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Editorial

Sustainability Challenges in Maritime Transport and Logistics Industry and Its Way Ahead

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Abstract: Sustainability issues in the field of shipping, port and maritime logistics, commonly known as the maritime transport and logistics industry, have historically received less stakeholder attention as compared to aviation and overland freight sectors. However, as International Maritime Organization (IMO) regulations on ships and port/city interaction has increased since 1997, the stakeholders in the industry have gradually started paying attention to sustainability issues, across all the sectors, such as, aviation, land transport, and supply chain. As a result, the industry has accumulated a significant body of academic research outcomes over the last two decades. This Special Issue aims to examine the various themes in recent sustainability studies, particularly relating to shipping, port, and maritime logistics, and identify and discuss the key topics emerging in sustainability in the industry. It will contribute to increasing industry stakeholders' understanding of the current situation in sustainability, assist them in the design of appropriate managerial insights and help them develop appropriate sustainability policies for the industry.

Keywords: sustainability; shipping; port; maritime logistics; maritime transport

1. Introduction

As far as sustainability issues in the shipping, port, and maritime logistics sectors (hereinafter *maritime transport and logistics*) are concerned, the International Maritime Organization (IMO) has great influence, directly and indirectly, because the IMO Convention describes its fundamental purpose as the conservation and "sustainable" use of oceans and their resources. As a result, the IMO has adopted several protocols and regulations in association with the United Nations Convention on the Law of the Sea (UNCLOS), such as the London Convention and Protocol (LC/LP), the Hong Kong Ship Recycling Convention and Annex VI Prevention of Air Pollution from Ships (entered into force 19 May 2005) of the International Convention for the Prevention of Pollution from Ships (MARPOL). In particular, thanks to "the 2030 Agenda for Sustainable Development" with 17 Sustainable Development Goals (SDGs) adopted by the UN on September 2015, the IMO, as a part of the UN, has developed several important regulations related to the SDGs as listed above.

Broadly, sustainability covers three key dimensions such as environmental, economic, and social, which are applied to many areas, including maritime transport and logistics [1]. Out of the three, the environmental dimension is widely addressed in the literature (e.g., [2–10]), mostly in relation to ships and port equipment. The former generates gas emissions at sea, in particular, in emission control areas (ECAs), and within ports, while the latter does, in association with the former and container trucks within ports. This Special Issue, however, does not consider the gas emissions generated by container trucks on the road from the origin of the cargoes to the ports. While ships are calling at, and loading/discharging cargoes in, ports, they emit greenhouse gas (GHG), such as NOx, Sox, CO2, and particulate matter (PM). Recent literature has estimated the GHG amount emitted [11–16] and the impact on the health of residents living adjacent to the ports [17–19]. However, international organizations and stakeholders are less active in dealing with environmental issues in the shipping and port sector because the sector has not only less interaction with cities but is also remote from city life as compared to the aviation and overland transportation sectors. Among the several international organizations, the IMO has played the leading role in taking several measures to reduce the GHG from ships in collaboration with ship owners/operators and shipbuilders. The key measure is the MARPOL Convention which was adopted on 2 November 1973 at IMO. Since then, several related annexes have been adopted. In 2011, IMO adopted mandatory measures to reduce greenhouse gas (GHG) emissions from ships' exhausts. The Annex VI regulates limits of SOx, NOx, and particulate matters (PMs) emissions from ships, prevents emissions of ozone-depleting substances and designates emission control areas (ECAs) with standards for the three gases. The IMO has designated four regions as ECAs: The Baltic Sea, the North Sea, the US Caribbean and the coastal waters of Canada and the United States. Responding to the IMO's initiative for ECAs and recognizing that the sulfur levels in marine bunker fuel alone are 100 to 3500 times higher than that permitted in on-road diesel fuel in China, the Chinese government has taken an experimental measure to introduce ECAs in January 2019. A report shows estimated data that "a medium- to large-size container ship running at 70% maximum power for one day using bunker fuel with 35,000 ppm (3.5%) sulfur emits as much PM2.5, equal to the average of half a million new trucks in China in the same time period" [20]. If winds blow from the East Sea to the Chinese land side, the large amounts of gas emissions may affect residents of the cities along the Chinese coastline. Therefore, sustainability across all three dimensions, i.e., economic, environmental and social, is imperative to minimize economic and social costs, to reduce environmental impacts caused by such ship operations, and to improve residents' health.

Out of the three dimensions of sustainability, the social dimension is becoming a major point of policy focus because some ports'/cities' interfaces have been affected by ships' exhausts. SOx, NOx, and PMs and the other ship emissions from port-related activities are said to cause lung cancer and heart-related diseases. Cruise ships are more to blame for emitting the above gases than cargo ships because the former are normally berthed nearer city centers. Like all major port cities in Europe, people living in Asian port cities, among others, Hong Kong, Shanghai, and Singapore are more exposed to highly polluted air due to the fastest growing cruise industry in the world. NABU estimates the amount of pollution caused by cruise ships in large German ports and concludes that "heavy fuel oil can contain 3500 times more sulphur than diesel that is used for land traffic vehicles" [21]. In dealing with the three dimensions of sustainability, we need to consider externalities arising from gas emission. Tzannatos [22] attempted to analyze ship gas emission in association with externalities. Despite the fact that the IMO has been implementing green shipping and port initiatives to reduce GHG from ships and port activities, it seems that sustainability in the maritime transport and logistics requires proactive measures referring to land transport and aviation sectors.

In the existing literature, three notable special issues have tried to deal with sustainability in shipping and ports [23–25]. The Special Issue of *Transportation Research Part D* edited by Cullinane and Bergqvist [23] focused on the following issues: The comparison of three options complying with ECA sulphur and NOX tier III regulation; costs and benefits analysis of sulphur reduction measures; discussion on energy replacement with liquefied natural gas (LNG) in ECAs; discussion on the limitations of the financial assessment of technologies assisting compliance with the sulphur regulations of MARPOL Annex VI; the future low-sulphur fuel requirements in Sulphur Emission Control Areas (SECA); case studies of SECA application to the North and Baltic Sea and the Mediterranean Sea; and estimation of emissions of noxious gases from vessel operations in a potential ECA in the Port of Incheon.

Another Special Issue—*Transportation Research Part E* edited by Cheng et al. [24]—covered the following topics: decision support to improving sustainability in maritime shipping; sustainability ranking of the UK major ports by an Analytic Hierarchy Process (AHP) method; application of scenario technique to assess total CO_2 emissions and costs of UK import trade re-routing containers; slow steaming sustainability initiatives to explore optimal speed decisions; a sustainable maritime supply chain design by Quality Function Deployment (QFD) and Analytical Network Process (ANP) from the viewpoint of customer requirements; and a proposal of environmental governance mechanisms to enhance shipping firms' environmental performance.

The other Special Issue, under the title *Transportation Research Part D* edited by Lee et al. [25], included five papers, of which the topics are: A vessel speed reduction program introduced by the Ports of Los Angeles and Long Beach to minimize gas emission by co-operation between shipping company and ports; development of a conceptual framework with institutional theory to empirically evaluate the impact of institutional pressures, internal green practices, and external green collaborations on green performance; development of a resilience system to avoid unnecessary poor green performance in the case of disruptions of truck arrangement within a container terminal; an investigation of strategic responses of inland ports (dry ports) to institutional forces pressuring their adoption of sustainability practices, applying institutional theory; and an estimation and analysis of ship exhaust emissions and their externalities, taking cases of two ports, Dubrovnik (Croatia) and Kotor (Montenegro) in the Adriatic Sea.

Cullinane and Bergqvist [23] contributed to the expanding literature related to ECA in association with quantitative analysis and legal aspects. Cheng et al. [24] covered the sustainability issue in terms of shipping, port and supply chain. Lee et al. [25] focused on the reduction and estimation of gas emission for achieving green shipping and ports and framework and key performance indicators to evaluate green shipping and ports. Having considered the limited scope and number of sustainability issues in the three special issues in terms of sustainability in maritime transport and logistics, this Special Issue aims to enrich and expand the existing literature in the topic.

2. Sustainability Issues in Shipping, Port and Maritime Logistics

The eight choice papers for this Special Issue have been collected from open invitation through the Sustainability journal website and two international conferences: The 1st international conference on Yangtze-River Research Innovation and Belt, held in Ocean College, Zhejiang University in Zhoushan City, China on 2–5 December 2018 and the 3rd International Conference on the Belt and Road Initiative in association with the Asian Logistics Round Table, held in Vietnam RMIT University in Ho Chi Minh City, Vietnam on 24–26 June 2018.

Shin et al. (Contribution 1) conducted a comprehensive literature review of sustainability published in maritime-related journals between 1993 and 2017, applying a generative probabilistic text-mining technique, called latent Dirichlet allocation (LDA) [26]. The journals cover transportation, logistics, shipping, and port-related topics and are listed on the science citation index (SCI), science citation index expanded (SCIE) and social science citation index (SSCI). A total of 155 papers were collected for the study. LDA can capture topics on shipping, port, maritime logistics issues in sustainability in terms of keywords frequency, their betweenness centrality, their network for co-occurrence of the papers, and co-authorship by country, affiliation, and collaboration between authors, respectively. One interesting result in this paper is that there are 18 high-frequency keywords above five occurrences which are related to maritime sustainability. Leaving aside sustainability, the term "management" has the highest occurrences, followed by "port," "emission," "impact," and "performance." For the shipping and port sector, these issues are related to green ports/shipping, carbon emission/climate change and region-specific environmental regulation/management. For the maritime logistics sector, sustainability issues are generally related to achieving optimal logistics systems, sustainable supply chain design, and service quality management. Another interesting test result shows that, recently, the keywords in sustainability studies in maritime transport and logistics have considered governance, corporate social responsibility, and supply chain management. Therefore, it can be said that this paper contributes to figuring out research trends and research networks in sustainability in maritime transport and logistics over the last 25 years using a solid technique, LDA.

Having considered both trade-off analysis and environmental policy intervention analysis, Dai et al. (Contribution 2) developed a comprehensive decision framework for a port-hinterland distribution network in the Yangtze River Economic Belt (YREB) encompassing road, railway, and inland waterways with a three-mode hybrid port-hinterland intermodal distribution network [27]. To minimize logistics costs and CO2 emissions generation, the authors designed a bi-objective decision framework to deal with policy intervention scenarios, taking into account emissions control policies, taxation policy, and emissions trading schemes. The decision framework developed in their paper contributes to offering comprehensive insights for shippers on strategic decisions about optimized intermodal and terminal, and flow distribution under various emissions control policies. The test results show that the transport flows on direct road from inland cities to gateway ports are insensitive to all policy intervention scenarios and that rail transport in the integration of road, railway, and waterway modes have more benefits than other transport modes under all policy intervention scenarios. It implies that policymakers should consider the conflict between logistics costs and carbon emissions under each policy intervention scenario. This study is unique because it is not replicated in the two previous special issues. It contributes to internalizing the carbon emissions effects by employing the emissions trading scheme, so-called cap-and-trade, considering the YREB region in Central China and its port-hinterland intermodal logistics network.

Arguing that the two port cities, Guangzhou and Shenzhen, are not two separate entities, but they are interdependent and cross-influential, Lam and Yap (Contribution 3) reviewed existing sustainability frameworks and conducted a stakeholder analysis for port city sustainable development by case study methodology, taking the cases of the two port cities in South China. The authors conclude that the stakeholders in both Guangzhou and Shenzhen aim to connect them to the Belt and Road Initiative, which provides vast opportunities in developing economic and transport connectivity along the Belt and Road in tandem with trade growth [28]. The port-city interface is not only driven by several external forces such as changes of port function, conflicts between the port authority and local government, environmental issues caused by port users' services and activities [29]. The two authors identify port city stakeholders and their objectives to investigate port city sustainable development through the analysis of existing sustainability frameworks. The three key dimensions of sustainability, i.e., economic, environmental, and social, are applied to compare Shenzhen and Guangzhou port cities. First, they draw three implications: (1) In terms of the economic aspect, China's Belt and Road Initiative (BRI) since 2013 provides vast opportunities in trade growth; (2) that for the social aspect, both port cities have a challenge arising out of the limited availability of coastal land for seaport terminals and city waterfront developments; and (3) that for the environmental aspect, they have the common problem of water and air pollution. Lam and Yap recommend that the port cities take innovative actions to explore new technologies to improve productivity and safety and to reduce negative ecological impacts simultaneously so that they can address the economic, social, and environmental dimensions of sustainability. This paper contributes to highlighting sustainability issues in port/city interfaces, taking cases of Shenzhen and Guangzhou.

Considering that coastal wave energy is attracting more attention as a source of clean energy for ports, Li et al. (Contribution 4) developed a decision framework to evaluate decisions on investment in wave energy. The authors proposed a model by considering the electricity generated from wave energy as a newsvendor-type product. Such a model for single-period inventory decisions under uncertainty is being widely used to understand optimal decision behaviors in industry supply chains. Assuming the electricity supply chain with a single port, a single user of electricity and investor in wave energy converters, and a single electricity plant, the authors constructed a newsvendor model for the optimization of construction of wave energy converters and production and wave energy electricity when the wave supply is uncertain. They performed numerical experiments for various scenarios having different demand levels of electricity, supply uncertainty of electricity generated from the wave energy, construction cost of wave energy converter, production costs of both electricity by wave energy and traditional electricity, price and salvage value in the electricity market. The authors derived several managerial insights and policy suggestions from simulations. The results showed that the salvage value of wave-energy is a critical mediator in the investment of ports to wave energy converters. They suggested that the government could encourage the port to invest more in wave energy by offering some subsidies either to reduce the construction or to increase the salvage value of wave-energy to the market. The authors also extended the distribution-free model when the information of wave-energy supply is available. The paper logically analyzed the economy of coastal wave energy for port operations from the supply chain perspective and suggested meaningful policy implications to boost the use of clean energy towards green port development.

Project planning and scheduling problems have been widely explored in many industries. Recently, industries are paying more attention to developing green projects to achieve environmental, economic, and social sustainability goals. The literature reveals that green project planning (GPP) has not been effectively investigated. Wang et al. (Contribution 5) investigated green project planning of ports to minimize the total costs and maximize the total emission reduction. The GPP problem is to determine the construction sequence and construction proportions of green projects by year for the planning period. To achieve green development goals, it should consider not only the total costs involved in project construction but also the total CO_2 emission reduction. The authors proposed a multi-objective optimization problem to plan the construction sequence of planned green projects considering a number of important constraints including budget, CO_2 emission reduction goals, and project duration and sequence. To address the problem, the research adopted a weight sets-based multi-objective evolutionary optimization approach, in which a single-objective evolution optimization process was performed to seek the best solution for each weighted sum single-objective problem. The numerical experiment using the data collected from a representative coastal port in the central and western regions of China. Based on the simulation, the authors have proved that the proposed algorithm can effectively reduce the computation time, but does not decrease the optimization performance, in comparison to common approaches such as the fast elitist non-dominated sorting genetic algorithm II (NSGA-II). This paper incorporated multi-objective considerations in green project planning of ports and also proposed an effective solution approach to deal with the real-world combinatorial optimization problem.

Building well-connected container transport networks from the ports is highly important, especially for an economy that is largely dependent on exports. In addition, better port connectivity with inland container networks has a significant impact on port services to local shippers as well as port productivity and efficiency. There are some well-known connectivity indicators in the field of transportation such as the air connectivity index (ACI) and the liner shipping connectivity index (LSCI). Li et al. (Contribution 6) proposed a simple but very practical transport network connectivity index (TNCI) to measure the container transport connectivity from a multi-modal perspective. TNCI is calculated from the capacity utilization ratio, the variance in cargo flow, the capacity and the cargo flow of all links connecting the nodes in the network. The case study was performed for container cargo flows of Busan, Gwangyang, and Incheon, which account for about 96% of total container port throughput in Korea. The TNCI was calculated to examine how Korean ports are well-connected with an inland multi-modal container transport network. The indicators also allow policymakers to find bottlenecks in inland container transport networks. This paper contributes to policy and port operations strategies by suggesting practically applicable connectivity measures for a multi-modal container transport network.

Vietnam has recently been experiencing rapid growth in trade volumes. The role of ports and port logistics companies is becoming increasingly important in supporting fast-growing exports and imports. Recent Logistics Performance Index analyses show that the logistics competitiveness of Vietnam ranked relatively low. As a part of efforts to improve the competitiveness of Vietnamese port logistics industry, Wang et al. (Contribution 7) performed the efficiency analysis for two airports and six seaport logistics companies in Vietnam from 2011 to 2022. The super- Slacks-Based Measures (SBM) model was used to analyze the efficiency ranking of eight logistics companies, as a way to clearly differentiate the efficiency scores among decision making units (DMUs). Several additive trend methods were examined and the additive Holt-Winters method was chosen to obtain the forecasts for input and output variables for the efficiency analysis of ports. The analysis showed that Da Nang Port always maintains the most efficient position and Noi Bai Cargo Terminal ranks in second position. The paper adopted an integrated approach to analyze the efficiency of port logistics companies by combining the forecasting and Data Envelopment Analysis (DEA) models in the research framework. It also gives valuable insights into the performance of Vietnamese port logistics industry in recent years.

The Chinese government recently introduced several policy initiatives that will influence port and maritime industries. In July 2017, Ministry of Transport and National Development and Reform Commission deregulated the port pricing mechanism. Port tariff and charging method with regard to pricing will be transformed from government pricing to government guidance. Another important policy initiative is to promote the regional port integration, which is motivated by the success case of the Ningbo-Zhoushan Port in August 2017. Under such port reform policies, deregulation and regional port integration will be accelerated to increase port competition and efficiency and to optimize resource allocation between regional ports. Dong and Zhong (Contribution 8) developed a game model to explore the possibility and degree of tacit collusion in the pricing strategy between regional ports under new environments with the deregulation of the port tariff and the development of regional port integration, particularly in the YREB. "Will the regional ports fiercely compete or tacitly collude in order to get more benefits for itself or themselves?" is one of the interesting questions explored using the proposed model. The authors suggested that the regional port's pricing strategy can be seen as a game under the Bertrand model. They formulated the game models—simultaneous game, sequential game, repeated game—to analyze three different scenarios of pricing decisions. The model is applied to regional ports in the YREB. The results revealed that tacit collusive pricing behavior exists under the deregulation of port tariffs. They concluded that the government should pay attention to monitoring and supervising to prevent tacit collusion that may lead to substantial welfare loss in the process of regional port integration. The paper contributes to increasing logical understanding of the pricing strategies under different regulative environments.

3. Concluding Remarks with Future Research Agenda in Sustainability Studies

Since the concept of sustainability appeared at the world's first Earth Summit in Rio de Janeiro in 1992, it has been widely applied by industries, governments, and international organizations. It is no exception in the field of shipping, port and maritime logistics, i.e., maritime transport and logistics. Furthermore, since the IMO adopted an International Convention Protocol to achieve sustainable maritime development in 1992, it has taken a series of proactive measures to reduce GHG caused by shipping and ports and their related activities at sea and in the marine environment. Sustainability issues in maritime transport and logistics have been dealt with in the transportation and economic studies. However, its research significance and scope were fragmentary in those research domains. On top of that, three special issues of the two international journals [23–25], contributed to covering sustainability issues in maritime transport and logistics, the topic scope and number of the papers appeared in them are still limited. Having said that, this Special Issue attempted to further enrich the literature of sustainability in shipping, port and maritime logistics. The eight papers included in it addressed the following topics: A comprehensive review of sustainability studies in shipping, port and maritime logistics with 155 papers published in 1993–2017; a port-hinterland freight intermodal distribution network considering policy intervention with tax incentives, taking the Case of the Yangtze River Economic Belt in China; port/city sustainability development from the perspective of their stakeholders; optimization of coastal wave energy supply for green port development; port sustainability analysis referring to port integration in China, applying a game theoretical model; sustainable container transport network in Korea in terms of efficient connectivity; evaluation of port service performances in Vietnam for attaining suitability; and green project planning with the realistic consideration of multiple objectives between minimizing the total cost and maximizing the total emission reduction. Although this Special Issue has not had enough room to cover all the key topics of sustainability in maritime transport and logistics, it has contributed to expanding sustainability studies to the integrated topics of shipping, port, maritime logistics into hinterland, energy supply, intermodal transport as well as case studies in China, Korea, and Vietnam.

Before closing this section, the guest editors would like to highlight emerging research topics of sustainability in maritime transport and logistics, referring to their observations and experience in preparing this Special Issue. First, further studies on achievement, performance, and implementation of sustainability in the port sector are necessary to take into account port governance, port development strategy [30], port generation type [31], and port development doctrines [32,33] because they will influence implementation and policy of sustainability subject to the central government's role and intervention policy. Second, as far as case studies of sustainability in China are concerned, in the context of the BRI, they may have to consider economic and/or transport corridors covering intermodal transport and dry port [28,34,35]. Third, the introduction of ECAs into China is expected to accelerate studies on the ECAs referring to existing studies (e.g., Cullinane and Bergqvist [23]). In doing so, further studies are required to consider peculiarities in shipping and the port sector to be made by behavior patterns of shipping companies, port integration policy, and the river–sea combined transport system in China [36,37]. Finally, research is required to explore what kind of methodologies have been applied to the sustainability topics in terms of its frequency and its applied life cycle and others [38,39], applying a mapping technique (Countribution 1).

4. List of Contributions

1. Shin, S.-H.; Kwon, O.K.; Ruan, X.; Chhetri, P.; Lee, P.T.-W.; Shahparvari, S. Analyzing sustainability literature in maritime studies with text mining.
2. Dai, Q.; Yang, J.; Li, D. Modeling a three-mode hybrid port-hinterland freight intermodal distribution network with environmental consideration: The case of the Yangtze River economic belt in China.
3. Lam, J.S.L.; Yap, W.Y. A stakeholder perspective of port city sustainable development.
4. Li, L.; Zhu, J.; Ye, G.; Feng, X. Development of green ports with the consideration of coastal wave energy.
5. Wang, W.; Chen, J.; Liu, Q.; Guo, Z. Green project planning with realistic multi-objective consideration in developing sustainable port.
6. Li, K.X.; Park, T.J.; Lee, P.T.W.; McLaughlin, H.; Shi, W. Container transport network for sustainable development in South Korea.
7. Wang, C.N.; Day, J. Der; Lien, N.T.K.; Chien, L.Q. Integrating the additive seasonal model and super-SBM model to compute the efficiency of port logistics companies in Vietnam.
8. Dong, G.; Zhong, D. Tacit collusion of pricing strategy game between regional ports: The case of Yangtze River Economic Belt.

Author Contributions: Introduction, P.T.-W.L.; Summary of the papers included in the Special Issue, O.K.K. and P.T.-W.L.; Concluding remark, X.R.; Research agenda, P.T.-W.L.; Writing-Original Draft Preparation, P.T.-W.L.; Writing-Review & Editing, O.K.K. and X.R.; Funding Acquisition, O.K.K. and P.T.-W.L.

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