TOWARDS SUSTAINABLE PORT DEVELOPMENT MODEL: A COMPARATIVE ANALYSIS BETWEEN SINGAPOREAN AND KOREAN PORTS

Saeyeon Roh[1], Vinh V. Thai[2*], Gi-Tae Yeo[3], Hyun-Mi Jang[4], Yiik Diew Wong[5]

[1]Plymouth University, Plymouth, United Kingdom
E-mail: rohsae@hotmail.com
[2] RMIT University, Melbourne, Australia
E-mail: vinh.thai@rmit.edu.au
[3]University of Incheon, Incheon, South Korea
E-mail: kyteo@inu.ac.kr
[4]Korea Maritime Institute, Busan, South Korea
E-mail: jangh@kmi.re.kr
[5]Nanyang Technological University, Singapore
E-mail: cydwong@ntu.edu.sg

Introduction

Increasing environmental pressure and awareness such as the impact of climate change posit new challenges to port development which, in turn, call for measures that aim at minimizing their impact and pursuing sustainable operations. In this respect, several legislations relating to the construction and extension of ports have been timely introduced at both international and national levels in an attempt to minimize the environmental impacts and pursue sustainable operations in the long run. Based on stricter standards, these legislations aim to incorporate environmental issues into core strategies of port development. Therefore, sustainability is increasingly seen as one of the key drivers of port development in the next decades.

Pots must plan and manage their future developments (growth and expansion) and operations in a sustainable manner in order to cope with the limited or decreased environmental space and intensified interactions with their hinterlands. The required harmony of ports with their surrounding cities clearly renders green growth an important economic driver (Black, 1996). In this respect, several studies have been conducted to measure ports' sustainable performance (i.e. Lirn et al. 2012; Wiegmans and Louw, 2011; Chin and Low, 2010: Tsinker, 2004). Nevertheless, there is little knowledge which describes clearly and comprehensively what sustainable port development actually entails or, in other words, what are included in terms of sustainable port development indicators. This study therefore aims to investigate the main factors that shape sustainable port development and their priorities from the perspectives of Singaporean and Korean Ports. It also aims to examine how these ports practise sustainable development so as to suggest academic, managerial and policy implications.

Literature Review

Environmental management is increasingly practiced as an essential business plan component of any operation that claims to be sustainable, efficient and compliant with legislations. This is particularly evident in port activities (Puig et al. 2015). Implementing environmental programs and green marketing strategies would lead to better environmental performance (Gimenez et al. 2012; Rao, 2002; Zhu and Sarkis, 2004) and firm competiveness (Yang et al. 2013). Promoting and practicing ISO 14001 series would enhance firms' environmental performance (Saengsupavanich et al. 2009; Yang et al. 2013).

Activities to reduce environmental damages are consistently needed as well (Wagner and Schaltegger, 2004; Yang et al. 2013; Zhu et al. 2007). Monitoring programs are implemented to reduce the cases of having business partners acting unethically or even illegally in terms of environmental and/or social issues (Carter and Rogers, 2008; Simpson and Power, 2005). In this regard, it is found that audits, evaluation, assessment practices of business partners have positive impact on environmental performance (Saengsupavanich et al. 2009; Yang et al. 2013).

It is important for port authorities to continuously collaborate with shipping companies in reducing environmental impacts such as reducing CO_2 emissions (Buhaug et al. 2009; Qi and Song, 2012), practicing low sulphur content emissions or vessel speed limit (Lai et al. 2011; Puig et al. 2014; Yang et al. 2013), and adopting environmental-friendly materials, equipment and design (Yang et al. 2013). It is also suggested that regular exercises of Port State Control for ship inspection are needed for sustainable development ports (Saenguspanvanich et al. 2009).
Meanwhile, internal social programs such as employee welfare, education and training play an important part in environmental management (Wu and Goh, 2010) as they have been positively related to the reduction of potentially damaging environmental practices and can lead to improvements of environmental performance (Florida, 1996; Gimenez et al. 2012; Marshall et al. 2005).

Success in addressing environmental management could improve a firm's image (Hick, 2000; Shrivastava, 1995) and provide new opportunities for firms to enhance their capabilities (Hansmann and Claudia, 2001). Gimenez et al. (2012) argued that the use of more environmentally friendly materials and processes can lead to resource reduction and efficiency resulting in reducing costs. Profitable firms can afford to make sustainable investment in green activities to raise their environmental performance (Stefan and Paul, 2008).

Greater collaboration among members of the supply chain is a key component not only to foster the development of improved environmental practices and reduced pollution (Gotschol et al. 2014; Vachon and Kassen, 2006) but also benefit supply chain members from the economic and environmental point of view (De Giovanni and Zaccour 2014). Yang et al. (2013) indicated that external green collaboration has positive impact on green performance and firm competiveness. Firms that integrate environmental responsibility in their economic strategies can achieve cost savings from resource reduction and efficiency while increasing revenue generated from improved stakeholder relations and brand image (Hart, 1995; Hoffman and Ventresca, 1999). Rao and Holt (2005) and Zhu and Sarkis (2004) also found that environmental programs that include both collaboration and assessment of business partners have a positive impact on economic performance.

It is nowadays believed that socially responsible firms, which contribute both economically and ethically to the society and local communities they serve, are better positioned to grow in terms of reputation and revenues (Drobetz et al. 2014). Environmental programs have positive effects on internal and external communities (Gimenez et al. 2012; Pullan et al. 2009). The adoption of a process that generates less pollution improves the working conditions as well as supporting community projects which may result in improvements to a firm's social performance and reputation. In the context of ports, relationship with the local community to promote positive image and building trust through various efforts from port authorities has been implemented (Saengsupavanich et al. 2009; Puig et al. 2015). Meanwhile, increased CSR reporting enhances firm's transparency and lowers information costs on the part of investors, potentially leading to positive financial effects (Drobetz et al. 2014).

Methodology

This study adopted multi-phased mixed methods, combining semi-structured validation interviews and Analytical Hierarchy Process (AHP). First, the main indicators for sustainable port development were identified through a comprehensive literature review. Secondly, for validation purpose, a semi-structured interview questionnaire was constructed based on the literature including internal and external management aspects of sustainable development following the previous studies of Gimenez et al. (2012), Gotschol et al. (2014) and Yang et al. (2013). The interview questionnaire was distributed via email to 17 ports in Korea and two ports in Singapore. A total of 67 responses from Korean port managers in three major ports in Korea (Busan, Incheon, Gwangyang) and two from Singaporean port managers were received. Lastly, after validating the sustainable port development indicators, AHP analysis was conducted to prioritise the identified sustainable port development factors.

Phase 1: Validation of Sustainable Port Development Factors

Since there is scarce literature on important factors of a sustainable port development model, semi-structured interviews were conducted to validate the sustainable port development factors and indicators which were derived from sustainable development studies in the supply chain and shipping literature. The objective of these validation interviews was to verify sustainable port development factors from port managers' point of view.

The interview questionnaire was distributed via email from August to November 2015 to 17 ports in Korea. In total, 67 responses from Korean port managers in three major ports in Korea (Busan North Port – 24 responses, Busan New Port – 8 responses, Incheon – 15 repsonses, Gwangyang – 20 responses). In Singapore, the same interview questionnaire was administered during September 2015 and two responses from port managers were received.

Phase 2: Analytical Hierarchy Process (AHP) Analysis

The AHP analysis allows the determination of relative importance of individual criteria and pairwise comparison matrix to be formed in order to determine the priority of major criteria. In this study, a total of 18 Korean port managers from Busan, Gwangyang, Incheon, and Ulsan participated in the AHP evaluation. For Singapore, two port experts from the Maritime and Port Authority of Singapore (MPA) and Jurong Port participated in the current study. They made individual evaluation using a scale of nine levels to determine the values of criteria in the pairwise comparison matrix. Table 1 shows an example of how the relevant importance is determined between two criteria and how it is converted into a numerical rating. The participants' consensus on the criteria's preferences is calculated using the geometric mean. Entries for the remaining cells of the matrix are completed by taking the reciprocal value of the numerical value of importance, when the comparison of two particular criteria is undertaken.

Definition	Numerical Value
Equal importance	1
Moderate importance	3
Strong importance	5
Very strong importance	7
Extreme importance	9
Intermediate values between adjacent scale values	2, 4, 6, 8

Table 1 Internal Management Criteria Results (unit: %)

The next step is to calculate the priority of each criterion in terms of their contribution so as to identify the most important criteria to port managers. This process is known as the synthetisation and can be determined using an exact mathematical method or by applying a procedure that provides a good approximation of the synthetisation result. The following synthetisation procedure was used: 1) calculate normalized pairwise comparison matrix through adding all values in each column and then dividing by each column's total; 2) compute priorities for each criterion by calculating the average of the values in each row of the normalized matrix (Anderson et al. 2013).

Since the comparison was carried out through personal or subjective judgments, some degrees of inconsistency may occur. Therefore, to ensure that the respondents' judgments are consistent, the consistency verification is undertaken in that the judgments are considered to be consistent and the pairwise comparisons are acceptable only if the corresponding consistency ratios are less than 0.1 (Saaty, 1980). If a consistency ratio is greater than 0.1, the pairwise comparisons have to be reviewed by the decision-makers before being analysed. To calculate the consistency ratio (CR), λmax which is an average of the values and calculated as follows: each value in a specific column of the pairwise comparison matrix is multiplied with the corresponding priority of that criterion; the values across the rows are then added to obtain the weighted sum; then the values in the weighted sum are divided by the corresponding priority of each criterion. Subsequently, the consistency index (CI) is computed (CI = (λmax – n)/(n – 1)), and then used to calculate CR (CR = CI/RI, with RI being the random consistency index of a randomly generated pairwise comparison matrix depending on the number of items being computed. In the current study, there are eight factors (n = 8), therefore RI = 1.41 according to the random consistency indices table (Saaty and Kearns, 1985; Anderson et al. 2013). The working mechanism of AHP process was described in more details by Torfi et al. (2010).

Findings

The port managers confirmed the following factors which should be included in the sustainable port development model (Table 2).

Internal Management
A. Internal Environmental Management
A1 Clear environmental statement
A2 Establishment or upgrade of the "Green Policies" annually
A3 Regular updates of environmental conservation information in the port's website
A4 Environmental Management System
A5 Management support environmental supply chain
A6 Environmental risk management practices
A7 Activities to reduce environmental damages
A8 Environmental education and training support
A9 Clear environmental performance indicators
A10 Budget on green performance, including promotion campaign
A11 Punishment mechanism to penalize operators that disobey environmental rules
A12 Regular exercise of Port State Control for ship inspection
A13 Green initiatives and eco-services to attract customers
B. Optimized Operation Planning
B1 Continuously implementing berth planning improvement strategy
B2 Continuously implementing quay crane scheduling improvement strategy
B3 Continuously implementing loading/unloading sequence improvement strategy
B4 Continuously implementing space planning improvement strategy
B5 Continuously reducing truck queuing time at the port's gates
B6 integrated various port operations activities

B7 Collaboration with business partners in information sharing, improving data accuracy, and integrated scheduling
B8 Continuously improving customer satisfaction monitoring programs
C. Cost Savings
C1 Use of cleaner technology port equipment, such as hybrid/alternative/ quay cranes, RTGs, etc.
C2 Use of automated port equipment
C3 Collaboration with business partners in sharing the cost of environmental-friendly equipment
D. Internal Social Programs
D1 Constantly giving support for corporate social activities
D2 Constantly improving employees' working conditions and safety
D3 Constantly improving employee welfare
D4 Constantly giving support for employees' training and education
D5 Constantly improving transparent employee evaluation system
D6 Constantly improving transparent recruiting sytem
External Management
E. External Environmental Management
E1 Having common environmental goals collectively with business partners
E2 Developing a mutual understanding of environmental risk and responsibilities with business partners
E3 Working together with business partners to address environmental risks and establish a green supply chain
E4 Requiring and guiding business partners to comply with ISO 14001 environmental management standards
E5 Including environmental criteria in selecting business partners
E6 Conducting environmental audits for partners
F. Environmental Collaboration with Shipping Companies
F1 Providing incentives to shipping companies which use cleaning-burning low sulphur fuels for their ships' main and auxiliary engines while at port
F2 Providing incentives to shipping companies which use environmental-friendly materials and equipment
F3 Providing incentives to shipping companies which adopt environmental-friendly design of shipbuilding
F4 Providing incentives to shipping companies whose ships reduce speed while at port
G. External Social Program
G1 Providing expansion plan project information to the public
G2 Giving support to community social activities
G3 Providing scholarships to students
G4 Providing internships to students for work experience
G5 Giving support to community economical activities
G6 Giving support to community projects in general
H. External Evaluation Collaboration
H1 Working with external partners such as academic/research institutions to evaluate port projects
H2 Collaboration with academics/research institutes for project evaluation
H3 Providing transparent trade information to establish fair transaction culture

Table 2 Sustainable Port Development Factors and Indicators

The computational results of AHP analysis are presented in Table 3 (Korean experts). The consistency ratio of the pairwise comparison matrix was 0.018 < 0.1, meaning the pairwise comparison was acceptable and consistent. As can be seen from Table 3, Optimized Operation Planning (B) was considered the most important factor with a weight of 0.204. The next two most important factors are Environmental Collaboration with Shipping Companies (F) and External Evaluation Collaboration (H) with the weights of 0.151 and 0.148 respectively. Meanwhile, Internal

Social Program (D) was considered the least important among factors of sustainable port development with a weight of 0.069, followed by Internal Environment Management (A) with a weight of 0.073.

	A	B	C	D	E	F	G	H	Weight
A	1.00	0.31	0.76	1.36	0.50	0.45	0.80	0.38	0.073
B	3.25	1.00	1.11	2.62	2.27	0.80	2.54	1.61	0.204
C	1.32	0.90	1.00	1.27	1.11	0.88	1.17	0.81	0.123
D	0.73	0.38	0.79	1.00	0.58	0.43	0.62	0.41	0.069
E	1.99	0.43	0.85	1.72	1.00	0.93	1.12	1.04	0.122
F	2.24	1.24	1.14	2.30	1.08	1.00	1.03	0.86	0.151
G	1.25	0.39	0.86	1.62	1.01	0.97	1.00	0.86	0.110
H	2.66	0.62	1.23	2.43	0.96	1.16	1.16	1.00	0.148
λmax = 8.174 CI = 0.025 RI = 1.41 CR = 0.018									

Table 3 Results from AHP Analysis (Korean experts)

Meanwhile, the computational results of AHP analysis in the case of Singapore are presented in Table 4. From the Singaporean port experts' perspective, Optimized Operation Planning (B) was also considered the most important factor with a weight of 0.210, similar to the view of Korean port managers. The next two most important factors are Internal Environmental Management (A) and Cost Savings (C) with the weights of 0.197 and 0.136 respectively. On the other side, External Evaluation Collaboration (H) was considered the least important among factors of sustainable port development with a weight of 0.066, followed by External Social Program (G) with a weight of 0.082.

	A	B	C	D	E	F	G	H	Weight
A	1.00	2.24	3.00	1.73	1.41	1.41	1.41	1.41	0.197
B	0.45	1.00	3.00	2.00	2.45	1.73	3.00	3.46	0.210
C	0.33	0.33	1.00	1.41	1.58	1.58	2.24	3.16	0.136
D	0.58	0.50	0.71	1.00	1.00	0.82	1.00	1.41	0.092
E	0.71	0.41	0.63	1.00	1.00	1.41	1.73	1.73	0.110
F	0.71	0.58	0.63	1.22	0.71	1.00	1.73	1.73	0.107
G	0.71	0.33	0.45	1.00	0.58	0.58	1.00	1.73	0.082
H	0.71	0.29	0.32	0.71	0.58	0.58	0.58	1.00	0.066
λmax = 8.473 CI = 0.068 RI = 1.41 CR = 0.048									

Table 4 Results from AHP Analysis (Singaporean experts)

Discussion

From the AHP analyses, Optimized Operation Planning (B) was identified the most important factor which should be included in the sustainable port development model for both countries (Table 5). Korean ports collaborate actively with business partners for facility improvements, system development through regular meetings as this collaboration was perceived the most important factor for sustainable port development. They share feedbacks from each other on how to improve their operations planning. Incentives are negotiated by securing a certain level of throughputs. Meanwhile, Singapore ports regularly reach out to business partners to explore how they can provide better value added services in all aspects including operations planning. Optimized operations planning is practiced at dedicated terminals. As Singapore plan for the next generation port, port operators are engaged in various port development projects and assured that their voices are clearly heard. They sit in various planning committees as the biggest stakeholder in the development of the next generation port. Meanwhile, for both countries, IT is applied throughout by computer-aided operations and management at the terminal level to achieve rapid and accurate information sharing and processing which may result in reduced harbour fees, minimized human errors, and reduced loading and unloading time. Optimization of planning to reduce truck waiting time is also planned as well.

Rank	Korean Experts	Singaporean Experts
1	Optimized Operation Planning	Optimized Operation Planning
2	Environmental Collaboration with Shipping Companies	Internal Environmental Management
3	External Evaluation Collaboration	Cost Savings
4	Cost Savings	External Environmental Management
5	External Environmental Management	Environmental Collaboration with Shipping Companies
6	External Social Program	Internal Social Program
7	Internal Environmental Management	External Social Program
8	Internal Social Program	External Evaluation Collaboration

Table 5 Comparison of Priority Factorsbetween Korean and Singaporean Experts

Environmental Collaboration with Shipping Companies (F) was ranked second by Korean port managers while Internal Environmental Management (A) was perceived the second priority by Singaporean port experts. Among Korean ports, only Busan Port Authority (BPA) provides incentives to shipping companies. Since 2014, BPA has implemented the Environmental Ship Index (ESI) scheme by assigning scores for four substances emitted by vessels namely NO_x, SO_x, CO_2, and OPS (Onshore Power Supply) on the scale of 1 – 100. Busan Port is the first in Asia to adopt this system by providing ESI incentives, reducing entry and departure charges by 15% for vessels with over 31 ESI points. In 2014, the number of eco-friendly vessel callings was 423, and a total of KRW 603 million was reduced for entry and departure fees (BPA, 2015). Meanwhile, the Maritime and Port Authority of Singapore (MPA) initiated the Maritime Singapore Green Initiative which seeks to reduce the environmental impact of shipping and related activities and to promote clean and green shipping in Singapore (MPA, 2013). In 2011, the MPA pledged to invest up to S$100 million over 5 years in the Maritime Singapore Green Initiative. It is a comprehensive initiative comprising three programmes – the Green Ship Programme, Green Port Programme and Green Technology Programme. These are voluntary programmes designed to recognise and provide incentives to companies that adopt clean and green shipping practices over and above the minimum required by International Maritime Organization (IMO) Conventions.

It is interesting to note from Table 5 that internal and external social programs were considered less important by experts in both countries although their ports implement and practice various social

programs in the name of corporate social responsibility (CSR). Korean ports also consistently improve their human resources through transparent recruiting and appraisal systems although this was considered the least important criterion of sustainable port development. They focus on developing training and education programs to strengthen their employees' work skills, capabilities and personal responsibility.

Port experts in two countries showed significantly different view regarding Internal Environmental Management (A) and External Evaluation Collaboration (H). Specifically, the former was perceived second least important by Korean port managers (while it was ranked second most important by Singaporean port experts). Meanwhile, the latter was ranked the third important factor by Korean port managers (while it was perceived least important by Siungaporean counterparts). Hence, these factors deserve further investigation.

Conclusion

This research empirically validated the factors and indicators contributing to sustainable port development and their priority ranking in Korea and Singapore. Unlike previous studies in which only one or two sustainable dimensions were considered, the current research applies a holistic approach in which sustainable port development involves all three dimensions of sustainable development (economic, social and environmental). Port experts in both countries confirmed that a sustainable development port should have most of the criteria in the proposed conceptual model. Through the AHP analysis, it was agreed by both Singaporean and Korean port managers that Optimized Operation Planning is the most important factor for a port to be developed sustainably. Meanwhile, Internal Social Program and External Evaluation Colaboration were perceived to be the least important factors by Korean and Singaporean port managers respectively. Sustainable port development factors and indicators provide a development model to port authorities and operators on how their port should be developed for sustainability. Given the factors' prioritised importance, port managers are informed of areas which should be focused on for improvement in order for their ports to be developed sustainably.

This research contributes to both existing literature and management practice, as it is the first in Korea and Singapore to consider sustainable port development taking an all-rounded approach. Nevertheless, there exist various limitations in the current research. Specifically, responses were low due to limited time frame. However, the current research could be a stepping stone for further research in validating a conceptual framework to inform port sustainable development policies in the future.

References

- Anderson, D.R., Sweeney, D.J., Williams, T.A., Camm, J.D. and Martin, K. (2013) An Introduction to Management Science: Quantitative Approaches to Decision Making. South Western Cengage Learning, Mason, Ohio pp. 865.
- Black, W.R. (1996) Sustainable transportation: a US perspective. *Journal of Transport Geography*, 4 (3), pp. 151-159.
- Buhaug, O., Corbett, J.J., Endersen, O., Eyring, V., Faber, J., Hanayama, S., Lee, D.S., Lee, D., Lindstad, H., Mjelde, A., Palssoon, C., Wanquing, W., Winerbrake, J.J. and Yoshida, K. (2009) *Second IMO Greenhouse Gas Study*. London: International Maritime Organization.
- Busan Port Authority (2015) A Sustainable port for the future: 2014. BPA Sustainability Report, BPA.
- Carter, C.R. and Rogers, D.S. (2008) A framework of sustainable supply chain management: moving toward new theory. *International Journal of Physical Distribution and Logistics Management*, 38 (5), pp. 360-387.

- Chin, A.T.H. and Low, J.M.W. (2010). Port performance in Asia: Does production efficiency imply environmental efficiency? *Transportation Research Part D*, 15 (8), pp. 483-488.
- De Giovanni, P. and Zaccour, G. (2014) A two-period model of closed-loop supply chain. *European Journal of Operational Research*, 232 (1), pp. 22-40.
- Drobetz, W., Merikas, A., Mrika, A. and Tsionas, M.G. (2014) Corporate social responsibility disclosure: The case of international shipping. *Transportation Research Part E*, 71, pp. 18-44.
- Florida, R. (1996) Lean and Green: the move to environmentally conscious manufacturing. *California Management Review*, 39 (1), pp. 80-105.
- Gimenez, C., Sierra, V. and Rodon, J. (2012) Sustainable operations: their impact on the triple bottom line. *International Journal of Production Economics*, 140 (1), pp. 149-159.
- Gotschol, A., De Giovanni, P. and Esposito Vinzi, V. (2014) Is environmental management an economically sustainable business? *Journal of Environmental Management,* 144, pp. 73-82.
- Hansmann, K.W. and Claudia, K. (2001) Environmental management policies, in SARKIS, J. (Ed.), *Green Manufacturing and Operations: From Design to Delivery and Back,* Sheffield: Greenleaf Publishing, pp. 192-204.
- Hart, S.L. (1995) A natural-resource-based view of the firm. *Academy of Management Review*, 20 (4), pp. 986-1014.
- Hick, S. (2000) Morals make the money. *Austrian CPA,* 70 (4), pp. 72-73.
- Hoffman, A.J. and Ventresca, M.J. (1999) The institutional framing of policy debates: economics versus the environment. *American Behavioral Scientist*, 42 (8), pp. 1368-1391.
- Lirn, T.C., Wu, Y.C.J. and Chen, Y. (2013) Green performance criteria for sustainable ports in Asia. *International Journal of Physical Distribution & Logistics Management*, 43 (4), pp. 427-451.
- Maritime and Port Authority of Singapore (MPA) (2013) Maritime Singapore Green Initiative. MPA, Singapore.
- Marshall, R.S., Cordano, M. and Silverman, M. (2005) Exploring individual and institutional drivers of proactive environmentalism. *Business Strategy and the Environment,* 14 (2), pp. 92-109.
- Puig, M., Wooldridge, C. and Darbra, R.M (2014) Identification and selection of Environmental Performance Indicators for sustainable port development. *Marine Pollution Bulletin*, 81 (1), pp. 124-130.
- Puig, M., Wooldridge, C., Michail, A. and Darbra, R.M. (2015) Current status and trends of the environmental performance in European ports. *Environmental Science and Policy*, 48, pp. 57-66.
- Pullman, M.E., Maloni, M.J. and Carter, C.G. (2009) Food for thought: social versus environmental sustainability programs and performance outcomes. *Journal of Supply Chain Management*. 45 (4), pp. 38-54.
- Rao, P. (2002) Greening the Supply Chain – A Guide for Managers in South East Asia. Asian Institute of Management: Makati
- Rao, P. and Holt, D. (2005) Do green supply chains lead to competitiveness and economic performance? *International Journal of Operations and Production Management*. 25 (9), pp. 898-916.
- Saaty, T.L. (1980) Fundamentals of Decision Making and Priority: Theory with the Analytic Hierarchy Process. RWS Publications, Pittsburgh.
- Saaty, T.L. and Kearns, K.P. (1985) Analytical Planning: The Organisation of Systems. Pergamon Press, Oxford, UK.
- Saensupavanich, C., Coowanitwong, N., Gallardo, W.G. and Leertsuchatavanich, C. (2009) Environmental performance evaluation of an industrial port and estate: ISO 14001, port state control-derived indicators. *Journal of Cleaner Production*, 17 (2), pp. 154-161.
- Shrivastava, P. (1995) Environmental technologies and competitive advantage. *Strategic Management Journal*, 16 (51), pp. 183-200.

- Simpson, D.F. and Power, D.J. (2005) Use of supply relationship to develop – lean and greens suppliers. *Supply Chain Management: An International Journal*, 10 (1), pp. 60-68.
- Stefan, A. and Paul, L. (2008) Does it pay to be green? A systematic overview. *The Academy of Management Perspective*, 22 (4), pp. 45-62.
- Tsinker, G.P. (2004) Port engineering: planning, construction, maintenance, and security, John Wiley & Sons Inc.: New Jersey.
- Torfi, F., Farahani, R.Z. and Rezapour, S. (2010) Fuzzy AHP to determine the relative weights of evaluation criteria and fuzzy TOPSIS to rank the alternatives. *Application of Soft Computing*, *10*, pp. 520–528.
- Vachon, S. and Klassen, R.D. (2008) Environmental management and manufacturing performance: the role of collaboration in the supply chain. *International Journal of Production Economics,* 111 (2), pp. 299-315.
- Wagner, M. and Schaltegger, S. (2004) The effect of corporate environmental strategy choice and environmental performance on competitiveness and economic performance: An empirical study of EU manufacturing. *European Management Journal*, 22 (5), pp. 557-572.
- Wiegmans, B.W. and Louw, E. (2011) Changing port-city relations at Amsterdam: A new phase at the interface? *Journal of Transport Geography*. 19 (4), pp. 575-583.
- Wu, Y.C. and Goh, M. (2010) Container port efficiency in emerging and more advance markets. *Transportation Research Part E,* 46 (6), pp. 1030-1042.
- Yang, C.S., Lu, C.S., Haider, J.J. and Marlow, P.B. (2013) The effect of green supply chain management on green performance and firm competitiveness in the context of container shipping Taiwan. *Transportation Research Part E*, 55, pp. 55-73.
- Yang, Y.C. and Chang, W.M. (2013) Impact of electric rubber-tired gantries on green performance. *Research in Transportation Business &* Management, 8, pp. 67-76.
- Zhu, Q. and Sarkis, J. (2004) Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises. *Journal of Operations Management*, 22 (3), pp. 265-289.
- Zhu, Q., Sarkis, J. and Lai, K.H. (2007) Initiatives and outcomes of green supply chain management implementation by Chinese manufacturers. *Journal of Environmental Management*, 85 (1), pp. 179-189.