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Assessing hierarchical corporate sustainability transition practices under uncertainty: An approach in the port and shipping industry in Southeast Asia

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RESEARCH ARTICLE

Assessing Hierarchical Corporate Sustainability Transition Practices Under Uncertainty: An Approach in the Port and Shipping Industry in Southeast Asia

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Abstract

The port and shipping industry in Southeast Asia has experienced significant development in response to the increasing demand for maritime logistics and transportation services. However, this expansion has resulted in notable social and environmental impacts. Consequently, it is imperative for both scholars and practitioners to comprehend the concept of corporate sustainability transition (CST), which entails the establishment of shipping operations that effectively balance environmental, social, and economic considerations. Additionally, technologies that are used to facilitate the transition process must be investigated. Several studies have been undertaken to ascertain the attributes pertaining to sustainability transition. Nevertheless, there has been a lack of sufficient focus and consideration in performing a comprehensive and valid assessment of CST attributes, particularly in terms of their causal interrelationships. In fact, this analysis has been predominantly overlooked or disregarded. Therefore, this study builds a hierarchical framework to address these issues using linguistic preferences. Regarding the attributes, the fuzzy Delphi method (FDM) is used to confirm their validity. In nature, there are complex interrelationships among the attributes; hence, the fuzzy decision-making trial and evaluation laboratory method (DEMATEL) is employed to visualize the interrelationships. The results reveal that stakeholder management, communication and cooperation are the most important influencing aspects. Research and development (R&D) promotion, environmental training, international treaties, shareholder value, and owner support are the top causal criteria that practitioners must improve to develop CST performance.

Keywords: Corporate sustainability transition, Fuzzy Delphi method, Fuzzy decision-making trial and evaluation laboratory method, Port and shipping industry

1. Introduction

Southeast Asian goods trading is predominantly covered by the shipping industry. China, European countries, the United States, and Japan are the largest external markets, and total exports amount to US$ 1,436,415.0 million. Moreover, intramaritime trade growth among Southeast Asian countries is increasing to 24.1 % of the total trade of the region and is predicted to triple by 2050 [1,2]. Therefore, port and maritime shipping is recognized as a vital actor for logistics chains in Southeast Asian countries. Ports serve as departure points for global trade, allowing the exchange of products and materials across countries. Moreover, shipping stands out as the predominant mode of transportation for goods, as an estimated 90 % of global trade is transported via maritime routes [3–5]. For these reasons, port and shipping authorities are expanding their infrastructure and services to meet the soaring demand for maritime logistics and transportation services [6]. Consequently, the social and environmental impacts caused by this development and by massive port and maritime shipping practices are not negligible [6–8].

Port and shipping operations remain unsustainable and are major contributors to pollution that

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negatively impacts public health, safety, and welfare [9–11]. The expansion and continued growth of marine commerce have had substantial environmental impacts, including biodiversity loss, noise and light pollution, and air and water pollution [12,13]. These environmental issues have caused negative societal impacts that potentially engender poor quality of life, safety, and health for employees and local communities [6,10,14]. Consequently, the port and shipping industry must enhance its operational processes so that environmental impacts can be minimized and better living conditions for the ecosystem and society can be realized. Hence, it is imperative for scholars and practitioners to identify the attributes that have the potential to improve operational processes and facilitate the transition toward sustainable port and shipping operations. To shift traditional shipping perspectives to sustainable shipping operations that potentially promote better environmental preservation, social welfare, and economic performance, a corporate sustainability transition (CST) must be achieved [15–17]. A CST that integrates the triple bottom line (TBL) of social, environmental, and economic dimensions is capable of guiding business operations to modernize and increase the sustainability of conventional activity [16,18,19]. A CST refers to fundamental, multiperspectival, and long-term shifting processes that activate the transformation toward sociotechnical systems; however, there are numerous attributes available [20,21]. To shift toward a sustainable port and shipping industry, the attributes promoting a better CST need to be revealed and discussed. Nevertheless, prior studies have not entirely revealed CST attributes. In particular, D'Amico et al. [15] and Oloruntobi et al. [5] argued that integrating innovation and technological adoption within TBL dimensions is imperative for optimizing productivity, establishing smart operations, and achieving enhanced CST performance. Consequently, it is imperative to incorporate technological sustainability transition practices into the framework of CST practices. By implementing improved practices within these dimensions, a CST approach results in enhanced activities and operations across multiple functions within an industry.

Several studies have been conducted to examine CST attributes, as discussed in the literature. For instance, Dooms [22] and Magnusson and Werner [23] carried out studies to investigate social and organizational indicators related to sustainability transition and posited that the successful attainment of a sustainability transition is heavily contingent upon the effective management of internal and external stakeholders, given their pivotal role in the planning process for establishing strategic sustainability objectives. Kang and Kim [24] examined the conceptual model of sustainability transition practices and emphasized the significance of enhancing communication and cooperation among stakeholders as a means to cultivate relationships and improve operational transparency. Laxe et al. [25] assessed the sustainability transition by employing synthetic index analysis across multiple ports and mentioned that process and quality improvement supported by all parties engaged is necessary to increase a port's competitive advantage and financial condition, which can encourage better CST practices. Moreover, Lim et al. [6] conducted a literature review and argued that constructing a better economic structure and business performance by implementing better initiatives and strategies is necessary to realize better growth performance and a sustainability transition while also promoting a country's economy and prosperity. Lam and Li [26] employed a study with the aim of examining the environmental indicators associated with sustainability transition and asserted that an environmental management strategy that specifically targets the mitigation of environmental impacts arising from port and shipping operations can effectively support trade, fulfill organizational and customer objectives, and facilitate the adoption of improved CST practices. Furthermore, D'Amico et al. [15] carried out an analysis of the technological enablers that can facilitate the transition toward sustainability and highlighted that environmental digital technology innovation in the port and shipping industry has the potential to assist administrators, urban planners, and policymakers in managing resources and raw materials more efficiently, reducing emissions and waste, improving productivity, promoting safety and comfort, and improving the management of information, data, investment, people, and other factors. In addition, due to the negative impact of infrastructure on the environment, Min [27] suggested that the implementation of smart infrastructure is needed and potentially enhances the utilization of technologies that lead ports to achieve better environmental performance, productivity, and a sustainability transition. Prior studies have examined the attributes of CST and emphasized several important attributes. However, there remains a lack of understanding regarding the existence of valid and comprehensive criteria. In addition, prior studies primarily focused on a specific dimension and lacked an all-encompassing viewpoint that incorporates both the TBL dimensions and the technological dimension [28,29]. Consequently, this limitation has impeded the development of a comprehensive understanding of CST.

Earlier studies overlooked the validity of industrial measures and the potential causal link between attributes [30]. Moreover, the identification and development of CST attributes is a complex and challenging task, as evidenced by the numerous attributes available [20,28,30]. Hence, to address these issues and fill the gaps, this study proposed the following research questions: what are the valid CST attributes that must be prioritized? what are the causal CST attributes that drive its performance? and what are the managerial implications of CST practices within the port and shipping industry? To answer these research questions, this study evaluates the CST measures in the port and shipping industry and develops a hierarchical framework of the attributes utilizing the fuzzy Delphi method (FDM), which entails validating and deleting redundant and erroneous attributes [29–31]. The causal interrelationships among the attributes are then identified using the fuzzy decision-making trial and evaluation laboratory (DEMATEL) method based on experts' qualitative evaluations [32–34]. In accordance with the research questions, the objectives of this study are as follows:

1. To establish a valid set of CST attributes using qualitative data,
2. To construct a CST hierarchical interrelationship framework based on the causal interrelationship among attributes,
3. To determine the critical criteria for industry improvement.

The contributions of this study are as follows: [1] Reveal a set of valid CST attributes [2]. Construct a hierarchical interrelationship framework that adds to and improves upon the literature and identifies the essential CST characteristics that can assist decision-makers [3]. Provide recommendations with relevant implications for the government and shipping and port industry to realize enhanced CST.

The remaining sections of this study are structured as follows: Section 2 contains the CST literature review, the proposed method, and the proposed measures. The method is detailed in Section 3. Section 4 presents the findings. Section 5 discusses the theoretical and managerial implications. In Section 6, the conclusion, results, and limitations of this study and suggestions for further research are presented.

2. Literature review

A review of the CST literature, the proposed methodology, and the proposed outcome measures are presented in this section.

2.1. Corporate sustainability transition

A CST refers to a multilevel process of transforming conventional social, technological, and economic systems with the aim of promoting the well-being of society and ensuring the long-term viability of a business or organization [20,35,36]. It is recognized as a corporate strategy for achieving social safety and welfare, environmental preservation, energy efficiency, better economic performance, and technological adoption [15,19,26]. CST yields a multitude of advantages, including but not limited to cost reduction, risk mitigation, and enhanced competitiveness [29]. Therefore, the implementation of a CST is of utmost importance in facilitating significant enhancements in an organization's operations, ultimately resulting in the successful achievement of its business objectives.

Corporations must enhance their CST performance by integrating the TBL and technological dimensions to generate success and better corporate daily operations since the concept can produce benefits by increasing the efficiency and competitiveness of companies and reducing risk and cost [6,9,28]. Zhou et al. [19] stated that the environmental component is considered a key element of the sustainability transition because it has the potential to effectively reduce and mitigate the development of hazardous waste generated by organizational activities. Lim et al. [6] argued that developing economic performance as the ultimate goal of companies is necessary to assist other sustainability practices and support the transition toward corporate sustainability. Barreiro-Gen et al. [4] highlighted that industries are unable to neglect social sustainability practices, especially gender equality, to gain holistic perspectives and achieve better CST performance. Additionally, D'Amico et al. [15] found that digital technology adoption plays a significant role in obtaining social, environmental, and economic data, promoting technical skills, and supporting company research and development (R&D), which are needed for a sustainability transition. Therefore, a comprehensive understanding of CST attributes, including social, environmental, economic, and technological dimensions, is still needed to achieve CST success.

From a social perspective, a transition to sustainability is essential to address concerns linked to employment, education and knowledge development, and the living conditions of surrounding communities [11,37]. Bjerkan et al. [21] argued that the development of a social sustainability transition, which is reflected by stakeholders' efforts and activities to establish goals, formulate strategies, and execute plans that promote the sustainability transition itself, is fundamental for promoting and achieving better sustainability within other dimensions. For instance, Laxe et al. [25] stated that institutions capable of formulating clear and effective regulations related to a sustainability transition are able to promote better economic, environmental, and technological advancement within the port itself. Dooms (2019) highlighted that internal and external stakeholder management, which is concerned with economic and environmental objectives, leads to a better planning process and reduces the industry's environmental impacts. In addition, Kang and Kim [24] argued that the establishment of efficient communication and cooperation among stakeholders is essential in dealing with increased regulatory, competition, and customer pressures. This is achieved by facilitating the exchange of information and best practices among the entities involved and throughout the operational chain [38]. By doing so, stakeholders can actively contribute to the successful execution of sustainability initiatives and the enhancement of the organization's competitive edge. Therefore, a social sustainability transition is recognized as a fundamental attribute for achieving CST.

An economic sustainability transition refers to an organization's efforts to optimize economic performance resulting from the adoption of sustainability practices without negatively impacting social and environmental development [6]. According to Schaltegger et al. [17], a company must make the transition to economic sustainability to expand its business prospects and reduce risks. This economic dimension includes better efficiency and quality improvement, funding and investment, and the utilization of infrastructure [6]. Kang and Kim [24] argued that CST can be realized by pursuing better organizational processes and quality improvement due to its capability to generate effective and efficient operational practices. Laxe et al. [25] found that an organization with a good economic structure, a good financial situation, and good business performance is encouraged to implement environmentally friendly practices that promote a better sustainability transition. Lim et al. [6] highlighted that organizational funding, such as foreign direct investment, leads organizations to increase employment and generate better growth performance so that the adoption of sustainability practices can be supported. Hence, an economic sustainability transition must be considered due to its crucial role in promoting a better CST.

An environmental sustainability transition denotes an organization's efforts to reduce the environmental impacts caused by various industrial operations and activities [6,19,39]. Gupta and Prakash [40] and Zhou et al. [19] argued that environmental sustainability transition entails a wide variety of kinds of environmental performance and management, including the quality of surrounding air and soil, water and noise pollution control, and waste and hazardous substance management and disposal. According to Lim et al. [6], environmental sustainability practices are essential for corporate operations and strategies to reduce the environmental impacts of daily industrial operations and to adhere to sustainable development principles and regulations. Environmental management practices can potentially enhance business competitiveness and assist organizations in achieving their objectives and customer goals, leading organizations to achieve business success [26,29]. Puig et al. [39] emphasized that due to the continual rise in the volume of maritime commerce, which causes an increase in pollution produced by port and shipping activities, concern for enhanced environmental management capable of producing a more pleasant living environment is crucial for achieving a sustainability transition. Therefore, environmental management that leads to a sustainability transition is needed and needs to be included in CST practices.

Due to their ability to increase operational and environmental efficiency by synchronizing communication across all industrial equipment, technological practices must also be incorporated into CST practices in addition to the TBL dimensions [27,41,42]. Chua et al. [8] and Zheng et al. [29] argued that cutting-edge technology adoption plays a pivotal role in enhancing the value of businesses, facilitating the establishment of sustainability, and enhancing responsiveness in the face of various disruptions. Technological adoption and innovation within the port and shipping industry are needed to facilitate operational management while addressing new challenges in sustaining long-term secure and energy-efficient facilities with a low environmental impact [5,29,43]. Furthermore, smart technology adoption may greatly minimize anthropogenic concerns and organizational vulnerabilities and increase company competitiveness [11,15,42].

For example, Kang and Kim [24] found that the adoption of environmental technologies, which encompass environmentally friendly equipment, operating procedures, and delivery mechanisms, can generate cost, resource, and energy efficiency, which is necessary to achieve CST. Furthermore, Min [27] stated that smart infrastructure capable of maximizing productivity and digital technology usage are critical for realizing a smart port and sustainability transition. Hence, technological sustainability transition practices must be included in CST practices.

2.2. Proposed method

CST success criteria were examined and revealed through qualitative analysis. Ryszawska [36] used content and multilevel perspective analysis to analyze the role of sustainable finance in sustainability transition development. Leeuwen and Koppen [7] applied a literature review of existing empirical materials to examine the current stage of environmental management and the role of the market-based mechanism in reducing environmental impacts to promote better CST performance. Skellern et al. [28] used content analysis and a systematic review of existing studies to determine CST success factors and build an interdisciplinary analytical model. For the purpose of identifying both industrial metrics and differentiating between sustainable and green development, Wu et al. [13] conducted a structured literature review. In addition, Barreiro-Gen et al. [4] employed semi-structured interviews involving top-level professionals to identify the effect of social-related measurement on CST performance.

Within the quantitative analysis, Sahin and Yip [48] used the Gaussian fuzzy analytic hierarchy process to identify shipping technology management issues for a sustainability transition. Moreover, to analyze the influence of diverse port sustainability initiatives on sustainability practices and compare outcomes, Hossain et al. [12] used structural equation modeling. Kong and Liu [16] adopted a slack-based measurement model of the directional distance function and coupling coordination degree to examine the internal interactions and external influences of port cities' sustainability transition.

Prior studies have examined the attributes of CST through the use of qualitative and quantitative methods. However, the limited and ambiguous information presented in these studies poses challenges to gaining a comprehensive understanding of CST. Likewise, the lack of attention given to the interrelationship of attributes also hinders the achievement of appropriate and realistic CST viewpoints. Therefore, to address these issues, this study employs a mixed-methods approach within the current framework. This approach combines quantitative and qualitative methodologies to determine the essential attributes of CST. This study employs an integrated approach combining the FDM and fuzzy DEMATEL methodologies to achieve a valid representation of CST attributes, given the inherent ambiguity and uncertainty associated with CST and assessment procedures [44,49]. The FDM is used to construct a hierarchical framework by validating the measurements, confirming their reliability, and removing any extraneous criteria based on expert judgments [30,31,44]. The fuzzy DEMATEL is then used to guide the causal interplay of the attributes to produce a representative depiction of a CST [32,33,46].

2.3. Proposed measures

CST encourages the transition from traditional business operations to sustainable practices that incorporate TBL and technological dimensions into the activities of firms [20,26,36]. In the port and shipping industry, it is essential to comprehensively understand the attributes of a sustainability transition. A set of attributes representing eight aspects and 29 criteria is proposed in this study. The aspects involved are internal stakeholder management (A1), external stakeholder management (A2), communication and cooperation (A3), economic structure and business performance (A4), process and quality improvement (A5), environmental management (A6), environmental technology innovation (A7), and smart infrastructure (A8). The valid set of attributes is provided in Appendix 1.

The port and shipping industry has focused on enhancing economic performance without ruining the environment to achieve a better sustainability transition. However, the contributions to social sustainability, which may drive the establishment of a greater sustainability transition, have been largely ignored [4]. Numerous port and shipping industry employees engage in hazardous workplaces with a high fatality rate [37]. In particular, seafaring, being far from friends and family, spending most of the time working and living on a ship with only a few people, and being exposed to various dangers during regular work require seafarers to work safely, be well prepared, and be educated [37]. To achieve employee well-being and promote a better social sustainability transition, the integrated involvement of employees, port management bodies, board members, and shareholders is essential [22]. Therefore, improvement in internal stakeholder management (A1) is needed to realize a better sustainability transition [3,4,22]. Magnusson and Werner [23] highlighted that internal stakeholder management is capable of developing devoted managerial personnel who can influence a corporation to drive environmental innovation while also resulting in greater competitive advantage and innovation-oriented behavior. In accordance with this aspect, employee gender equality (C1) is perceived as an important criterion for balancing the view toward sustainability dimensions [4]. To prevent accidents or employee health issues, employee health and safety (C2) are essential to enhancing social welfare within ports [6,43]. Employees' sustainable knowledge (C3) is a dynamic capability that is able to improve the coherence between port strategies and operations and that can facilitate better port competitiveness and a sustainability transition [14]. Shareholder value (C4), which is associated with sustainability and green practices, potentially drives the realization of a sustainability transition [47]. Owner support (C5) for sustainability practices can promote the performance of intermediaries and enhance the intermediation efforts that facilitate a port's sustainability transition [21]. In addition, the contribution of port authorities to formulating port regulations (C6) to control activities and promote the safe handling of vessels and goods, environmental protection, and employee well-being is necessary to achieve a sustainability transition [11,21,23].

In addition to internal stakeholder management, external stakeholder management (A2) plays a significant role in promoting a sustainability transition (Magnusson and Werner, 2022). External stakeholders, including customers, suppliers, communities, and governments, could potentially stimulate and determine the implementation of sustainability practices within ports [22,47]. This aspect incorporates society's rising awareness (C7) of port sustainability practices that improve the understanding of the consequences generated by traditional and unsustainable activities [47]. Society's sustainable knowledge (C8), which can be obtained through education and discussion with stakeholders, generates improved innovative approaches for sustainability practice implementation and creates a better position to exploit existing sustainability processes [8,14]. Moreover, the international organization, as an external stakeholder, must establish international treaties (C9) that contribute to the existence and enforcement of practical guidelines and policies that can foster the development of better economic performance and technological adoption, which promote environmentally friendly practices and better social well-being, resulting in a better sustainability transition [25,47].

Along with the social dimension, the transition to port sustainability necessitates enhanced communication and cooperation (A3) among all stakeholders involved. Port authorities, industries, governments, and other stakeholders must cooperate and coordinate to respond to the increasing pressures from competitors and customers. Moreover, effective communication and collaboration facilitate the exchange of knowledge and best practices across the operational chain, ultimately contributing to the objective of enhanced integration to promote a successful transition toward sustainability [38]. Better communication and cooperation among stakeholders can develop operational efficiency and enhance visibility to realize a port sustainability transition Kang and Kim [24]. In accordance with this aspect, operational transparency (C10) among the stakeholders involved is needed to construct better trust and relationships among key actors and provide transparent tracking of corporate efforts to achieve a sustainability transition Kang and Kim [24]. In addition, the exchange of information and knowledge (C11) can generate more innovation to foster the shift toward sustainability transition.

For corporations, achieving economic sustainability and enhancing economic performance are needed to assist in their transformation toward sustainable practices [36]. The economic structure and business performance (A4) are essential to supporting economic sustainability, with the aim of optimizing economic performance by executing initiatives that promote sustainability without causing environmental or social impacts [6]. This aspect is considered one of the major components that drives a company's growth performance and leads to better sustainability implementation [6]. This aspect includes foreign direct investment (C12), which is recognized as a key factor in increasing growth performance, which in turn promotes port sustainability to positively influence national and international economies by generating job vacancies, employment, and exports [6,41]. Moreover, port profits and growth (C13) play an indispensable role in supporting the innovation and adoption of technology to promote sustainability practices [3].

Another aspect that is necessary and related to economic sustainability is process and quality improvement (A5). This aspect is able to generate operational efficiency, especially through the better utilization of port areas, automation systems, and the optimization of modal shifts, benefiting ports by maximizing profit and promoting the sustainability transition (Kang and Kim, 2017) [24]. In accordance with this aspect, supply chain integration and collaborative planning (C14) between a port and its supply chain partners are capable of aligning a port's demand, supply, and operation itself while generating better growth in profitability Kang and Kim [24]. The effective utilization of port infrastructure (C15) maximizes port infrastructure and physical asset productivity and is also able to foster port economic growth and support a shift toward sustainability Kang and Kim [24]. Enhancement of service quality (C16) can increase port competitiveness and attract more port users Kang and Kim [24]. Furthermore, R&D promotion (C17) is necessary to boost innovation related to sustainable practices and technologies and to enhance port operation processes and service quality [25].

Researchers have raised concerns over the application of environmental sustainability practices due to the significant environmental impacts of the port and shipping industry [12]. Port and shipping businesses are expected to integrate environmental assessment into their business and operations to comply with sustainable development guidelines and legislation [6,29,40]. Therefore, environmental management (A6) is necessary. Environmental management is the functional organization requirement to provide environmental protection and promote sustainable growth while adhering to the highest compliance and accountability standards [39]. It aims to manage and integrate environmental concerns into corporate practices to reduce the environmental impact caused by various port and shipping activities [6]. This aspect covers air pollution control (C18) to manage air quality, especially within ports and port cities, which promotes better community well-being [6,40,43]. The utilization of energy and resources (C19) is perceived as the most salient effort to decarbonize the port and shipping industry and achieve environmental goals while also fostering economic growth [6,39,40]. Noise pollution control (C20), which is able to control and maintain low noise exposure, is needed to protect community health and promote well-being [6,40,43]. Moreover, soil contamination control (C21), waste pollution control (C22), and odor pollution control (C23) are essential to minimize risks to human health and environmental ecosystems, which is key to achieving a sustainability transition [6,43]. Furthermore, increasing the number of employees with environmental training (C24) can improve employees' awareness of environmental concerns and aid the port and shipping industry in adhering to environmental standards [25].

In terms of technology, environmental technology innovation (A7) supports businesses in improving their reputation, productivity, and environmental management and is acknowledged as a tool for promoting CST [24,49]. In the port and shipping industry, technology adoption and innovation are considered critical for integrating sustainability into business models for long-term company success [42,48]. Environmental technology innovation promotes the capacity of corporations to exploit opportunities, detect threats, and maintain their competitiveness [5,48]. In accordance with this aspect, the introduction of new equipment and technology (C25) is able to support the port and shipping industry in managing market sales digitally, which promotes better economic and environmental performance while also fostering a sustainability transition [15,18,24]. Alternative and renewable energy sources (C26) assist the industry in generating lower carbon emissions to comply with regulations and promote CST [18,24]. Additionally, environmentally clean technologies (C27) are needed to decrease and optimize the use of natural resources, thereby reducing the undesirable ecological effects of port and shipping activities [23,48].

Another aspect of the technological dimension is smart infrastructure (A8), which is necessary to enhance productivity and digital technology utilization to support a sustainability transition. This aspect includes sensor deployment (C28), which is useful for measuring temperature, pressure, humidity, radiation, and other conditions within port areas and computing the mean, standard deviation, and variance of each measurement for better operational control [27,41]. Additionally, greater on-demand computing resources, including data and software, need to be provided through cloud computing services (C29), which may improve operating efficiency and reduce costs [27].

3. Methodology

The case background of a CST in Southeast Asia is further developed, and the methods used in this study, which include the FDM and fuzzy DEMATEL, are elaborated in this section.

3.1. Case background

Ports play a crucial role in facilitating international commerce by serving as pivotal hubs for the transportation and exchange of various goods and resources between countries. Moreover, the shipping industry is an essential transportation service that plays a vital role in facilitating connectivity between Southeast Asia and other countries [2]. The mutual dependency and indispensability of ports and the shipping industry are crucial for facilitating international trade. Ports play a crucial role in facilitating the transportation of commodities for shipping businesses, providing the essential infrastructure and services needed for effective operations. Concurrently, the shipping business generates demand for port services and facilities, as well as making a major contribution to the economic prosperity of both port cities and countries.

Particularly in Southeast Asia, the port and shipping industry plays a significant role in driving economic development, notably owing to its primary role in enabling both domestic and international trade between countries [51], (UNCTAD, 2021). Moreover, the maritime trade facilitated by the port and shipping industry acts as a major driver in achieving the Master Plan on ASEAN Connectivity 2025, which aims to construct a shared vision among member countries to realize a comprehensive and seamless connection and integrated region that is able to foster inclusiveness, competitiveness, and a better sense of community [50,51]. Therefore, as an essential sector that aligns with the vision of the Association of Southeast Asian Nations (ASEAN) and potentially fosters the economic growth of countries in Southeast Asia, the port and shipping industry is expected to continuously grow in the following decades. Although it is significant for countries' economies, increased port and shipping industry activities elevate the risk to society and the environment. Within the view of the port and shipping industry, negative externalities from increased energy consumption, effluent discharge, dredging oil disposal, light and noise pollution, and other phenomena that harm surrounding populations, wildlife, and the environment can be found [10,50]. Therefore, the port and shipping industry is needed to encourage CST to balance social well-being, economic performance, environmental protection, and the adoption of technology. The Southeast Asian port and shipping industry needs to address numerous attributes to achieve CST.

By identifying the major attributes, this study provides practitioners with recommendations for improving CST performance. In this study, a convenient and purposive sampling method was employed, and data from 26 professionals from the academic sector and the port and shipping industry with an average of 10 years of extensive experience in related fields across Southeast Asia were obtained via face-to-face interviews. This number of samples is sufficient for conducting assessments based on the FDM and fuzzy DEMATEL [30,34]. Furthermore, Appendix 2 presents a table of the expert demographics.

3.2. Fuzzy Delphi method

This study uses the FDM, which integrates the Delphi method and fuzzy set theory into one method. These merged methods can contribute to improving questionnaire design while overcoming the limitations of expert opinions [30, 45]. Moreover, the vagueness and ambiguity issues of qualitative information can be addressed by using this integrated method [30,34]. By implementing this method, expert judgments and linguistic preferences are used to validate the initial set of attributes. Furthermore, based on expert opinions, of the 8 aspects and 46 criteria, the less necessary and invalid aspects and criteria are eliminated by using this method. This method also reduces the data collection time due to the limited sample of respondents [30,31,44].

This method is used in tandem with the viewpoints of professionals. Professional α evaluates importance value b as $j = (x_{ab}; y_{ab}; z_{ab})$; $\alpha = 1, 2, 3, \ldots, n$; $b = 1, 2, 3, \ldots, m$. Subsequently, the weight j_b of attribute b is reflected as $j = (x_b; y_b; z_b)$, where $x_{ab} = \min(x_{ab})$, $y_b = (\prod_1^n y_{ab})^{1/n}$, and $z_b = \max(z_{ab})$. The translation of linguistic terms with triangular fuzzy numbers (TFNs) to linguistic values is depicted in Table 1. The results are then obtained by using cut α.

$$u_b = z_b - \alpha(z_b - y_b), l_b = x_b - \alpha(y_b - yx_b),\\ b = 1, 2, 3, \ldots, m \tag{1}$$

In general, 0.5 is used to characterize α, which varies from zero to one depending on the negative or positive nature of the professionals as evaluators. Furthermore, the value of D_b may be calculated using the formula below:

Table 1. Linguistic terms conversion.

Linguistic terms (performance/importance)	Corresponding triangular fuzzy numbers
Extreme	(0.75, 1.0, 1.0)
Demonstrated	(0.5, 0.75, 1.0)
Strong	(0.25, 0.5, 0.75)
Moderate	(0, 0.25, 0.5)
Equal	(0, 0, 0.25)

$$u_b = \int (u_b, l_b) = \delta[u_b + (1-\delta)l_b] \quad (2)$$

In this method, ™ is utilized to represent decision-makers' level of positivity while also achieving equilibrium between professionals' judgments. Subsequently, the threshold used to evaluate the primary criterion is reflected as $\gamma = \sum_{a=1}^{n}(D_b/n)$. When $D_b > \gamma$, the criterion is accepted. However, if $D_b < \gamma$, the criterion is rejected.

3.3. Fuzzy decision-making trial and evaluation laboratory

The fuzzy DEMATEL method is applied after the invalid and irrelevant attributes are removed using the FDM. This method aims to exclude subjective preferences from qualitative information and utilize the causal interrelationships among the attributes to establish a CST hierarchical framework that is capable of assisting decision makers by providing unambiguous, valid, and realistic attributes [31,32,34]. Based on the set of attributes reflected as Q = {q1,q2,q3,⋯,qn}, pairwise comparisons are performed to create the statistical interrelationships. In this method, the analysis is guided by TFNs and linguistic scales ranging from very low influence (VLI) to very high influence (VHI), resulting in crisp values. Then, the defuzzification process is employed to transform the linguistic data into TFNs. The objective of the TFN analysis is to ascertain the total weighted values.

The following formula produces the TFNs:

$$Q = \left(q\tilde{e}_{1ij}^{k}, q\tilde{e}_{2ij}^{k}, q\tilde{e}_{3ij}^{k}\right) = \left[\frac{\left(e_{1ij}^{k} - min\ e_{1ij}^{k}\right)}{\Delta}, \frac{\left(e_{2ij}^{k} - min\ e_{2ij}^{k}\right)}{\Delta}, \frac{\left(e_{3ij}^{k} - min\ e_{3ij}^{k}\right)}{\Delta}\right] \quad (3)$$

where $\Delta = \max e_{3ij}^{k} - \min e$.

The following formula determines the left (l) and right (r) normalized values.

$$\left(l_{ij}^{n}, r_{ij}^{n}\right) = \left[\frac{\left(qe_{2ij}^{k}\right)}{\left(1 + qe_{2ij}^{k} - qe_{1ij}^{k}\right)}, \frac{qe_{3ij}^{k}}{\left(1 + qe_{3ij}^{k} - qe_{2ij}^{k}\right)}\right]. \quad (4)$$

Using the following formula, the normalized crisp values (nc) are then computed.

$$nc_{ij}^{k} = \frac{\left[l_{ij}^{k}\left(1 - l_{ij}^{k}\right) + \left(r_{ij}^{k}\right)^{2}\right]}{\left(1 - l_{ij}^{k} + r_{ij}^{k}\right)}. \quad (5)$$

The discrete evaluations of respondent k are used to produce the synthetic crisp values:

$$\tilde{e}_{ij}^{k} = \frac{\left(nc_{ij}^{1} + nc_{ij}^{2} + nc_{ij}^{3} + \cdots + nc_{ij}^{3}\right)}{k}. \quad (6)$$

The initial direct relation matrix (IM) is then constructed based on the pairwise comparisons. $\tilde{e}_{ij}^{k}\tilde{e}_{ij}^{k}$ Denotes the degree to which attribute i has an impact on attribute j, and the matrix is defined as $IM = [\tilde{e}_{ij}^{k}]_{n\times n}$.

Subsequently, the normalized direct relation matrix (U) is produced by computing the formula below:

$$U = \tau \otimes IM$$

$$\tau = \frac{1}{\max_{1\le i\le k} \sum_{j=1}^{k} \tilde{e}_{ij}^{k}}. \quad (7)$$

Additionally, the interrelationship matrix (W) is computed using the following formula:

W=U(I−U)(-1), **(8)**

where W is $[w_{ij}]_{n\times n}$ $i,j = 1, 2, \cdots n$.

Furthermore, the row and column total values of the interrelationship matrix are utilized to compute and generate the driving power (ϑ) and dependent power (μ).

$$\vartheta = \left[\sum_{i-1}^{n} w_{ij}\right]_{n\times n} = [w_i]_{n\times 1} \quad (9)$$

$$\mu = \left[\sum_{j-1}^{n} w_{ij}\right]_{n\times n} = [w_j]_{1\times n}. \quad (10)$$

On the basis of [(ϑ + μ), (ϑ - μ)], the attribute cause-and-effect diagram, symbolized by horizontal and vertical vectors, is visualized. The significance level of an attribute is represented by (ϑ + μ). More important attributes are indicated by a higher (ϑ + μ) value. Furthermore, based on the (ϑ - μ) value of the attributes, the causal group and effect group are organized. Positive values place the attributes in the causal group, while negative values place the attributes in the effect group.

4. Results

The analytical results of the study are presented in this section. The major attributes are revealed, and the interrelationships are elaborated. Furthermore, the implications are detailed.

4.1. Fuzzy Delphi method

In conducting the FDM analysis, 46 criteria, including four perspectives and eight aspects, are proposed. In this method, the fuzzy scale is used to evaluate the CST criteria based on the judgments of professionals. Appendix 3 shows the defuzzification process, which is carried out using equations [1,2]. The linguistic terms are then transformed into corresponding TFNs, and FDM analysis is employed to assess the professionals' judgments on each specified criterion. Furthermore, with a threshold of 0.634, the findings exhibiting the criterion and each of its weights are shown in Table 2. Consequently, 29 criteria are approved, while the remaining 17 are rejected.

4.2. Fuzzy decision-making trial and evaluation laboratory

In this method, equations [3]-(6) are used to convert linguistic preferences into crisp values. As indicated in Table 3, the initial direction matrix is created by averaging the defuzzified values and fuzzy direct relation matrix into crisp values. Subsequently, by using equations [7,8], the total interrelation matrix of the aspects is produced and presented in Table 4. A value of 0.437–0.511 is considered a weak interrelationship, a value of 0.511–0.582 represents a moderate interrelationship, and a value of 0.582–0.652 indicates a strong interrelationship. In addition, Appendix 4 displays the total interrelationship matrix of the criteria.

The cause-and-effect interrelationships among certain aspects are obtained and illustrated in Table 5 as the outcomes of computing Equations [9,10]. In addition, Table 6 displays the cause-and-effect interrelationships among the criteria. The visualization of the cause ($\theta + \mu$) and effect ($\theta - \mu$) axes makes it possible to construct these tables.

Using the ($\theta + \mu$) and ($\theta - \mu$) axes, Fig. 1 depicts a diagram of the cause-and-effect relationships among the aspects. This diagram shows that the cause group incorporates internal stakeholder management (A1), external stakeholder management (A2), and communication and cooperation (A3). On the other hand, economic structure and business performance (A4), process and quality improvement (A5), environmental management (A6), environmental technology innovation (A7), and smart infrastructure (A8) belong to the effect group. According to this figure, A1 has a strong impact on A4, A5, A6, and A7 while having a moderate impact on A3 and A8. A2 has a strong impact on A5, A6, and A7, in addition to a moderate impact on A4 and A8. Furthermore, A3 has a

Table 2. FDM criteria list.

Criteria		Results
C1	Employees' gender equality	0.665
C2	Employees' health and safety	0.696
C3	Employees' sustainable knowledge	0.654
C4	Shareholder's value	0.689
C5	Owner support	0.769
C6	Port's regulation	0.674
C7	Society's raising awareness	0.796
C8	Society' sustainable knowledge	0.646
C9	International treaties	0.683
C10	Operational transparency	0.678
C11	Exchange of information and knowledge	0.686
C12	Foreign direct investment	0.659
C13	Port's profits and growth	0.659
C14	Supply chain integration and collaborative planning	0.680
C15	Effective utilization of port infrastructure	0.671
C16	Enhancement of service quality	0.693
C17	R&D promotion	0.654
C18	Air pollution control	0.657
C19	Utilization of energy and resources	0.680
C20	Noise pollution control	0.696
C21	Soil contamination control	0.665
C22	Waste pollution control	0.803
C23	Odor pollution control	0.638
C24	Environmental training	0.669
C25	Introduction of new equipment and technology	0.686
C26	Alternative and renewable energy sources	0.703
C27	Environmentally clean technologies	0.789
C28	Sensor deployment	0.671
C29	Cloud computing services	0.657
Threshold		0.634

Table 3. Initial direction matrix.

	A1	A2	A3	A4	A5	A6	A7	A8	Row
A1	0.860	0.637	0.689	0.594	0.589	0.622	0.568	0.528	5.085
A2	0.747	0.845	0.371	0.392	0.567	0.571	0.581	0.594	4.668
A3	0.647	0.490	0.860	0.601	0.568	0.529	0.485	0.192	4.371
A4	0.356	0.059	0.356	0.706	0.581	0.581	0.614	0.587	3.841
A5	0.264	0.271	0.461	0.587	0.681	0.516	0.457	0.466	3.703
A6	0.076	0.301	0.069	0.627	0.522	0.710	0.608	0.470	3.383
A7	0.083	0.255	0.054	0.581	0.622	0.663	0.697	0.512	3.468
A8	0.097	0.066	0.711	0.491	0.581	0.523	0.581	0.732	3.782
								MAX	5.085

Table 4. Total interrelationship matrix.

	A1	A2	A3	A4	A5	A6	A7	A8
A1	0.489	0.426	0.517	0.637	0.644	0.652	0.627	0.560
A2	0.438	0.445	0.418	0.550	0.596	0.598	0.588	0.541
A3	0.406	0.357	0.498	0.567	0.567	0.560	0.538	0.425
A4	0.273	0.203	0.332	0.512	0.491	0.491	0.488	0.442
A5	0.258	0.248	0.350	0.479	0.503	0.469	0.448	0.410
A6	0.181	0.223	0.226	0.442	0.426	0.465	0.437	0.377
A7	0.184	0.216	0.227	0.440	0.453	0.462	0.461	0.391
A8	0.218	0.201	0.404	0.462	0.483	0.471	0.473	0.460

Table 5. The level of aspects' cause-and-effect interrelationships.

	θ	μ	(θ + μ)	(θ - μ)
A1	4.552	2.447	6.999	2.105
A2	4.174	2.318	6.491	1.856
A3	3.917	2.972	6.889	0.945
A4	3.232	4.090	7.322	(0.857)
A5	3.166	4.162	7.328	(0.996)
A6	2.776	4.168	6.944	(1.391)
A7	2.834	4.059	6.893	(1.226)
A8	3.172	3.607	6.778	(0.435)

moderate impact on A4, A5, A6, and A7. Hence, A1, A2, and A3 are the aspects that must be emphasized, as determined by this study.

The criteria grouped into causal and effect groups are depicted in Fig. 2. The cause group contains employee gender equality (C1), employees' sustainable knowledge (C3), shareholder value (C4), owner support (C5), society's rising awareness (C7), society's sustainable knowledge (C8), international treaties (C9), operational transparency (C10), foreign direct investment (C12), supply chain integration and collaborative planning (C14), R&D promotion (C17), and environmental training (C24).

Table 6. The level of criteria's cause-and-effect interrelationships.

	θ	μ	(θ + μ)	(θ - μ)
C1	1.629	1.348	2.977	0.281
C2	2.623	3.705	6.327	(1.082)
C3	3.506	2.611	6.117	0.894
C4	4.164	2.540	6.704	1.624
C5	4.040	2.562	6.602	1.478
C6	3.661	3.756	7.417	(0.095)
C7	2.104	1.472	3.576	0.632
C8	2.128	1.795	3.924	0.333
C9	4.028	2.687	6.714	1.341
C10	2.890	2.517	5.407	0.373
C11	2.414	2.800	5.214	(0.385)
C12	3.368	3.203	6.572	0.165
C13	3.456	3.495	6.951	(0.038)
C14	2.765	2.599	5.363	0.166
C15	2.186	3.082	5.268	(0.896)
C16	4.002	4.028	8.030	(0.026)
C17	3.873	3.664	7.536	0.209
C18	2.981	3.723	6.704	(0.741)
C19	3.298	3.831	7.128	(0.533)
C20	2.498	3.280	5.778	(0.782)
C21	2.701	3.521	6.222	(0.821)
C22	2.991	3.557	6.547	(0.566)
C23	2.974	3.592	6.566	(0.618)
C24	3.493	3.458	6.952	0.035
C25	3.602	3.791	7.394	(0.189)
C26	3.339	3.472	6.811	(0.134)
C27	3.636	3.840	7.476	(0.205)
C28	3.311	3.624	6.936	(0.313)
C29	2.729	2.835	5.564	(0.106)
MAX			8.030	1.624
MIN			2.977	(1.082)
AVERGAGE			6.234	0.000

The effect group includes employee health and safety (C2), port regulation (C6), the exchange of information and knowledge (C11), port profit and growth (C13), the effective utilization of port infrastructure (C15), enhancement of service quality (C16), air pollution control (C18), the utilization of energy and resources (C19), noise pollution control (C20), soil contamination control (C21), waste pollution control (C22), odor pollution control (C23), the introduction of new equipment and technology (C25), alternative and renewable energy sources (C26), environmentally clean technologies (C27), sensor deployment (C28), and cloud computing services (C29).

The top five criteria based on the total value of all of the criteria are as follows: R&D promotion (C17), environmental training (C24), international treaties (C9), shareholder value (C4), and owner support (C5). These criteria are associated with CST enhancement in the port and shipping industry.

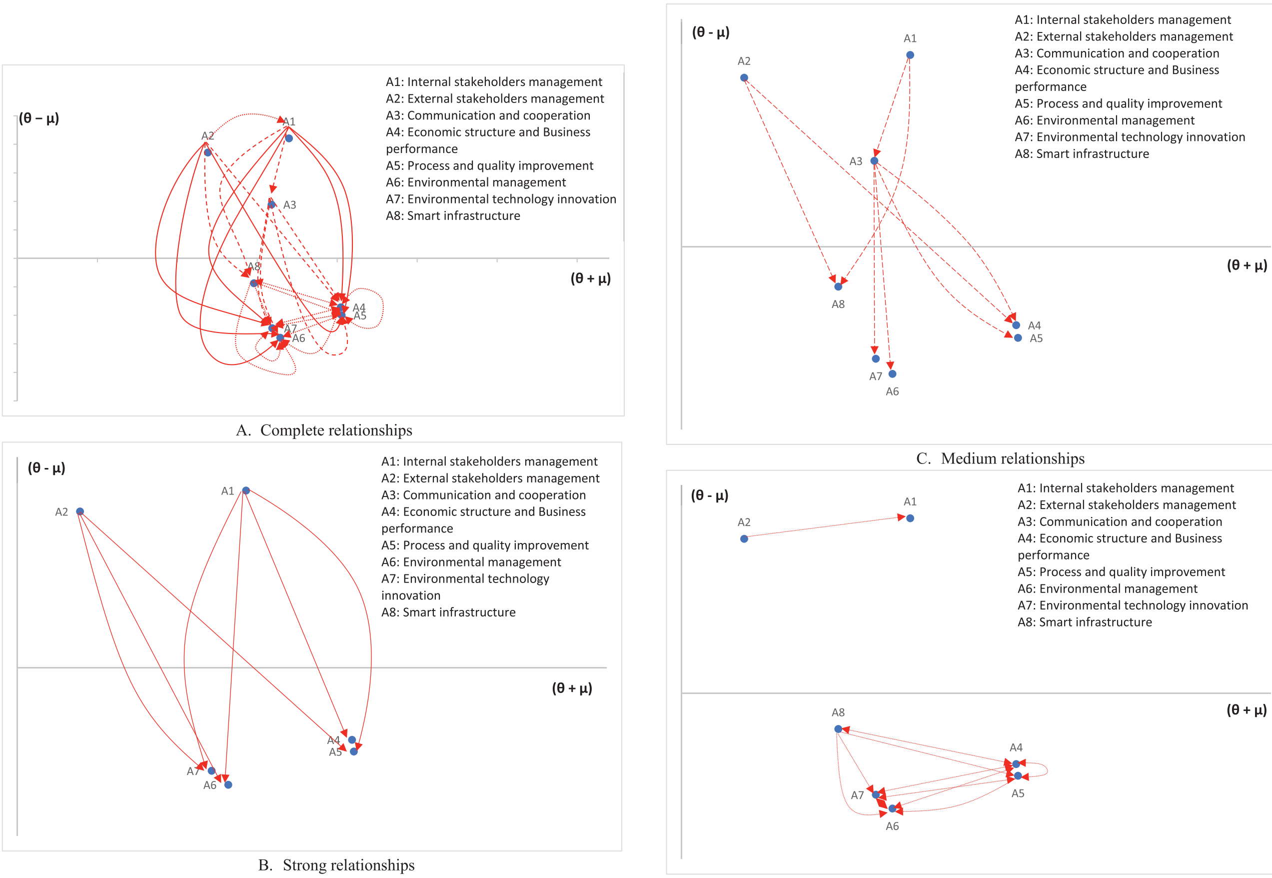
5. Discussion

This section goes into further detail on the theoretical implications of the results. Subsequently, to assist the industry in making a better CST, managerial implications are also discussed.

5.1. Theoretical implications

This work theoretically contributes to the corpus of knowledge. The merging of TBL and technological dimensions results in the creation of a complete assessment for achieving high CST performance. In addition, to determine the strategic approach, a theoretical framework constructed from the causal links between aspects is proposed. The findings reveal that internal stakeholder management (A1), external stakeholder management (A2), and communication and cooperation (A3) appear to have a significant influence on the other aspects.

Earlier studies have underlined the necessity of internal stakeholder management, which is associated with the activities of shareholders, board members, managing bodies, and workers. Internal stakeholder management is described as the effort to effectively and efficiently deploy, bundle, and utilize internal resources to achieve better sustainability. This aspect is recognized as capable of supporting the development of all operational activities that lead toward better TBL and technological performance. Better internal stakeholder management that aims to realize better environmental performance by installing more eco-friendly assets generates financial benefits due to reduced operating



A. Complete relationships

B. Strong relationships

C. Medium relationships

D. Weak relationship

Fig. 1. Diagram of the cause-and-effect relationships among the aspects.

costs, and it also potentially improves operational safety and promotes a better corporate image (Doom, 2019; Tran et al., 2020). Furthermore, enhanced internal stakeholder management that focuses on improving employees' sustainable knowledge (e.g., exploring innovative solutions through investment in R&D) leads to better employee capability in sustainably exploiting recent

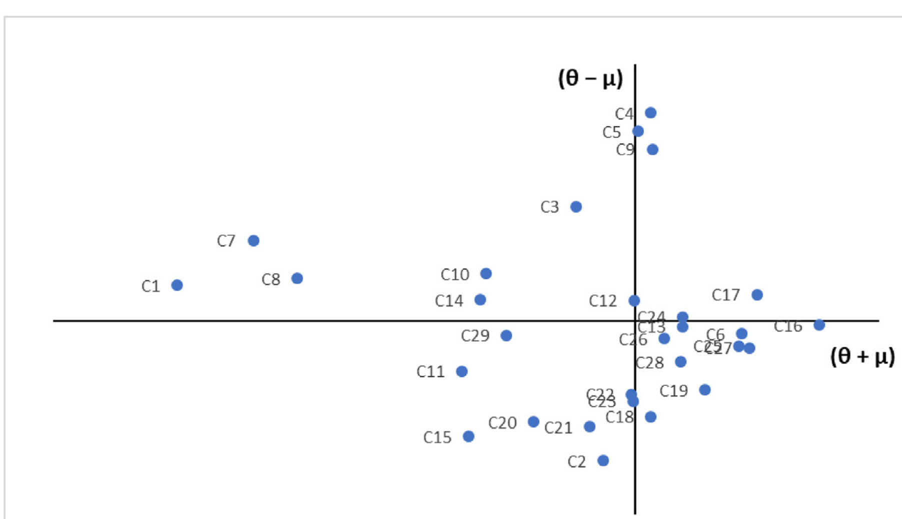


Fig. 2. Diagram of the cause-and-effect relationships among the criteria.

processes. In addition, internal stakeholder management is capable of establishing an organizational culture in which personnel are supportive and devoted to sustainability. Therefore, having better internal stakeholder management can complement business strategies and assist companies in realizing a sustainability transition.

To encourage and ensure that sustainability implementation occurs within companies, better external stakeholder management is needed. Such management includes any entities outside the managing bodies that involve and influence operational activities, for instance, suppliers, customers, local communities, governments and regulators, nongovernmental organizations, trade associations, and even the media. Various external stakeholders strongly determine the development of the industry itself, especially the achievement of sustainability. Improved external stakeholder management that aims to support sustainability practices, particularly in the regulatory and legislative domains, can exert pressure on organizations to implement sustainability measures to mitigate issues regarding legitimacy by reducing regulatory and compliance risks [23]. Related to this issue, corporations are likely to adopt sustainability practices due to the demands of local governments, which are a highly prominent stakeholder within the industry that is also supported by various media and nongovernmental organizations. In addition, society's rising awareness and knowledge of sustainability incorporated in external stakeholder management can enhance the demand for better operational practices and gain governmental attention that drives the port sustainability transition [14]. Hence, external stakeholder management that aims to mitigate environmental issues potentially fosters a sustainability transition in the industry.

Furthermore, communication and cooperation are fundamental in assisting the industry's sustainability transition. Their function is critical in developing a long-term sustainability plan or strategy, both internally and externally. The shift toward a more sustainable industry is difficult to undertake when there is a lack of communication and cooperation among shareholders, board members, management bodies, and workers within the industry itself. Additionally, communication and cooperation with external entities such as customers, business partners, communities, and others are crucial for generating greater sustainability growth; otherwise, losses in sales of services or goods may be incurred. Hence, to respond to the rising demands of all types of stakeholders, including competitors, customers, and regulators, all stakeholders, from the corporation itself to the governments and communities involved, must effectively communicate and coordinate. Prior studies have argued that sustainability transition success is dependent on the sustainability of the relationships among stakeholders, which is potentially obtained from better communication and cooperation among all stakeholders in a business [23,24]. Such sustainability enables the industry to adjust quickly to changing expectations and environments while maintaining operational performance with enhanced efficiency and service differentiation. Therefore, communication and cooperation among all stakeholders involved can generate greater sustainability plans and strategies that lead to better CST performance.

In summary, this study discovers comprehensive CST attributes. The major attributes include internal stakeholder management, which significantly influences the formulation of port and shipping companies' vision, mission, and objectives, which in turn determine the implementation of sustainability practices; external stakeholder management, which is essential for ensuring and encouraging the implementation of sustainability practices; and communication and cooperation, which play a critical role in developing a long-term plan or strategy both internally and externally. Stronger internal stakeholder management that focuses on promoting sustainability is essential for the port and shipping industry to achieve CST that balances social welfare, economic performance, and environmental performance. Developing external stakeholder management that can enforce and assist environmental performance is essential to supporting a sustainability transition. Furthermore, communication and cooperation among stakeholders that aid the industry in swiftly adapting to changing demands and circumstances while upholding operational performance improvement are fundamental to assisting a sustainability transition. The success of a company and its employees may be directly affected by improvements in these areas. Consequently, internal stakeholder management, external stakeholder management, and communication and cooperation among stakeholders are necessary to realize improved CST performance.

5.2. Managerial implications

For the port and shipping industry, this study offers numerous implications that can benefit CST performance. Several attributes have been uncovered in earlier studies; however, the relationships between attributes have not been explained. Furthermore, continuous changes in business circumstances impact attribute relevancy and render specific attributes outdated. The five most essential causal criteria discovered in this study are R&D promotion (C17), environmental training (C24), international treaties (C9), shareholder value (C4), and owner support (C5). The primary criteria for promoting CST performance were discovered to be these five criteria. For the port and shipping industry to improve and move toward sustainability, these criteria must be included in operating procedures.

One of the most crucial issues for the port and shipping industry to address to promote operational changes, enable decarbonization, and complete the sustainable transition is R&D promotion (C17). In Southeast Asia's port and shipping industry, R&D promotion is needed to produce long-term innovation decisions while advancing technological development to enable the realization of zero carbon emissions by 2050 and to comply with sustainability objectives. Research and technology development are capable of unleashing prospective future value creation within the industry and potentially ensuring sustainable growth. Investment in R&D might improve the port interface and develop better strategies for businesses to lessen the adverse effects of their operations. For instance, the development of propulsion technology and projects in ammonia, hydrogen, and battery power for future energy to obtain zero carbon emissions have led to sustainability. Moreover, R&D promotion leads to new technology that delivers improved digital solutions, which is fundamental for restructuring the Southeast Asian maritime industry in a sustainable manner. Therefore, a massive increase in finance for technology and R&D in the port and shipping industry is essential and needs to be prioritized.

To achieve a better sustainability transition, another effort, environmental training (C24), is needed. Within Southeast Asia's port and shipping industry, environmental education and training are mainly already offered for employees; nevertheless, constant improvement based on global standards is needed. This training is needed for seafarers, office personnel, and port and waterfront communities to enhance their awareness and knowledge of operating standards so that environmental oversight can be avoided while also complying with environmental regulations. The capacity of Southeast Asia's port and shipping industry to apply sustainable practices is also reliant on the level of environmental training, knowledge, and experience, as well as the understanding of sustainability demands that are potentially gained from focus group discussions with stakeholders. The implementation of environmental training that effectively enhances employees' environmental awareness is capable of generating continuous improvement in environmental performance due to its ability to provide skills to execute jobs efficiently, make employees more aware of their duties and responsibilities, and encourage individuals to develop fresh ideas through discussion and consultation. Furthermore, employees are more willing to minimize risks, obey protocols, and assist in the operation and adoption of sustainable practices when they are aware of the consequences. Therefore, environmental training that is able to enhance awareness of the potential consequences of traditional unsustainable practices is critical to promoting proper practical implementation and successful routine management.

International treaties (C9) encourage and drive sustainable practice implementation and support CST development. As a result of governments and the maritime sector among countries, international treaties on the sustainable port and shipping industry contribute to reducing the environmental impacts produced by seagoing vessels and port operations. The reason is the capacity of an international treaty to influence signatory states to align their domestic laws with the convention and essentially vow to comply with it. For instance, to avoid the spread of exotic organisms present in ballast water, the international ballast water agreement requires ships to include a ballast water treatment system that purifies the ballast water of exotic organisms before disposal. Another example is the global agreement to reduce the air pollution produced by ships. This agreement asserts that from 2025, all new ships are needed to be at least 30 % more energy efficient. In addition, in Southeast Asia's port and shipping industry, the collaboration agreement with the partnership in Environmental Management for the Seas of East Asia on improving safety, health, and environmental management is advantageous in assisting both entities to produce a proactive approach to achieve better quality and sustainability in safety, health, and the environment. Therefore, the sustainability practices adopted in the port and shipping industry are caused and driven by international conventions or treaties. Hence, the transition to sustainability is greatly aided by international treaties.

The primary financial goal of every firm, including those in the port and shipping industry, is to increase the wealth of its shareholders. This function emphasizes that management bodies behave in the best interests of their shareholders; thus, the investments that they make lead to the best returns for shareholders themselves. Hence, the port and shipping industry always tries to increase shareholder value (C4) to satisfy and maintain shareholders themselves while also attracting more investment. The concept of “shareholder value” refers to the advantage offered to shareholders by management's capacity to generate revenue, profit, and cash flow, resulting in greater dividends and capital gains. In Southeast Asia's port and shipping industry, management that focuses on optimizing shareholder value is considered short-termism, with a focus on quarterly results rather than long-term company health. However, when investment increases, the benefits serve not only shareholders but also port operations, users, employees, and even communities. Therefore, this study argues that shareholder value, which is linked with sustainability concerns, is essential in driving sustainability implementation in the port and shipping industry.

A key factor in the realization of CST performance in Southeast Asia's port and shipping industry is owner support (C5), which involves the port authority, landlord, or trustee of areas, facilities, and infrastructure. The owner is responsible for maintaining, managing, and developing a port's physical sources. In addition, the establishment of policies and strategies related to port infrastructure and operations is dependent on the owner's focus. Owner support for sustainability implementation can foster transition work due to the owner's ability to encourage operational enhancement, which leads to greater economic growth while protecting communities and ecosystems. Owner support is also able to ensure environmental concern while interacting and dealing with users and engaging in other port economic activities. Furthermore, owner support is capable of ensuring sustainability in waste reception, construction activities, and infrastructure development. Hence, owner support is needed to aid the port and shipping sector in improving CST performance.

Therefore, this study emphasizes the most important causal criteria, which include R&D promotion, environmental training, international treaties, shareholder value, and owner support. These criteria are necessary and must be prioritized in the operational activities of the port and shipping industry to achieve improved CST performance. These criteria are the results of a survey of experts in the port and shipping industry of several Southeast Asian countries. Furthermore, these criteria are valid and pertinent for other countries with relevant characteristics, legislative regulations, and development. As a result, these criteria are indispensable in helping practitioners from relevant contexts achieve high CST performance.

6. Conclusion

The concept of CST has undergone analysis and has garnered recognition as a significant concern in contemporary times. Despite the implementation of various strategies aimed at improving CST performance, there is still a lack of clear knowledge regarding the valid comprehensive attributes that encompass all dimensions of TBL and the technological dimension. Therefore, the objective of this study is to examine the assessments made by experts to uncover the valid holistic major drivers that contribute to the achievement of improved CST performance. A proposed framework consisting of eight aspects and 46 criteria is proposed to establish a valid theoretical or hierarchical model to offer comprehensive guidance for practical enhancements in the context of CST performance. The present study utilized an integrated approach, integrating the FDM and fuzzy DEMATEL methods. The application of fuzzy set theory facilitated the transformation of experts' subjective assessments into objective and quantifiable information. The application of the FDM was utilized to validate and remove criteria that were deemed by experts to have less influence on inhibiting CST. Next, a fuzzy DEMATEL analysis was performed to determine the causal relationships between attributes, thereby enabling a more accurate understanding of the attributes influencing CST performance.

The results of this study reveal that internal stakeholder management, external stakeholder management, and communication and cooperation are the causal aspects. In particular, internal stakeholder management and external stakeholder management are the aspects with the greatest influence on other aspects within the hierarchical framework. Therefore, organizations are recommended to prioritize the enhancement of internal stakeholder management and external stakeholder management to encourage and ensure sustainability implementation while also strengthening the operational activities that lead to better social, economic, environmental, and technological performance. The results reveal that R&D promotion, environmental training, international treaties, shareholder value, and owner support are the top five causal criteria that practitioners must improve to develop CST performance. Furthermore, the results of this study provide valid recommendations for firms, organizations, and governments to formulate policies that are capable of increasing firms' economic growth while also preserving the environment and protecting human welfare. These recommendations are supported by valid and weighted attributes; therefore, they can aid practitioners in making better decisions and promoting CST performance. Thus, these qualities must be prioritized in the port and shipping industry.

This study makes a valuable contribution to the literature on CST by developing a hierarchical framework and identifying key attributes that require enhancement to further improve CST performance. The identification of key attributes and their causal interrelationships can provide valuable insights for organizations and practitioners seeking to enhance their CST performance. The identification of internal stakeholder management and external stakeholder management, as well as communication and cooperation, as causal factors highlights their significance in attaining higher CST performance. Moreover, to enhance the decision-making procedure and improve CST performance, the criteria proposed in this study have been linked to establishing a set of guidelines for industry professionals and practitioners. These guidelines encompass recommendations for promoting research and development (R&D), providing environmental training, adhering to international treaties, prioritizing shareholder value, and garnering support from business owners.

This study has certain limitations. Because the measures presented in this study were derived from the literature, the comprehensiveness of the framework may be limited. To reinforce the CST framework, further research is needed to expand and develop the proposed measures. The TBL and technology perspectives might well be developed to provide a better set of attributes to improve CST performance. Furthermore, this study focuses only on the port and shipping industry of several Southeast Asian countries. Future studies might examine other countries to gain a better understanding of CST attributes. In addition, future studies may cover comparisons between geographic locations. Furthermore, there are some limitations to the methods used in this study. In this study, the need for specialized expertise, proficiency, and industry understanding restricts the number of experts and professionals, which may result in bias in the results. Moreover, the assessment technique is based on professional experience and expertise, which may lead to bias due to the experts' familiarity with the industry. To address this issue, future research must expand the number of experts engaged and include additional cross-sectional experts. Furthermore, the methodology utilized in this study might be used in other fields to improve the literature.

Conflict of interest

The authors declare that there is no conflict of interest in the study presented.

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Appendix 1

Table A1. Valid set of attributes.

Perspectives	Aspects	Criteria	Description	References
Social sustainability transition	Internal stake-holders' management	Employees' gender equality	Gender equality occurs when men and women have equal rights, responsibilities, and opportunities.	[4]
		Employees' health and safety	Associated with the avoidance of accidents and illness among employees and those who may be harmed by their employment.	[6]
		Employees' sustainable knowledge	Employees' understanding of sustainability issues and practices.	[14]
		Shareholder's value	The value provided to a corporation's equity share-holders as a result of management's capacity to increase sustainability.	[47]
		Owner support	The support from the port authority or owner to implement more sustainable operations.	[21]
		Port's regulation	The existence of ports' regulation that support ports' sustainability.	
	External stake-holders' management	Society's raising awareness	Society's raising awareness toward shipping industry sustainability.	[14]
		Society' sustainable knowledge	Society's knowledge about sustainability issues and practices.	
		International treaties	The international agreements between states and/or in-ternational organizations related to port sustainability.	[47]
	Communication and cooperation	Operational transparency	Operational transparency can be defined as a situation wherein the stage of service is clear and transparent.	[24]
		Exchange of information and knowledge	Smooth exchange of information and knowledge within the port.	
Economic sustain-ability transition	Economic structure and business performance	Foreign direct investment	When a firm purchases a majority stake in a foreign company, this is known as foreign direct investment (FDI). This implies that they are contributing more than simply money; they are also bringing expertise, know-how, and technology.	[6]
		Port's profits and growth	Profits and growth generated by ports.	[3, 47]
	Process and quality improvement	Supply chain integration and collaborative planning	Planning collaboration between the port and its supply chain partners.	[24]
		Effective utilization of port infrastructure	Better utilization of port infrastructure and physical assets.	
		Enhancement of service quality	Improvement of existing service quality.	
		R&D promotion	Port research and development promotion to support better port sustainability.	[25]

Environmental sustainability transition	Environmental management	Air pollution control	A collection of precise strategies and actions chosen and carried out to reduce air pollution in order to meet an air quality standard or target is known as an air quality control plan.	[6]
		Utilization of energy and resources	Efficiency in the use of resources and energy.	
		Noise pollution control	The goal of noise control is to keep noise levels low so that people's health and wellbeing are preserved.	
		Soil contamination control	Attempts to lessen soil contamination.	
		Waste pollution control	Attempts to lessen waste pollution.	
		Odor pollution control	Effort in odor waste pollution.	
		Environmental training	Increased number of employees with environmental training.	[25]
Technological sustainability transition	Environmental technology	Introduction of new equipment and technology	Launch of innovative, environmentally friendly technology.	[24]
		Alternative and renewable energy sources	The development of renewable and alternative energy sources that are friendly to the environment.	
		Environmentally clean technologies	It describes a collection of technological innovations that either maximize or minimize the use of natural resources while also minimizing the detrimental effects of technology on the environment and its ecosystems.	[48]
	Smart infrastructure	Sensor deployment	The use of sensors that can calculate the average, standard deviation, and variance for a set of data while also measuring pressure, temperature, humidity, gas flows, magnetic fields, radiation, and ultrasonics.	[27]
		Cloud computing services	Cloud computing services increase processing capacity while reducing costs by offering on-demand computing resources such as data, software, platforms, and infrastructure via hosted services on the Internet.	

Appendix 2

Table A2. Experts' demographic.

Expert	Nationality	Position	Education levels	Years of experience	Organization type (academia/practices)
1	Taiwan	Professor	Ph. D	27	Academia
2	Taiwan	Professor	Ph. D	18	Academia
3	Thailand	Associate Professor	Ph. D	16	Academia
4	Thailand	Associate Professor	Ph. D	17	Academia
5	Philippines	Lecturer	Ph. D	15	Academia
6	Malaysia	Lecturer	Ph. D	8	Academia
7	Vietnam	Lecturer	Master	8	Academia
8	Indonesia	Lecturer	Master	9	Academia
9	Indonesia	Lecturer	Master	6	Academia
10	Philippines	Second Engineer	Ph. D	9	Practices
11	Philippines	Second Engineer	Ph. D	9	Practices
12	Thailand	Second Engineer	Master	10	Practices
13	Philippines	Third Engineer	Master	7	Practices
14	Philippines	Third Engineer	Master	6	Practices
15	Vietnam	Third Engineer	Bachelor	7	Practices
16	Vietnam	Third Engineer	Bachelor	7	Practices
17	Indonesia	Chief of Human Resource Management	Ph. D	12	Practices
18	Indonesia	Vice Chief of Human Resource Management	Master	9	Practices
19	Indonesia	Vice Chief of Human Resource Management	Master	8	Practices
20	Indonesia	Staff of Human Resource Management	Bachelor	4	Practices
21	Indonesia	Managing Director of Infrastructure and Maritime Affairs	Ph. D	9	Practices
22	Indonesia	Staff of Infrastructure and Maritime Affairs	Bachelor	6	Practices
23	Indonesia	Port Safety Manager	Master	8	Practices
24	Indonesia	Vice Chief of Internal Auditor Department	Ph. D	10	Practices
25	Indonesia	Staff of Auditor Department	Bachelor	7	Practices
26	Indonesia	Staff of Auditor Department	Bachelor	6	Practices

Appendix 3

Table A3. Aspects' linguistic preferences by expert 1.

A1			
A1	1.000	1.000	1.000
A2	0.700	0.900	1.000
A3	0.500	0.700	0.900
A4	0.300	0.500	0.700
A5	0.100	0.300	0.500
A6	0.100	0.300	0.500
A7	0.100	0.300	0.500
A8	0.100	0.300	0.500
	xl	xm	xr
A1	1.000	0.778	0.556
A2	0.667	0.667	0.556
A3	0.444	0.444	0.444
A4	0.222	0.222	0.222
A5	0.000	0.000	0.000
A6	0.000	0.000	0.000
A7	0.000	0.000	0.000
A8	0.000	0.000	0.000
	xls	xrs	
A1	1.000	0.714	
A2	0.667	0.625	
A3	0.444	0.444	
A4	0.222	0.222	
A5	0.000	0.000	
A6	0.000	0.000	
A7	0.000	0.000	
A8	0.000	0.000	
	xij		
A1	0.714		
A2	0.639		
A3	0.444		
A4	0.222		
A5	0.000		
A6	0.000		
A7	0.000		
A8	0.000		
	zij		
A1	0.743		
A2	0.676		
A3	0.500		
A4	0.300		
A5	0.100		
A6	0.100		
A7	0.100		
A8	0.100		

A2			
A1	0.500	0.700	0.900
A2	1.000	1.000	1.000
A3	0.500	0.700	0.900
A4	0.100	0.300	0.500
A5	0.300	0.500	0.700
A6	0.300	0.500	0.700
A7	0.100	0.300	0.500
A8	0.100	0.300	0.500
	xl	xm	xr
A1	0.444	0.444	0.444
A2	1.000	0.778	0.556
A3	0.444	0.444	0.444
A4	0.000	0.000	0.000
A5	0.222	0.222	0.222
A6	0.222	0.222	0.222
A7	0.000	0.000	0.000
A8	0.000	0.000	0.000
	xls	xrs	
A1	0.444	0.444	
A2	1.000	0.714	
A3	0.444	0.444	
A4	0.000	0.000	
A5	0.222	0.222	
A6	0.222	0.222	
A7	0.000	0.000	
A8	0.000	0.000	
	xij		
A1	0.444		
A2	0.714		
A3	0.444		
A4	0.000		
A5	0.222		
A6	0.222		
A7	0.000		
A8	0.000		
	zij		
A1	0.500		
A2	0.743		
A3	0.500		
A4	0.100		
A5	0.300		
A6	0.300		
A7	0.100		
A8	0.100		

A3			
A1	0.700	0.900	1.000
A2	0.300	0.500	0.700
A3	1.000	1.000	1.000
A4	0.300	0.500	0.700
A5	0.300	0.500	0.700
A6	0.100	0.300	0.500
A7	0.100	0.300	0.500
A8	0.700	0.900	1.000
	xl	xm	xr
A1	0.667	0.667	0.556
A2	0.222	0.222	0.222
A3	1.000	0.778	0.556
A4	0.222	0.222	0.222
A5	0.222	0.222	0.222
A6	0.000	0.000	0.000
A7	0.000	0.000	0.000
A8	0.667	0.667	0.556
	xls	xrs	
A1	0.667	0.625	
A2	0.222	0.222	
A3	1.000	0.714	
A4	0.222	0.222	
A5	0.222	0.222	
A6	0.000	0.000	
A7	0.000	0.000	
A8	0.667	0.625	
	xij		
A1	0.639		
A2	0.222		
A3	0.714		
A4	0.222		
A5	0.222		
A6	0.000		
A7	0.000		
A8	0.639		
	zij		
A1	0.676		
A2	0.300		
A3	0.743		
A4	0.300		
A5	0.300		
A6	0.100		
A7	0.100		
A8	0.676		

A4			
A1	0.700	0.900	1.000
A2	0.500	0.700	0.900
A3	0.700	0.900	1.000
A4	1.000	1.000	1.000
A5	0.700	0.900	1.000
A6	0.700	0.900	1.000
A7	0.700	0.900	1.000
A8	0.500	0.700	0.900
	xl	xm	xr
A1	0.400	0.400	0.200
A2	0.000	0.000	0.000
A3	0.400	0.400	0.200
A4	1.000	0.600	0.200
A5	0.400	0.400	0.200
A6	0.400	0.400	0.200
A7	0.400	0.400	0.200
A8	0.000	0.000	0.000
	xls	xrs	
A1	0.400	0.250	
A2	0.000	0.000	
A3	0.400	0.250	
A4	1.000	0.333	
A5	0.400	0.250	
A6	0.400	0.250	
A7	0.400	0.250	
A8	0.000	0.000	
	xij		
A1	0.356		
A2	0.000		
A3	0.356		
A4	0.333		
A5	0.356		
A6	0.356		
A7	0.356		
A8	0.000		
	zij		
A1	0.678		
A2	0.500		
A3	0.678		
A4	0.667		
A5	0.678		
A6	0.678		
A7	0.678		
A8	0.500		

A5			
A1	0.700	0.900	1.000
A2	0.500	0.700	0.900
A3	0.700	0.900	1.000
A4	0.500	0.700	0.900
A5	1.000	1.000	1.000
A6	0.500	0.700	0.900
A7	0.700	0.900	1.000
A8	0.700	0.900	1.000
	xl	xm	xr
A1	0.400	0.400	0.200
A2	0.000	0.000	0.000
A3	0.400	0.400	0.200
A4	0.000	0.000	0.000
A5	1.000	0.600	0.200
A6	0.000	0.000	0.000
A7	0.400	0.400	0.200
A8	0.400	0.400	0.200
	xls	xrs	
A1	0.400	0.250	
A2	0.000	0.000	
A3	0.400	0.250	
A4	0.000	0.000	
A5	1.000	0.333	
A6	0.000	0.000	
A7	0.400	0.250	
A8	0.400	0.250	
	xij		
A1	0.356		
A2	0.000		
A3	0.356		
A4	0.000		
A5	0.333		
A6	0.000		
A7	0.356		
A8	0.356		
	zij		
A1	0.678		
A2	0.500		
A3	0.678		
A4	0.500		
A5	0.667		
A6	0.500		
A7	0.678		
A8	0.678		

A6			
A1	0.700	0.900	1.000
A2	0.500	0.700	0.900
A3	0.500	0.700	0.900
A4	0.700	0.900	1.000
A5	0.500	0.700	0.900
A6	1.000	1.000	1.000
A7	0.700	0.900	1.000
A8	0.500	0.700	0.900
	xl	xm	xr
A1	0.400	0.400	0.200
A2	0.000	0.000	0.000
A3	0.000	0.000	0.000
A4	0.400	0.400	0.200
A5	0.000	0.000	0.000
A6	1.000	0.600	0.200
A7	0.400	0.400	0.200
A8	0.000	0.000	0.000
	xls	xrs	
A1	0.400	0.250	
A2	0.000	0.000	
A3	0.000	0.000	
A4	0.400	0.250	
A5	0.000	0.000	
A6	1.000	0.333	
A7	0.400	0.250	
A8	0.000	0.000	
	xij		
A1	0.356		
A2	0.000		
A3	0.000		
A4	0.356		
A5	0.000		
A6	0.333		
A7	0.356		
A8	0.000		
	zij		
A1	0.678		
A2	0.500		
A3	0.500		
A4	0.678		
A5	0.500		
A6	0.667		
A7	0.678		
A8	0.500		

A7			
A1	0.700	0.900	1.000
A2	0.500	0.700	0.900
A3	0.300	0.500	0.700
A4	0.700	0.900	1.000
A5	0.500	0.700	0.900
A6	0.700	0.900	1.000
A7	1.000	1.000	1.000
A8	0.700	0.900	1.000
	xl	xm	xr
A1	0.571	0.571	0.429
A2	0.286	0.286	0.286
A3	0.000	0.000	0.000
A4	0.571	0.571	0.429
A5	0.286	0.286	0.286
A6	0.571	0.571	0.429
A7	1.000	0.714	0.429
A8	0.571	0.571	0.429
	xls	xrs	
A1	0.571	0.500	
A2	0.286	0.286	
A3	0.000	0.000	
A4	0.571	0.500	
A5	0.286	0.286	
A6	0.571	0.500	
A7	1.000	0.600	
A8	0.571	0.500	
	xij		
A1	0.533		
A2	0.286		
A3	0.000		
A4	0.533		
A5	0.286		
A6	0.533		
A7	0.600		
A8	0.533		
	zij		
A1	0.673		
A2	0.500		
A3	0.300		
A4	0.673		
A5	0.500		
A6	0.673		
A7	0.720		
A8	0.673		

A8			
A1	0.700	0.900	1.000
A2	0.500	0.700	0.900
A3	0.300	0.500	0.700
A4	0.700	0.900	1.000
A5	0.500	0.700	0.900
A6	0.500	0.700	0.900
A7	0.500	0.700	0.900
A8	1.000	1.000	1.000
	xl	xm	xr
A1	0.571	0.571	0.429
A2	0.286	0.286	0.286
A3	0.000	0.000	0.000
A4	0.571	0.571	0.429
A5	0.286	0.286	0.286
A6	0.286	0.286	0.286
A7	0.286	0.286	0.286
A8	1.000	0.714	0.429
	xls	xrs	
A1	0.571	0.500	
A2	0.286	0.286	
A3	0.000	0.000	
A4	0.571	0.500	
A5	0.286	0.286	
A6	0.286	0.286	
A7	0.286	0.286	
A8	1.000	0.600	
	xij		
A1	0.533		
A2	0.286		
A3	0.000		
A4	0.533		
A5	0.286		
A6	0.286		
A7	0.286		
A8	0.600		
	zij		
A1	0.673		
A2	0.500		
A3	0.300		
A4	0.673		
A5	0.500		
A6	0.500		
A7	0.500		
A8	0.720		

Appendix 4

Table A4. Total interrelationship matrix of criteria.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28	C29
C1	0.072	0.055	0.063	0.040	0.037	0.075	0.045	0.036	0.048	0.050	0.078	0.046	0.079	0.061	0.054	0.085	0.052	0.059	0.061	0.053	0.052	0.059	0.059	0.060	0.054	0.050	0.053	0.052	0.043
C2	0.043	0.134	0.072	0.085	0.066	0.120	0.031	0.074	0.103	0.068	0.070	0.086	0.097	0.067	0.079	0.118	0.093	0.112	0.106	0.099	0.098	0.100	0.102	0.115	0.103	0.113	0.120	0.085	0.066
C3	0.061	0.144	0.129	0.102	0.096	0.138	0.043	0.076	0.097	0.109	0.117	0.112	0.137	0.112	0.126	0.155	0.141	0.146	0.145	0.135	0.141	0.138	0.137	0.141	0.132	0.126	0.138	0.129	0.103
C4	0.089	0.170	0.123	0.140	0.130	0.168	0.068	0.072	0.105	0.123	0.136	0.151	0.160	0.125	0.140	0.181	0.163	0.168	0.175	0.147	0.153	0.163	0.156	0.159	0.171	0.163	0.173	0.160	0.131
C5	0.079	0.165	0.127	0.120	0.139	0.163	0.050	0.087	0.103	0.119	0.130	0.145	0.152	0.122	0.140	0.171	0.156	0.165	0.169	0.143	0.152	0.153	0.163	0.149	0.162	0.158	0.172	0.160	0.127
C6	0.072	0.152	0.109	0.082	0.083	0.161	0.059	0.077	0.106	0.114	0.119	0.122	0.138	0.111	0.129	0.153	0.139	0.152	0.156	0.134	0.138	0.149	0.143	0.144	0.152	0.147	0.156	0.144	0.120
C7	0.049	0.091	0.060	0.063	0.054	0.092	0.024	0.072	0.083	0.048	0.060	0.066	0.066	0.052	0.059	0.074	0.098	0.093	0.099	0.092	0.093	0.087	0.089	0.071	0.083	0.078	0.085	0.068	0.054
C8	0.041	0.095	0.083	0.061	0.053	0.102	0.023	0.086	0.085	0.048	0.053	0.064	0.063	0.053	0.063	0.081	0.071	0.094	0.104	0.091	0.095	0.088	0.095	0.083	0.077	0.071	0.078	0.071	0.055
C9	0.086	0.165	0.118	0.119	0.126	0.163	0.049	0.086	0.143	0.114	0.117	0.136	0.136	0.121	0.131	0.169	0.159	0.165	0.167	0.149	0.160	0.159	0.163	0.153	0.165	0.155	0.169	0.157	0.127
C10	0.036	0.101	0.075	0.073	0.067	0.118	0.086	0.048	0.070	0.113	0.108	0.101	0.117	0.085	0.096	0.137	0.100	0.124	0.128	0.101	0.107	0.120	0.109	0.093	0.116	0.108	0.123	0.128	0.102
C11	0.034	0.097	0.092	0.056	0.064	0.083	0.030	0.067	0.070	0.093	0.109	0.071	0.100	0.087	0.078	0.111	0.085	0.096	0.100	0.091	0.095	0.096	0.094	0.079	0.105	0.088	0.097	0.079	0.068
C12	0.043	0.137	0.085	0.102	0.102	0.137	0.080	0.057	0.080	0.074	0.082	0.144	0.134	0.101	0.106	0.154	0.121	0.139	0.145	0.125	0.134	0.140	0.134	0.119	0.147	0.133	0.148	0.144	0.122
C13	0.044	0.142	0.091	0.108	0.104	0.141	0.067	0.057	0.090	0.076	0.092	0.117	0.161	0.090	0.106	0.149	0.139	0.144	0.151	0.134	0.143	0.141	0.143	0.137	0.147	0.139	0.147	0.143	0.117
C14	0.034	0.089	0.064	0.068	0.071	0.106	0.063	0.045	0.078	0.095	0.100	0.098	0.120	0.112	0.094	0.123	0.107	0.114	0.116	0.104	0.108	0.111	0.112	0.097	0.116	0.110	0.118	0.099	0.094
C15	0.026	0.085	0.051	0.050	0.051	0.095	0.048	0.037	0.055	0.069	0.080	0.072	0.102	0.062	0.108	0.112	0.072	0.084	0.107	0.076	0.080	0.080	0.083	0.072	0.078	0.079	0.086	0.102	0.085
C16	0.048	0.144	0.099	0.121	0.124	0.156	0.066	0.065	0.117	0.124	0.134	0.149	0.156	0.124	0.124	0.185	0.165	0.161	0.164	0.150	0.152	0.158	0.158	0.157	0.170	0.159	0.172	0.165	0.136
C17	0.076	0.155	0.114	0.111	0.111	0.147	0.069	0.062	0.103	0.113	0.122	0.121	0.147	0.120	0.133	0.169	0.172	0.159	0.162	0.144	0.152	0.156	0.156	0.145	0.162	0.152	0.163	0.150	0.130
C18	0.032	0.132	0.094	0.082	0.081	0.130	0.037	0.057	0.099	0.076	0.077	0.113	0.115	0.075	0.106	0.130	0.135	0.147	0.135	0.088	0.094	0.095	0.129	0.122	0.130	0.123	0.138	0.127	0.083
C19	0.035	0.138	0.088	0.095	0.098	0.132	0.041	0.052	0.110	0.081	0.089	0.124	0.136	0.100	0.116	0.153	0.143	0.145	0.160	0.096	0.128	0.114	0.141	0.125	0.147	0.139	0.148	0.136	0.088
C20	0.029	0.115	0.071	0.075	0.075	0.115	0.032	0.057	0.091	0.065	0.073	0.102	0.088	0.066	0.093	0.116	0.117	0.083	0.086	0.124	0.079	0.080	0.082	0.083	0.119	0.078	0.118	0.112	0.074
C21	0.031	0.125	0.074	0.084	0.084	0.122	0.033	0.065	0.096	0.068	0.076	0.110	0.093	0.063	0.099	0.127	0.122	0.088	0.092	0.081	0.134	0.115	0.085	0.108	0.123	0.086	0.118	0.120	0.078
C22	0.033	0.133	0.078	0.090	0.089	0.129	0.037	0.066	0.101	0.068	0.082	0.118	0.102	0.099	0.106	0.131	0.133	0.109	0.099	0.090	0.119	0.143	0.096	0.127	0.136	0.122	0.136	0.127	0.090
C23	0.032	0.132	0.092	0.079	0.080	0.132	0.036	0.055	0.102	0.074	0.080	0.112	0.105	0.076	0.107	0.135	0.133	0.136	0.133	0.088	0.095	0.094	0.143	0.117	0.126	0.131	0.136	0.127	0.085
C24	0.042	0.136	0.115	0.090	0.095	0.138	0.060	0.060	0.096	0.102	0.120	0.115	0.128	0.090	0.121	0.154	0.141	0.150	0.152	0.135	0.143	0.142	0.141	0.154	0.143	0.138	0.149	0.142	0.100
C25	0.045	0.151	0.094	0.092	0.093	0.144	0.072	0.057	0.099	0.101	0.120	0.128	0.141	0.096	0.126	0.160	0.153	0.140	0.152	0.133	0.143	0.142	0.143	0.133	0.167	0.146	0.155	0.150	0.126
C26	0.035	0.141	0.089	0.087	0.090	0.144	0.040	0.067	0.103	0.074	0.112	0.124	0.136	0.078	0.102	0.151	0.144	0.146	0.146	0.102	0.138	0.138	0.141	0.139	0.147	0.152	0.149	0.132	0.091
C27	0.038	0.156	0.107	0.094	0.107	0.148	0.076	0.058	0.105	0.081	0.088	0.135	0.146	0.081	0.128	0.161	0.154	0.152	0.155	0.141	0.148	0.148	0.148	0.147	0.157	0.140	0.170	0.153	0.115
C28	0.034	0.134	0.093	0.085	0.099	0.143	0.041	0.052	0.080	0.110	0.108	0.113	0.128	0.078	0.125	0.150	0.142	0.142	0.140	0.132	0.137	0.138	0.138	0.133	0.134	0.103	0.135	0.155	0.110
C29	0.029	0.092	0.062	0.086	0.093	0.115	0.066	0.045	0.067	0.065	0.069	0.108	0.111	0.094	0.088	0.131	0.114	0.110	0.125	0.105	0.111	0.109	0.110	0.095	0.122	0.084	0.091	0.112	0.119

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