Container terminal employees' perceptions of the effects of sustainable supply chain management on sustainability performance.

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Abstract

Sustainability has become an important issue in container terminal operations. However, relatively little research has been conducted to assess its association with sustainable supply chain management. In this study, sustainable supply chain management consists of internal sustainability practices and external sustainability collaboration. We empirically examined the effects of internal sustainability practices and external sustainability collaboration on sustainability performance in container terminal operations at the Port of Kaohsiung in Taiwan. We developed a model adopting the sustainable supply chain management construct, which consisted of two dimensions: internal sustainability practices and external sustainability collaboration. Several research hypotheses were formulated from the theory and the hypotheses were tested using survey data collected from 141 employees who worked with container terminals. We found that internal sustainability practices and external sustainability collaboration positively affected sustainability performance, whereas external sustainability collaboration had a positive influence on internal sustainability practices. There is a discussion of the implications of these findings for developing sustainability and improving sustainability performance in container terminals and ports.

Keywords: Container Terminals; Sustainability Performance; Sustainable Supply Chain; Structural Equation Modeling

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1. Introduction

World container port throughput rose by a significant 3.8 percent to 601.8 million TEUs in 2012 because of the development of international trade, (UNCTAD 2014). A container terminal plays an important role in the global supply chain and provides an interface between sea and land transports (Fransoo and Lee 2013; Zhang et al. 2003). The major functions of a container terminal include loading and unloading containers on the quayside, as well as the temporary storage of containers dropped off by or to be delivered to inland shippers (Jin, Lee, and Cao 2014). However, the dramatic growth in the container volumes has also brought about some concerns about its environmental impact, including noise, air pollution, waste, and energy demand. In particular, in the coming decades, climate change will be a global challenge and one of the defining issues of our era. Climate change is likely to cause sea levels to rise, lake levels to drop, more frequent and severe storms, and increases in extreme high temperatures. It poses a serious threat to human development and prosperity, with implications for water and food security, coastal infrastructure, human health, biodiversity, migration, global trade, and security. The latest scientific findings indicate that matters may be worse than previously calculated, with forecasts of global warming and sea level rise exceeding earlier predictions (Lu, Marlow, and Lai 2010).

To address this issue, many terminal operators, such as Modern Terminals Limited (MTL) and Hong Kong International Terminals (HIT), have proactively addressed their environmental and related socio-economic responsibilities through an environmental system. In addition to environmental compliance requirements, container terminal operators continue to face daunting challenges in this time of significant growth. On the other hand, among other realities, heightened community concerns about port expansion plans, the magnitude of anticipated resources and capital investments, the rising costs of energy resources, and the management of waste by-products have left many ports looking for an all-inclusive, systems-based management approach to operations. Increasingly, ports are looking holistically at their overall business practices with a view toward *sustainability*. Consequently, container terminal operators are beginning to define broader sustainability policies that extend beyond environment stewardship. A key concept of sustainability is that it is not limited to environmental stewardship. Rather, sustainability focuses on understanding the connections between the economy, society, and the environment, and the equitable distribution of resources and opportunities (Lu, Marlow, and Lai 2010).

Notably, container terminals play a key role in the international container transport chain and their services highly related to shippers, shipping lines, and intermodal transport operators (Lun and Browne 2009). Container terminal operators handle activities ranging from receiving and dispatching containers to loading and discharging ships. Consequently, the sustainable development of container terminal operations needs to take into account internal and external members. In particular, the interaction between sustainability and the supply chain has become critical in light of research into the associations between terminal operations, sustainability, and environmental impact. While important contributions have been made to integrate environmental practices into port policy, strategy, operations, port operation, and carrier environmental management, it is critical to move forward to address the systemic issues that exist at the intersection of sustainability, environmental management, and supply chain in container terminal operations (Lu, Marlow, and Lai 2010). The United Nations Commission on Sustainable Development (UNCSD) (2011) indicated that to achieve sustainable

development, it is necessary to take into consideration the linkages between social, economic, and environmental aspects.
Notably, sustainable supply chain management (SSCM) has received increasing attention from both practitioners and academics over the past several years (Linton, Klassen, and Jayaraman 2007; Lam 2015). Supply chain management (SCM) is the systematic and strategic coordination of traditional business functions and tactics across all business functions for the purposes of improving the long-term performance of the companies and the supply chain as a whole (Mentzer 2001). SCM refers to the integration of key business processes across the supply chain to create value for customers and stakeholders (Lambert, 2008). From summarizing prior studies of Lee and Klassen (2008), Linton, Klassen, and Jayaraman (2007), and Zhu, Sarkis, and Lai (2008), SSCM can be defined as the degree to which a firm can strategically collaborate with its customers, suppliers, and partners and cooperatively manage intra- and inter-organizational processes to improve sustainability performance, including environmental, social, economic issues. SSCM consists of the internal sustainability functions, as well as the collaboration with customers, suppliers, and partners (Stank, Keller, and Daugherty 2001). Despite the increasing research interest in SSCM, the understanding is still very limited about how SSCM influences sustainability performance, as well as the relationship between internal sustainability practices and external collaboration. Some studies about the port sector have discussed the environmental sustainability with a framework of innovation (Acciaro et al. 2014), postulated port sustainability indicators (Shiau and Chuang 2015), and provided management tools for the green port development (Lam and Notteboom 2014). There is a need for empirically testing the impact of internal sustainability practices and external sustainability collaboration on sustainability performance, and the relationship between internal sustainability practices and external sustainability collaboration to improve the understanding about the mechanism of SSCM. This research seeks to fill that gap and addresses two major research questions: (1) How do internal sustainability practices and external sustainability collaboration influence sustainability performance? (2) How is the impact of internal sustainability practices influenced by external sustainability collaboration?

The remainder of this research is organized as follows. First, the theoretical background and research hypotheses are discussed. Next, the research methodology is described, followed by the presentation of the results and findings from factor analysis and structural equation modeling. The final section consists of a discussion of managerial implications, main conclusions drawn from the research findings, and limitations of this study for future research.

2. Literature review

2.1.Definition of sustainability and sustainability performance indicators

Sustainability is a broad concept with many and varied definitions. The most widely accepted definition is that from the World Commission on Environment and Development (WCED; also known as the Brundtland Commission) of the United Nations in 1987. They defined sustainable development as *development that meets the needs of the present without compromising the ability of future generations to meet their own needs*. It contains two key concepts:

- the concept of needs, in particular the essential needs of the world's poor, to which overriding priority should be given; and
- the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs.

Thus, the goals of economic and social development must be defined in terms of sustainability in all countries: developed or developing, market-oriented, or centrally planned. Interpretations will vary but according to the UN General Assembly, all interpretations must share certain general features, must flow from a consensus on the basic concept of sustainability development, and must agree to build a broad strategic framework for achieving it (United Nations General Assembly 1987). Another common concept used in the definition of sustainability is the idea of three dimensions: economic, environmental, and social needs (Global Reporting Initiative 2013; Marlow 2008; Seuring and Muller 2008). Therefore, environmental, economic, and social dimensions all need to be considered when evaluating sustainability performance (Seuring and Muller 2008).

From the foregoing, a comprehensive evaluation method is needed to assist port and terminal operators to effectively evaluate sustainability performance. In regard to the environmental aspect, indicators need to be taken into consideration, such as air quality, greenhouse gas emissions, soil and land resources, debris, light, noise problems, water, and climate change. In regard to the economic aspect, indicators for consideration should include benefits to port and terminal users, reasonable competition, employment, local area economic development, tourism, and port investment (Ryan and Throgmorton 2003; Port of Long Beach 2005; Sydney Ports Corporation 2007; Port of Los Angeles 2008; Department of Transport of UK 2009; Gutiérrez et al. 2015). In regard to the social aspect, indicators for appraisal should include security, safety, and neighbouring relationships (Holmes 1978; Abbott and Monsen 1979; Sydney Ports Corporation 2007; Port of Los Angeles 2008). Notably, the evaluation of sustainability performance should be based on the concept of sustainable supply chain management (Lu, Marlow, and Lai 2010) including internal sustainability practices (De Burgos and Lorente 2001; United Nation General Assembly 2005) and external collaboration with partners (Handfield et al. 1997; Sarkis 2001).

2.2. Theoretical background and research hypotheses

Over the past two decades, the focus on optimizing operations has moved from a specific organization to the entire supply chain. A focus on the supply chain is a step toward the broader adoption and development of sustainability, because the supply chain considers the product from initial processing of raw materials to delivery to the customer. However, sustainability must also integrate issues and flows that extend beyond the core of supply chain management (Linton, Klassen, and Jayaraman 2007). Supply chain management has a much broader scope and considers the effect of functions other than logistics on business processes spanning multiple organizations. Thus, research on sustainability or environmental management needs to be viewed from a supply chain standpoint, so any related management system should span the entire supply chain.

Internal integration management is an important determinant in improving an enterprise's performance and competitiveness (Yang et al. 2013). Internal integration recognizes that different departments and functional areas within a firm should operate as part of an integrated process, and this integration is expected to directly contribute to performance (Flynn, Huo, and Zhao 2010). Similarly, for container terminal operators, we argue that internal sustainability practices are positively associated with sustainability performance. Thus, it is hypothesized that terminal operators that implement internal sustainability practices activities, such as participation in sustainability, policy setting, and personnel sustainability training, will experience an increase in sustainable performance. Therefore, this study postulated the following.

Hypothesis 1: Internal sustainability practices are positively related to sustainability performance in container terminal operations.

Collaboration is a process of decision-making among supply chain members. It may involve joint ownership of decisions and collective responsibility for sustainable development. Collaboration is effective when port partners are willing to work together, understand others' viewpoints, share information and resources, and achieve collective goals (Stank, Keller, and Daugherty 2001). Collaboration should lead to improvements in environmental protection as well (Lee and Klassen 2008). For example, a terminal operator can develop a collaboration plan with carriers to reduce air pollution through vessel speed reduction. Furthermore, a terminal operator could encourage trucking companies to implement useful projects to reduce the environmental impact of shipping goods by applying more efficient routes, operations, and technologies. Therefore, higher levels of external sustainability collaborations are expected to result in enhanced sustainable development performance. Correspondingly, this research posits the following.

Hypothesis 2: External sustainability collaborations are positively related to sustainability performance in container terminal operations.

The relationship between internal sustainability practices and external sustainability collaboration should be considered to effectively implement sustainability. Walton, Handfield, and Melnyk (1998) suggested that various suppliers should have defined roles in the sustainability initiative, in light of the competitiveness of the environment. A successful sustainability development has been found to require collaboration and integration among members in the supply chain (Handfield et al. 1997; Mentzer, Flint, and Hult 2001; Kleindorfer, Singhal, van Wassenhove 2005; Seruing and Muller 2008). A few previous studies have found that internal integration is positively related to external supplier and customer integration (Huo 2012; Zhao et al. 2011; Zsidisin et al. 2015), but the effect of sustainable supply chain management on sustainability performance has not been confirmed by research. Some prior studies of supply chain collaboration suggest the positive relationship between internal and external collaboration (Stank, Keller, and Daugherty 2001; Zhao et al. 2011). Yang et al. (2013) confirmed that internal green practices are positively related to external green collaboration in the context of container shipping; internal green practices and external green collaboration were found to have a positive influence on green performance, which in turn help to increase firm's competitiveness. Nevertheless, there is a lack of research examining the relationship between organizational sustainability management and sustainability collaboration with suppliers or customers in container terminal operators. Therefore, this research contends that sustainability practices can positively influence supplier/customer sustainability collaboration. When a company has a clear sustainability policy, practices and participation, it will be more likely to cooperate with external suppliers, partners and customers, and understand their businesses, which, in turn, will facilitate supply chain collaboration. In contrast, if a firm is less likely to plan well for its internal sustainability practices, then it will be less likely to set up synchronised processes, and facilitate sustainability operations with its supply chain members (Zhao et al. 2011). Therefore, this research hypothesizes that firms emphasizing sustainability practices will increase sustainability collaborations with their suppliers and customers. Thus, this research posits the third hypothesis.

Hypothesis 3: Internal sustainability practices are positively related to external sustainability collaboration in container terminal operations.

3. Methodology

3.1. Sample

This study used a questionnaire survey to collect information from container terminal operators at the Port of Kaohsiung in Taiwan. The Port of Kaohsiung is the largest container port in Taiwan, accounting for 70.7% of total container traffic in 2013, and ranked as the 14th busiest container port in the world (Container international 2014). With the growing amount of cargo volume, the issue of sustainability in ports has become more important than ever before. The questionnaire was sent to nine main dedicated container operators: Lien Jai, Wan Hai, OOCL, APL, YML, Evergreen, Hyundai, Hanjin, and NYK. The four-page questionnaire was sent to 209 employees at container terminals in June 2012. The sample is composed of those who had the position of supervisor or above and general employees. The total number of usable responses was 141; the overall response rate was 67.5%.

3.2. Measures, non-response bias, and common method bias

The questionnaire collected information including job title, work department, age, and years of working experience. The respondents' perceived importance of 19 internal sustainability practices items and 12 external sustainability collaboration items was assessed by asking them to indicate their level of agreement with the items, using a five-point Likert scale ranging from "1 = strongly disagree" to "5 = strongly agree."

Internal sustainability practices items were considered to include collaboration among departments within a single container terminal operation. These items were selected from similar previous studies (Stank, Keller, and Daugherty 2001, Zhu, Sarkis, and Lai 2007; 2008; Seuring and Muller 2008, and Lu, Marlow, and Lai 2010). External sustainability collaboration items were considered to include collaboration among container terminal operators, suppliers, partners, and customers. These items were selected from previous studies (Zhu, Sarkis, and Lai 2007;08). Sustainability performance was assessed based on 14 items, including environmental, social, and economic issues, which were adapted from the prior studies of Lam (2015), Lu, Shang, and Lin (2012), and reports of Port of Long Beach (2005) and the Department of Transport of UK (2009). The actual reported data on sustainability performance are confidential and contain sensitive information about container terminal operators or employees. Self-reporting of sustainability performance and perceptions of sustainability can offer alternative measures for determining sustainability performance. The employees' perception of sustainability is considered to be a useful measure of sustainability performance (Lam 2015; Shiau and Chuang 2015). Thus, we asked respondents to indicate the improvement of sustainability they perceived at their container terminals the year before the survey.

A non-response bias is considered in this study. Early and late (after two weeks) responses on internal sustainability practices, external sustainability collaboration, and sustainability performance were compared (Armstrong and Overton, 1977), with the t-test showing no significant differences, thereby indicating that a non-response bias does not appear to be a major concern in this research. Since we used one informant to answer the self-report questionnaire in this research, the potential common method variance (CMV) is checked. Respondents are familiar with the measures because they have been in a relatively senior position with responsibility for sustainability for more than five years. Most of the respondents are probably the most qualified people to provide information on the issue of sustainability at port. Furthermore, Harman's one-factor test of common method variance was performed on the factors of internal sustainability practices, external sustainability collaboration, and sustainability performance, using exploratory factor analysis (Podsakoff et al. 2003; Podsakoff and Organ 1986). The results show these factors with eigenvalues above 1.0, thereby explaining more than 63% of total variance. For example, the first factor in internal sustainability practices explained 26.73% of the variance (not the majority of the total variance), which is acceptable for this study where constructs are correlated, both conceptually and empirically. Therefore, it is reasonable to conclude that CMV bias does not appear to be a problem in this study.

3.3. Analysis methods

Exploratory factor analysis was conducted in order to identify and summarize a large number of internal sustainability practices and external sustainability collaboration attributes into a smaller, manageable set of underlying factors and dimensions (Hair et al. 2006). A reliability test was conducted to assess whether these dimensions were appropriate. Then, confirmatory factor analysis was conducted to verify the measurement models. This involved the use of the structural equation modeling software AMOS to analyse the measurement models, assess psychometric proprieties, and to specify the relationship between the latent variables and the proposed measures.

4. Results

4.1. Profile of respondents

In regard to gender, 85% of respondents were male. Concerning age, 51.8% were greater than 40 years old. For the job title, 51.8% of respondents were general employee, 15.8% were managers or assistant managers, and 13.3% were vice presidents or above. Approximately 80% of respondents had been in the industry for more than five years, and 65% of them had been in it for more than 10 years. Considering the respondents' work departments, 27% worked in the operations department, 8.5% worked in the warehousing department, and the remaining employees worked in other departments. In addition, more than half (50.4%) of the respondents' firms operated more than 1 million TEUs in 2011. Furthermore, almost half (48.2%) of the firms were foreign. Lastly, more than half (61.3%) of the respondents' firms hired less than 100 employees in the terminal area.

4.2. Factor analysis result and validation of second-order constructs

Exploratory factor analysis for the 19 internal sustainability practices items and 12 external sustainability collaboration items was conducted with VARIMAX rotation to define smaller sets of underlying factors. Variables with loadings of 0.5 or greater on only one factor were extracted, which is a conservative criterion suggested by Hair et al. (2006).

The result of an exploratory factor analysis for internal sustainability practices items is shown in Table 1. Based on the Cronbach alpha statistic, the reliability test was adopted to determine whether these factors were consistent and reliable. The reliability value for each aspect was in an acceptable range (0.70) (Iacobucci and Churchill 2010), as shown in Table 1. Three internal sustainability practices factors (dimensions) are labelled and described in Table 1.

****** <Insert Table 1 around here>******

(1) Seven items related to communication and participation were considered in Factor 1. Thus,

Factor 1 accounted for 26.73% of the total variance. This factor was labelled an internal sustainability dimension. “Communicating sustainable development issues with staff effectively” had the greatest factor loading for this factor

(2) Another seven items, including practice and related activities, constituted Factor 2. Factor 2 accounted for 23.88% of the total variance. This factor was labelled as employee training dimension. “Periodically attending sustainable development conferences” had the greatest factor loading for this factor.

(3) The last four items, which were associated with environmental activities, constituted Factor 3. Factor 3 accounted for 18.63% of the total variance. This factor was entitled a green shipping dimension. “Asking ships to sail in economy mode to reduce fuel cost” had the greatest factor loading for this factor.

To capture the different facets of internal sustainability practices, we model it as a second-order latent construct with communication and participation, employee training, and green shipping as key manifest variables of internal sustainability practices in sustainability. We validated the second-order latent construct of internal sustainability practices separately, using confirmatory factor analysis (CFA). To conduct the CFA, we used the three first-order latent constructs as manifest variables of internal sustainability practices. An indication of possible re-specification of the model is the modification index (MI) that is used to decide which parameters should be added to the model (Jöreskog 1993). An examination of the results reveals that two items (i.e., SSC13 and SSC14) have a high modification index. Thus, these two items were eliminated in the revised second-order model (Anderson and Gerbing 1988). The results indicated that the root mean square residual (RMR) for the CFA was 0.03, with a comparative fit index (CFI) of 0.94 and a Tucker-Lewis index (TLI) of 0.929. The Chi-square (df) value of the second-order construct validation was 197.226 (101), with a Chi-square/df value of less than two, as suggested by Browner and Cudeck (1993). This reflects a good fit to the second order CFA model.

Table 2 shows the results of EFA for the external sustainability collaboration items. Three factors were found to emphasize the external sustainability collaboration. The Cronbach’s alpha value for these dimensions were all above 0.9, and thus exhibited satisfactory reliability. Three external sustainability collaboration factors (dimensions) were labelled and are described below.

****** <Insert Table 2 around here>******

(1) Four items are related to the first aspect, supplier collaboration. This factor accounted for 81.65% of the total variance. A set of sustainability indicators with suppliers had the highest factor loadings for this factor. The Cronbach’s alpha value for this dimension was above 0.9, and thus represented a satisfactory level of reliability. In addition, because the factors were all related to the supplier, this factor was labelled the supplier collaboration dimension.

(2) Four items encompassed the customer collaboration aspect. . This factor accounted for 79.90% of the total variance. The Cronbach’s alpha for this dimension was above 0.9. In addition, because the factors were all related to the customer, this factor was labelled the customer collaboration dimension.

(3) The last four items are related to partner collaboration. This factor accounted for 84.99% of the total variance. The Cronbach’s alpha value for this dimension was above 0.9, and thus represented a satisfactory level of reliability. This factor was identified as the partner collaboration dimension.

A second-order factor analysis was also conducted to validate the constructs of external sustainability collaboration. After modifications, SSC2, SSC6, SSC10 were removed from their corresponding constructs because these items had high modification index and their removals did not much affect the coverage of the domain of their corresponding constructs (Jöreskog 1993). The results found that that the RMR for the CFA was 0.019, less than the critical value of 0.05. The CFI and TLI were 0.944 and 0.916, respectively, above the critical value of 0.9. This reflects a good fit to the second-order analysis for the constructs of external sustainability collaboration.

A discriminant validity test with the chi-square differences for external collaboration dimensions was assessed in this study. A constrained confirmatory factor analysis (CFA) model is constructed for all possible pairs of latent variables (constructs) in which the correlations among this pair of latent variables are fixed to 1.0. Furthermore, this model is compared with the original unconstrained model, in which the correlations among latent variables are freely estimated. The difference in Chi-square values for the fixed (for constrained) and free solution indicates whether a unidimensional model will be sufficient to account for the intercorrelations among the variables observed in each pair. A significant difference of the Chi-square value between the fixed and unconstrained models indicates high discriminant validity (Fornell and Larcker 1981). The results indicate that the difference in χ^2 for the fixed and free solutions was very significant (i.e., the minimum χ^2 *difference* = 406.6, P < 0.01, d.f. = 1), as can be seen in Table 6. Therefore, discriminant validity test is ensured.

***** <Insert Table 3 around here>*****

The presence of meaningful patterns in regard to self-reported sustainability performance in the last three years was detected by factor analysis, as can be seen in Table 3. Sustainable performance dimensions were chosen from three categories and 14 items were included. One dimension accounted for 43.20% of the total variance and the second dimension accounted for 20.35% of the total variance. They were labelled and are described in Table 4.

***** <Insert Table 4 around here>*****

(1) Factor 1 was labelled the environmental and social performance dimension; it consisted of five items (Table 3). This factor accounted for 43.20% of the total variance. “I perceive that traffic accidents in port areas have been significantly reduced” had the greatest factor loading for this factor.
(2) Factor 2 consisted of four items. Because these items were related to economic activities, this factor was called the economic performance dimension. “I perceive that energy cost has been significantly reduced” had the greatest factor loading for this factor. Factor 2 accounted for 20.35% of the total variance.

To assess the validation of constructs, we subsequently model a second-order latent construct of self-reported sustainability performance using CFA. Two items (i.e., SP5 and SP8) have high modification index and were eliminated in the revised second-order model (Anderson and Gerbing 1988). The revised model indicated that the root mean square error of approximation (RMSEA) for the CFA was 0.054, with a CFI of 0.979 and a TLI of 0.974. The Chi-square (df) value of the second-order construct validation was 101.386 (72), with a Chi-square/df value of below two, as suggested by Browne and Cudeck (1993). Therefore, these numbers suggest a good fit to the second order CFA model for the constructs of sustainability performance.

A one-way analysis of variance (ANOVA) was used to analyze the differences in the level of agreement assigned to internal sustainability practices, external sustainability collaboration, and sustainability performance, according to firm size in terms of the cargo volume of TEUs (Twenty-foot Equivalent Unit), as shown in Table 5. Results indicated that customer/carrier collaboration had the most agreement of external sustainability collaboration dimension to small (had fewer than 0.5 million TEUs) and large firms (had greater than 1.0 million TEUs), followed by partner collaboration and supplier collaboration. On the other hand, the most agreement of internal sustainability practices dimensions to small and large firms were green shipping, employee training, and communication and participation. In addition, the differences in sustainability performance among the three groups were employed. Results indicated that sustainability performance with respect to environmental and social performance, and economic performance significantly differed among the three groups at the $p<0.05$ significance level. Large container terminal operators had the best environmental and social performance (mean = 3.952), followed by medium (mean = 3.763) and small-sized terminal operators (mean = 3.626). The results were not surprising because large firms have more resources for the improvement of environment and social issues compared with small and medium-sized firms.

****** <Insert Table 5 around here>******

4.3. Confirmatory factor analysis

Before testing the hypotheses, a confirmatory factor analysis (CFA) was performed to ensure the validity of the measurement scales (Anderson and Gerbing 1988). Goodness-of-fit indices were used to evaluate the fit and unidimensionality of the model (Hu and Bentler 1995). The CFA model indicated that the RMSEA and RMR for the CFA was 0.076 and 0.049, respectively, with a CFI of 0.880 and a TLI of 0.871. The chi-square (df) value of the model was 1243.26 (691), with a chi-square/df value of below two, as suggested by Browne and Cudeck (1993). Thus, the results show an adequate model fit, therefore indicating that the proposed model was appropriate (Bollen 1989).

The convergent validity was tested with t-values, all of which were statistically significant for the factor loadings, as shown in Table 6. The t-value in the AMOS output reflected the critical ratio (CR), which represents the parameter estimate divided by its standard error. Composite reliability provides a measure of the internal consistency and homogeneity of the items (Iacobucci and Churchill 2010).

All composite reliability values in this study were larger than 0.7, thus indicating that all indicators measured the same construct and providing satisfactory evidence of the convergent validity and unidimensionality of each construct (Anderson and Gerbing 1988). Indeed, as a rule of thumb, the composite reliability value needs to be greater than 0.7 for the estimate to be acceptable (Hair et al. 2010). In addition, the reliability (R^2) of the items can be used to measure the reliability of a particular observed variable or item (Koufteros 1999). In this study, all R^2 values were greater than 0.5; thus, there is evidence of convergence (Hair et al. 2010).

****** <Insert Table 6 around here>******

The discriminate validity was assessed by comparing the average variance extracted (AVE) with the squared correlation between the constructs. The highest squared correlation was 0.570, which was observed between external sustainability collaboration and sustainability performance (see Table 7). This value was significantly lower than their individual AVE values of 0.674 and 0.717, respectively. Therefore, the results demonstrate evidence of discriminate validity for the study variables.

****** <Insert Table 7 around here>******

4.4. Results of hypothesis testing

In this section, the proposed structural model was applied to examine the relationships in the hypotheses that were established in Section 2. The data effectively supported the estimated model, as shown in Figure 1. All hypothesized relationships were significant and in the expected direction (see Table 8). Internal sustainability practices were found to have a significant relationship with sustainability performance (estimate = 0.709, CR = 5.946), internal sustainability practices were significantly associated with external sustainability collaboration (estimate = 0.718, CR = 5.243), and external sustainability collaboration was found to have a significant relationship with sustainability performance (estimate = 0.209, CR = 2.184), as shown in Figure 1. Therefore, the three research hypotheses were all supported.

****** <Insert Table 8 around here>******

****** <Insert Figure 1 around here>******

5. Discussion and conclusions

While prior research suggests supply chain management has a positive influence on performance (Christopher and Ryals 1999; Klassen and McLaughlin 1996; Wolf 2011), few empirical studies have examined the effects of sustainable supply chain management, including internal sustainability practices and external sustainability collaboration, on sustainability performance in container terminal operations. Applying the notion of how supply chain management views and implements sustainability practices may help us better understand what practices are the most effective (Wolf 2011). Given this gap in the literature, this research considered the interdisciplinary studies of sustainability, supply chain, and terminal operations; and investigated sustainability practices in container terminal operations at the Port of Kaohsiung. To the best of the authors' knowledge, no prior research has examined sustainable supply chain practices in the context of container terminal operations.

Several research conclusions can be drawn from this study. First, container terminal operators in sustainable practices need to integrate external customers (i.e., carriers), supply chain partners (i.e., truck companies and stevedoring companies), and internal sustainability practices to improve their sustainable performance. Second, with respect to internal sustainability practices items, it is important for firms to effectively communicate sustainable development issues with their staff and to allow the employees to be involved in the sustainability development policy. This research also suggests that terminal operators should work with their staff to design sustainability goals and regulations, develop a clear organization of responsibility, and engage employees in training programs for implementing sustainability in practice. Third, the results indicate that internal and external sustainability collaboration were positively associated with sustainability performance, including environmental, social, and economic performance. Internal sustainability practices had a stronger impact on sustainability performance than external sustainability collaboration, thereby showing the importance of establishing effective internal sustainability practices to improve sustainability performance. However, it should be noted that this research survey only focused on major container terminal operators at the Port of Kaohsiung in Taiwan. According to the report of UNCTAD (2014), the Port of Kaohsiung had 9.938 million TEUs of container throughput, which was ranked as the

13rd largest container port in the world. The research findings can be generalized and applied to other container terminal operators across the world. For example, this research offers a current profile of container terminal operators' sustainability practices and external sustainability collaboration in ports. Global container terminal operators can use the study's results to modify their current sustainability policies to more accurately meet the stakeholders' requirements. More importantly, this study provides a useful approach for effectively evaluating their sustainability management and sustainability performance. The list of sustainability criteria may help global container terminal operators identify and assess their sustainability performance.

From these findings we can provide several suggestions for container terminal operators in practice. First, terminal operators can develop sustainability management strategies that incorporate specific internal resources, competences, and capabilities. These sustainability management initiatives can be introduced via the supply chain management approach. Second, terminal operators can develop closer supply chain collaboration with external stakeholders, including carriers and service suppliers, in order to facilitate an effective implementation of sustainability management and to further improve sustainability performance. Finally, the research findings suggest that a successful development of sustainability in container operations requires the combination of internal sustainability practices within organizations, as well as external sustainability collaboration with supply chain members.

This study attempted to examine the effects of international sustainability practices and external sustainability collaboration on sustainability performance in container terminal operators. However, there are some limitations and suggestions for future research.

First, this study provided a model for understanding the impact of international sustainability practices and external sustainability collaboration on sustainability performance from a container terminal operator's perspective. However, the development of sustainability collaboration requires interaction between two parties, hence future research could usefully examine sustainability collaboration from an ocean carrier's viewpoint since container terminal operator and ocean carrier concerns in this context may differ. Future research would benefit from more diverse perspectives, such as the perspective of carriers, bulk stevedoring companies, truck companies, and other groups. Second, this study applied a cross-sectional survey. A longitudinal study to assess sustainable supply chain management and sustainability performance at different time points may more accurately determine what practices are most effective for achieving sustainability. Third, the data obtained from respondents were merely their perceptions of sustainability performance and may have been biased because of their reluctance to report actual performance because of potential personal repercussions and their self-interest in avoiding trouble with their employing company. Thus, this study is potentially flawed in its use of self-reported measures of sustainability performance. Objective measures should be used in future studies to ensure accuracy. Although it is important to understand the relationships between internal sustainability practices, external sustainability collaboration, and sustainability performance in major container terminal operators at the Port of Kaohsiung, the generalizability of the study findings may be limited, as the cross-sectional data used were only from one port. Future research could aim at testing and validating the model in different container terminal operators in other countries.

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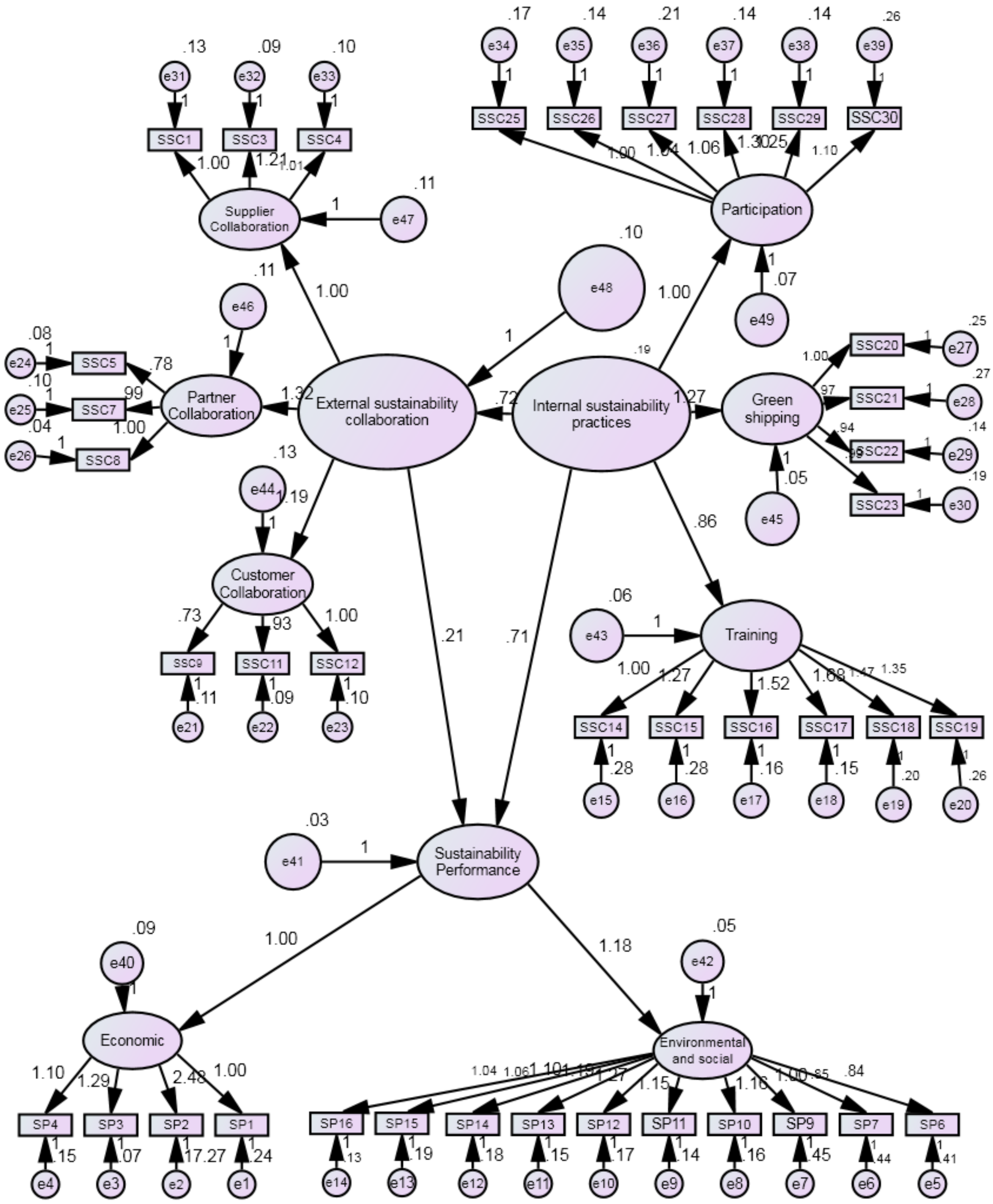

Figure 1: Results of the structural equation modelling.

Table 1: Factor analysis of internal sustainability practices items

Items	Factor		
	1	2	3
SSC29 My company communicates sustainable development issues with staff effectively	0.804	0.332	0.183
SSC30 My company allows employees to be involved in sustainable development policy	0.794	0.223	0.117
SSC27 My company provides sustainable development information to staff	0.757	0.139	0.291
SSC28 My company periodically attends sustainable development conferences	0.754	0.336	0.288
SSC26 My company improves sustainable development through cross-sectional coordination	0.718	0.267	0.347
SSC25 My company encourages employees to participate in goal setting for sustainable development	0.691	0.320	0.277
SSC31 My company actually implements sustainable development procedures	0.628	0.314	0.397
SSC16 My company provides enough sustainable development training courses	0.278	0.834	0.190
SSC17 My company provides sustainable development programs with excellent course designs	0.349	0.787	0.223
SSC15 My company establishes evaluation indicators for recycling, greenhouse gas mitigation, and resource saving	0.078	0.742	0.345
SSC18 My company effectively applies sustainable development coursework into practice	0.372	0.731	0.214
SSC14 My company publishes a written sustainable development policy	0.370	0.591	0.222
SSC19 My company aims to achieve sustainable development beyond the legal requirement	0.295	0.566	0.463
SSC13 My company sets sustainable development codes of practice	0.311	0.502	0.376
SSC21 My company requests that ships sail in economy mode to reduce fuel cost	0.216	0.267	0.792
SSC22 My company mitigates emission of CO2 and noise from berthing ships	0.304	0.301	0.744
SSC23 My company uses green materials in port design and port construction	0.326	0.213	0.743
SSC20 My company stays current on sustainability regulation	0.310	0.453	0.627
Eigenvalues	9.998	1.429	1.034
Percent variance (%)	26.73	23.87	18.63
Accumulated percent variance (%)	26.73	50.60	69.23
Cronbach's α	0.927	0.905	0.868

Table 2: Factor analysis of external sustainability collaboration

Supplier collaboration	
Items	Factor
SSC1 Establishing a set of reliable sustainability indicators with suppliers	0.924
SSC4 Discussing with suppliers to solve issues of sustainability development	0.903
SSC3 Collaborating with suppliers to achieve goals of sustainability development	0.896
SSC2 Working together with suppliers to reduce the impact on the port area	0.891
Eigenvalues	3.266
Accumulated percent variance (%)	81.649
Cronbach's α	0.925
Customer collaboration	
Items	Factor
SSC9 Establishing a set of reliable sustainability indicators with customers	0.915
SSC12 Discussing with customers to solve the issues of sustainability development	0.899
SSC11 Collaborating with customers to achieve the goal of sustainability development	0.884
SSC10 Working together with customers to reduce the impact on the port area	0.877
Eigenvalues	3.196
Accumulated percent variance (%)	79.895
Cronbach's α	0.916
Partner collaboration	
Items	Factor
SSC5 Establishing a set of reliable sustainability indicators with partners	0.945
SSC8 Discussing with partners to solve the issues of sustainability development	0.932
SSC7 Collaborating with partners to achieve the goal of sustainability development	0.916
SSC6 My firm works together with partners to reduce the impact on the port area	0.893
Eigenvalues	3.400
Accumulated percent variance (%)	84.992
Cronbach's α	0.941

Table 3.: Discriminant validity test with the chi-square differences

Conceptual model $\chi^2(51)=100.37$	Pair of Constructs ($\Phi=1$)	
	χ^2(d.f.)	χ^2 different (d.f.)
Supplier collaboration vs. partner collaboration	506.97 (52)	406.6 (1) **
Supplier collaboration vs. customer collaboration	702.07 (52)	601.7 (1) **
Partner collaboration vs. customer collaboration	678.35 (49)	577.9 (1) **

Note: $^{**}p<0.01$

Table 4. Factor analysis of self-reported sustainability performance

Items	Factor 1	Factor 2
SP12 I perceive that noise in the container yard has been significantly reduced	0.832	0.259
SP13 I perceive that the waste generated in the container yard has been significantly reduced	0.816	0.300
SP11 I perceive that the exhaust emission of each ship has been significantly reduced	0.795	0.320
SP10 I perceive that the waste oil of each ship has been significantly reduced	0.785	0.332
SP8 I perceive that the usage of environmentally friendly materials for container ships has significantly increased	0.779	0.317
SP15 I perceive that the ability to deal with scrap containers and ships has significantly increased	0.776	0.251
SP14 I perceive that the fuel consumption of each ship has been significantly reduced	0.746	0.361
SP9 I perceive that the caring of the disadvantaged groups has been significantly increased	0.691	0.083
SP6 I perceive that the employees' working benefits have been significantly increased	0.663	0.070
SP5 I perceive that traffic accidents in the container yards have been significantly reduced	0.502	0.436
SP3 I perceive that energy cost has been significantly reduced	0.471	0.732
SP1 I perceive that profitability has significantly increased	0.327	0.725
SP4 I perceive that the cost of dealing with scraps has been significantly reduced	0.419	0.714
SP2 I perceive that procurement costs in material has been significantly reduced	-0.050	0.643
Eigenvalues	7.72	1.17
Percent variance %	43.20	20.35
Accumulated percent variance (%)	43.20	63.55
Cronbach's α	0.933	0.771

Table 5: Agreement of internal sustainability practices, external sustainability collaboration, and self-reported sustainability performance according to firm size

Constructs	Dimensions	Million TEUs < 0.5 (1) N=41	0.5-1.0 (2) N=23	> 1.0 (3) N=77	F
Internal sustainability practices	Communication and participation	3.770	3.783	3.850	0.270
	Employee training	3.777	3.727	4.028	3.477*
	Green shipping	3.811	3.783	4.224	8.751*
External sustainability collaboration	Supplier collaboration	3.963	4.239	4.234	2.790
	Customer collaboration	4.183	4.217	4.328	0.917
	Partner collaboration	3.988	4.250	4.318	3.745*
Sustainability performance	Environmental and social performance	3.626	3.763	3.952	4.168*
	Economic performance	3.896	3.739	4.091	4.151*

Note: mean: 1 = strongly disagree to 5 = strongly agree; * = $p < 0.05$.

Table 6: Convergent validity

Dimensions	Factors	Loading Factor	AVE	Composite Reliability	R^2
External sustainability collaboration	Supplier collaboration	0.77	0.674	0.806	0.595
	Customer collaboration	0.82			0.674
	Partner collaboration	0.87			0.765
Internal sustainability practices	Internal sustainability participation	0.82	0.717	0.883	0.675
	Employee training	0.86			0.740
	Green shipping	0.86			0.746
Sustainability performance	Environmental and social performance	0.89	0.708	0.828	0.802
	Economic performance	0.79			0.634

Note: AVE: average variance extracted.

Table 7: Discriminate validity

	External sustainability collaboration	Internal sustainability practices	Sustainability performance
External sustainability collaboration	0.674[a]	-	-
Internal sustainability practices	0.373[b]	0.717[a]	-
Sustainability performance	0.399[b]	0.570[b]	0.708[a]

a: AVE; b: Squared correlation

Table 8: Structural equation modelling results.

	Paths	Estimates			
		Standardized β	SE[a]	CR[b]	P
H1	(Internal sustainability practices) → (Sustainability performance)	0.718	0.121	5.946	**[c]
H2	(External sustainability collaboration) → (Sustainability performance)	0.209	0.096	2.184	0.029*
H3	(Internal sustainability practices) → (External sustainability collaboration)	0.709	0.085	5.243	**

Note: a. SE is an estimate of the standard error of the covariance.
b. CR is critical ratio, which is obtained by dividing the covariance estimate by its standard error.
c. * P value is significant at the 0.05 level;** P value is significant at the 0.01 level.