to grow within the next decade or so.

9.5 Conclusions

This chapter examined the evolution of the literature of green ports and maritime logistics by providing some author, affiliation and keyword statistics as well as identifying the primary research clusters through citation and co-citation analyses. Overall, while still in its early growth and expansion period, it is expected that the field will continue to grow in a number of directions as suggested by our data clustering results. Most of the research clusters have been shaped around emissions reduction, eco-efficiency, and the related environmental regulatory policy issues. This is not surprising given the global emissions reduction trends. It is expected that research in all clusters as well an interdisciplinary multi-cluster research will continue to grow as practitioners and governments face challenges that research can help solve.

Despite the interesting results of our literature mapping and data analysis, limitations do exist. The keyword structure was designed through a number of trials to ensure the most effective and feasible search space. However, there may still be some related works that this keyword structure has not captured. In addition, the literature mapping and network analysis methodology presented in this paper shows how a subject area can be objectively reviewed to identify the key papers and investigators. However, the methodology is not able to interpret the knowledge in these papers to explore the reasons why particular papers have been central to the development of the field. Future review efforts can focus on the development of tools and methodologies to address these limitations.

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