Competitive advantage in container port sustainability performance

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INTRODUCTION

In recent discussions surrounding port sustainability, there has been a heightened focus on the need for a more comprehensive approach that goes beyond merely economic considerations. While maximising economic benefits has traditionally been a primary goal for ports, there is now a critical recognition of the need to balance economic, environmental, and social aspects to ensure long-term viability and resilience. In this sense, ports have been making considerable efforts to align their operations with sustainability principles, not only to comply with regulations but also to maintain their competitive advantage in the evolving global market. This phenomenon highlights the understanding of the increasing influence of environmentally and socially driven practices of port operations and market dynamics.

Sustainability is not just a moral imperative but also a strategic advantage for business. There is no doubt that ports that proactively integrate sustainability into their operations can enhance their reputation, attract investment, and mitigate risks associated with environmental degradation and social inequities (see, for example, Hou and Geerlings 2016). Additionally, research has acknowledged that sustainable responsibility is increasingly influential for port competitiveness (Yu et al. 2023). Traditionally, port competitiveness was determined by human and logistical resources and services in ports, but sustainability considerations have been now reshaping port market dynamics and transforming organisational processes by accelerating their internal and external capabilities to sustainable development (Hossain et al. 2021). It is thus essential for ports to understand sustainability practices and their impacts within the port sector, and design strategic actions aimed at achieving intended sustainability goals.

While there have been numerous studies to evaluate port sustainability performance in terms of effectiveness and efficiency, there is currently a notable shortage of research regarding the impact of sustainability practices on port competitiveness, highlighting the need for further investigation in this area. Hence, this research, drawing upon the Natural-Resource-Based View (NRBV), investigates the relationship between sustainability implementation and port performance, i.e. competitiveness, to understand the complex interplay between sustainability and port performance and to elucidate the concrete outcomes of sustainability in enhancing port competitiveness. Specifically, this research seeks to provide empirical evidence of the economic value of the sustainability performance of ports and propose port sustainability management strategies aimed at enhancing port business capability. Therefore, the research adopts the Structural Equation Modelling (SEM) to identify the multiple relationships between port sustainability performance and its impact on competitive outcomes and to statistically validate the reliability port sustainability activities.

The research presented in this paper was undertaken in the context of container ports, and henceforth, the term 'port' specifically refers to 'container port'. Container ports serve as pivotal nodes within global transportation and logistics networks. Given that achieving genuine sustainable development requires a holistic approach across closely interlinked sectors, it becomes imperative to analyse the capacity of container ports to generate positive outcomes in sustainable and economic domains for logistics and supply chain networks. By doing so, ports can optimise the functionality of international logistics hubs, thereby ensuring their contribution to the sustainability and competitiveness of global logistics networks.

LITERATURE REVIEW

The research employs the Natural-Resource-Based View (NRBV), an extension of the Resource-Based View (RBV), to examine the causal connections between sustainability performance and competitive advantage. The core premise of the RBV is that a firm's competitive advantage and superior performance stem from the specific types of resources and capabilities it possesses and controls (Barney 1991). According to the RBV, an organisation's resources should be valuable, rare, inimitable, and non-substitutable, and these resources are inherently linked to performance outcomes as they generate economic rent and lasting value, contributing to the organisation's competitive advantage (Ma 2000). Recognising the significance of sustainable development as a potential source of competitive advantage for organisations, the NRBV was developed to incorporate an organisation's ability to manage and control sustainability initiatives. Drawn upon the NRBV perspective, the study proposes that a port actively developing certain sustainability practices is more likely to gain a competitive advantage because those practices may have the potential to lower costs and differentiate the port's services.

Competitive advantage in its various forms serves as a crucial metric for assessing organisational success, indicating superiority over competitors (Sigalas 2015). Porter (1991) argued that implementing well-constructed environmental management practices could positively influence technological and operational enhancements, thus reshaping competitive dynamics. Consequently, sustainability efforts have become integral components for securing a competitive edge and ensuring long-term success. The ability of ports to manage sustainability performance effectively is increasingly acknowledged as a strategic necessity (Yu et al. 2023). The idea of sustainable development offers both its holistic nature and the necessity for integration. In this sense, the multidimensional character of sustainability consistently stresses that the environmental and social sustainability performance of organisations should be closely linked with economic outcomes (Lehtonen 2004).

While the interaction between environmental and social aspects in measuring sustainable development has often been overlooked, their intertwined nature is crucial. A sustainable environment provides a stable resource foundation for societal longevity, and similarly, social sustainability entails equitable distribution of power and the fostering of eco-friendly behaviours. In the context of ports, social sustainability encompasses human resource management, such as education, health, and employment of employees who play a vital role in managing and controlling sustainability activities that impact environmental performance positively (Kim et al. 2019). Similarly, organisations have increasingly recognised that economic systems cannot be sustained without a stable supply of natural resources. Many port studies have confirmed the relationship between environmental management and economic performance. Environmental practices, such as adopting green engineering or technologies (e.g. solar panels) and energy-saving machinery, contribute to efficient operations, high-quality services, and cost savings, leading to long-term economic benefits for organisations (Sifakis and Tsoutsos 2021). This, in turn, encourages proactive planning and implementation of environmental management strategies. Furthermore, in the economic system, organisational activities directly or indirectly affect employees, consumers, and communities, impacting cultural diversity and human rights. These social impacts translate into business opportunities, leading to increased economic

benefits for organisations. Satisfied employees contribute to organisational productivity and customer services, while socially responsible organisations attract more customers, enhancing brand image and market desirability. Ports that invest in employee education and training can improve worker performance, reduce accidents, and thereby enhance economic benefits through cost-saving measures and improved services (Khan 2012; Sarkar et al. 2020).

From the NRBV, the environmental strategy relies on human capital, such as the expertise and know-how of employees, to reduce pollution through ongoing improvement methods (Hart 1995). These unique skills, which are difficult to replicate, are pivotal in determining an organisation's competitive edge. While conflicting opinions have existed concerning sustainability management as a crucial determinant of port selections (e.g. Ding et al. 2019; Kaliszewski et al. 2020), some studies have highlighted the potential of sustainability activities in bolstering the competitive position of ports. For example, Acciaro et al. (2014) confirmed the positive relationship between energy management in ports and operational efficiency and economic viability, thus elevating competitiveness. Similarly, Parola et al. (2017) emphasised the role of environmental and safety-centric port management in enhancing overall operational efficiency and competitiveness through technical and procedural innovations. Other positive effects of port sustainability practices beyond operational enhancements have included increasing its public image, attracting green-oriented industries, and positioning ports advantageously against competitors (Kim and Chiang 2017). Given their dual roles as social enterprises and public agencies closely tied to regional economic development (Cheon 2017), maintaining legal and ethical standards in port management is crucial for attracting local stakeholders and securing port investments. Consequently, environmentally harmful or unethical practices by ports can lead to rejection by users or investors, potentially jeopardising their benefits and competitive standing in the market. Additionally, the discussion on the interconnectedness between environmental, social, and economic sustainability, and the competitive advantage of ports posits the mediating role of the three sustainability aspects on competitive advantage. Therefore, based on the discussion above, the research developed nine hypotheses, as summarised in Table 1.

Hypothesis	Description
Hypothesis 1	Port social sustainability has a positive influence on port environmental sustainability.
Hypothesis 2	Port social sustainability has a positive influence on port economic sustainability.
Hypothesis 3	Port environmental sustainability has a positive influence on port economic sustainability.
Hypothesis 4	The implementation of environmental sustainability has a positive influence on the achievement of a competitive advantage of ports.
Hypothesis 5	The implementation of social sustainability has a positive influence on the achievement of a competitive advantage of ports.
Hypothesis 6	The implementation of economic sustainability has a positive influence on the achievement of a competitive advantage.
Hypothesis 7	The implementation of environmental sustainability has a positive influence on the achievement of a competitive advantage of ports through mediation by economic sustainability.
Hypothesis 8	The implementation of social sustainability has a positive influence on the achievement of a competitive advantage of ports through mediation by environmental sustainability.
Hypothesis 9	The implementation of social sustainability has a positive influence on the achievement of a competitive advantage of ports through mediation by economic sustainability.

Table 1: Research hypotheses of the study[1]

[1] The research hypotheses follow a process developed in research by Lim (2022).

RESEARCH METHODOLOGY

This study utilised a survey methodology to collect data, employing a web-based questionnaire designed for individuals to be completed and submitted through online service software. The questionnaire comprised two main sections: Part A, which addressed the hypothesised relationships; and Part B, which gathered demographic information of respondents. The measurement items for the study constructs related to port sustainability aspects were primarily derived from key performance indicators synthesised by Lim et al. (2019). Additionally, the measurement items for competitive advantage were developed based on previous research across diverse disciplines, including the port research area (e.g. Lirn et al. 2014; Lu et al. 2016; Walsh and Dodds 2017). In total, 39 items were initially formulated and measured using a Likert scale, where respondents rated their level of agreement on a scale from 1 to 7. 1 represented "Strongly disagree" and 7 denoted "Strongly agree". Examples of questions included, 'My port/terminal has provided employee training and education' and 'Controlling deterioration of water quality strengthens the competitive advantage of my port/terminal'. The questionnaire was distributed to professionals at the management level, from frontline- to top-level managers in container ports and terminals around the world. The survey was carried out over a period of five months, from March to July for five months in 2020.

ANALYSIS

Descriptive analysis

A total of 248 completed questionnaires were returned, resulting in a response rate of 49%, which is considered acceptable for SEM research (Hox et al., 2010). The data were collected from 37 countries, with the largest number of ports located in the United States (8.9%), followed by Brazil (7.3%), Malaysia (6.9%), and Great Britain (6.0%). The 37 countries were further grouped based on the continents. The majority of responses came from Europe (25%), followed by East and Southeast Asia (24%), and Oceania (11%). Africa accounted for the smallest proportion of responses, at 6%. In terms of port size, based on annual container throughput, more than half of the respondents (53%) worked in medium-sized ports, followed by small-sized ports (23%) and large-sized ports (21%). Regarding the management levels of respondents in their ports, more than half of the respondents (58%) were middle-level managers, while front-line and top-level managers accounted for 27% and 14%, respectively. Furthermore, the largest group of respondents had more than 15 years of working experience (39.1%), followed by those with between 1 and 5 years (25.4%), 6 to 10 years (17.3%), and 11 to 15 years (12.5%) of experience. Only a small proportion (2.8%) had less than one years work experience in the port industry.

EFA and CFA analyses

The information collected went through a data preparation process involving screening for missing data and outliers. Following the treatment process, a total of 236 usable responses remained. The initial theoretical model underwent a pre-test via EFA to refine the variables and eliminate unnecessary items and noise. The EFA followed procedures outlined by Costello and Osborne (2005) and Hair et al. (2014). After the EFA analysis, decisions were made to remove inappropriate variables, including those with cross-loadings. Consequently, 26 out of 39 variables were retained for the further analysis. The reliability and validity of the variables post-EFA were further confirmed by satisfying the Kaiser-Meyer-Olkin (KMO), which indicated an overall value of 0.927, with each construct scoring greater than 0.80. Additionally, Bartlett's test of sphericity showed significance for both overall and individual constructs.

CFA was carried out to assess the validity of the measurement model, which consisted of four constructs: Competitive Advantage (CA, 6 variables), Environmental Sustainability (EN, 8 variables), Social Sustainability (SO, 6 variables), and Economic Sustainability (ES, 6 variables). All standardised factor loadings exceeded 0.60, indicating their significance in the model (Figure 1). Additionally, all variables demonstrated significant t-values at $p <$

0.001. The overall measurement model demonstrated a favourable fit to the data, satisfying recommended thresholds for goodness-of-fit indices (χ^2/df=2.045; SRMR=0.0535; CFI=0.916; IFI=0.917; TLI=0.907; RMSEA=0.067). Furthermore, the CFA results confirmed the unidimensional nature of the study constructs, with correlation estimates among the constructs below 0.80.

Research hypotheses testing

Following the successful assessment of the goodness-of-fit measures by the overall CFA model, the proposed structural model showed identical model fit results to the CFA model, providing support for the study's proposed model. Figure 1 illustrates the standardised paths representing the final results of structural equation modelling.

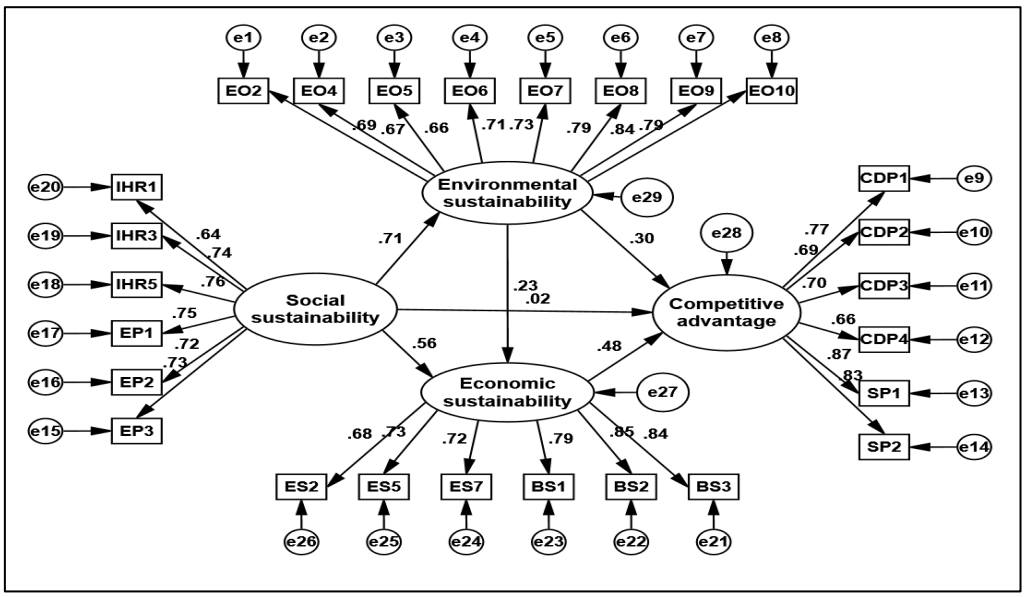

Figure1: Final structural equation modelling results

The nine established hypotheses of the study were tested, examining the causal relationships regarding the direct and indirect effects among the four constructs. The overall results of hypothesis testing, including p-value indicating statistical significance, are summarised in Table 2.

Hypothesis	Hypothesised relationship	p-value	Result
H1	SO → EN	***	Supported
H2	SO → EC	***	Supported
H3	EN → EC	**	Supported
H4	EN→ CA	***	Supported
H5	SO → CA	0.858	Not supported
H6	EC → CA	***	Supported
H7	EN → EC → CA	*	Supported
H8	SO→ EN →CA	***	Supported
H9	SO→ EC →CA	**	Supported

Table 2: Overview of hypothesis testing results (***: $p < 0.001$, **: $p < 0.01$, *: $p < 0.05$)

All hypotheses were validated except for hypothesis 5, which concerns the direct impact of social sustainability on competitive advantage. It is, however, interesting to note that this relationship demonstrated statistical significance when considering the indirect effects of environmental and economic aspects on this pathway. Consequently, all indirect paths were fully supported, affirming the mediating effects of the relationships among them.

DISCUSSION

The significant relationships regarding the interdependence among environmental, social, and economic aspects of sustainability suggest that container ports are progressing towards sustainability as intended by port sustainability management objectives, which aim for a balanced approach encompassing environmental and social responsibility alongside economic benefits. The stronger correlation observed between environmental and social performance (standardised coefficient=0.706) compared to that between environmental and economic performance (0.229) or social and economic performance (0.563) indicates the potential for a stronger interface between environmental and social factors in port operations. This may imply that ports can harness mutual or complementary benefits by integrating environmental and social sustainability frameworks, suggesting the importance of actively developing eco-social practices, such as safety and environmental management training programmes and waste-to-energy projects. Furthermore, the results indicate significant direct effects of sustainability performance from both environmental and economic aspects on enhancing the competitive positioning of ports. This implies that container ports can gain competitive advantages by implementing and emphasising environmental and economic sustainability-related practices or activities. These practices can contribute to differentiating the port in terms of reputation, services, technology, and user satisfaction. The finding provides empirical evidence strengthening the previous argument in port research that sustainability initiatives have enhanced port competitiveness and overall port performance in terms of effectiveness and efficiency (e.g. Lun 2011; Yuen and Thai 2017).

The observation of mediated effects between social performance and port competitive advantage through environmental and economic performance suggests that the robustness of social sustainability performance in enhancing competitive advantage relies on the supportive roles of environmental and economic sustainability initiatives. Thus, container ports with stronger pollution prevention and economic development strategies are more likely to generate higher levels of social performance. This further emphasises the critical role of intervention and support from environmental and economic sustainability efforts to drive positive social sustainability outcomes, thereby elevating port competitiveness. This argument resonates with research in the field of sustainability business management, which has emphasised that a sequential interdependence of sustainability practices fosters synergistic interactions, ultimately enhancing organisational performance and competitiveness (Galeazzo et al. 2014; McDougall et al. 2021).

However, the weak direct relationship between social performance and competitiveness may suggest a lack of systematic approaches to address societal issues within the port industry. This observation also implies that the structure of social sustainability is complex, intertwined with environmental and economic sustainability activities. This complexity poses challenges in accurately predicting and tackling specific societal-related operations, particularly for individual ports. Hence, the findings suggest the imperative need for collective efforts through organised networks, such as the ESPO's EcoPorts project (ESPO, 2012), in order for both individual ports and the entire port sector to reap the benefit of social sustainability practices. By doing so, ports can facilitate more robust social practices and policies and significantly enhance the balanced effectiveness of sustainability performance and the competitive advantage of ports.

CONCLUSION

This study examined the relationship between sustainability performance and its influence on strengthening port competitiveness advantage. Through the exploration of nine hypotheses, the study evidenced positive associations between port sustainability performance and competitive advantage, with the exception of a direct link between social performance and competitive advantage. However, this relationship is further substantiated by the full mediation of environmental and economic performance factors. The findings offer significant insights into the status of ports concerning sustainability progress and its consequential impacts on port operational performance in terms of

competitive advantage. In this sense, the study contributes to providing decision-makers in container ports with evidence regarding the rationale of sustainability performance and facilitating the development of optimal practices in port sustainability management with holistic sustainability management strategies. Moreover, this research enriches the theoretical discourse on port sustainability management by elucidating the linkage between sustainability performance and competitive advantage through the lens of the NRBV.

Although this study implicitly encompasses Key Performance Indicators (KPIs) pertinent to port sustainability performance, it suggests that the methodological approach and metrics from SEM could be explicitly extended into the development of a KPI framework for future assessments of port sustainability performance. Furthermore, it is important to acknowledge that the findings of this study may have limited applicability and generalisation to current circumstances due to the time elapsed since data collection. Especially, as a consequence of the COVID-19 pandemic, pertinent perceptions of sustainability performance within ports may have evolved, necessitating future studies to capture more recent data. Such investigation would enable a more appropriate reflection of the current landscape and facilitate the discernment of nuanced shifts in sustainability perceptions and their impacts on port performance.

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