Measures for evaluating green shipping practices implementation

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Abstract: Despite the need for environmental management in shipping, there is no extant measurement scale that comprehensively captures green shipping practices (GSP) in shipping operations. In view of this research void, we investigate the construct of and develop a measurement scale for evaluating GSP implementation in the shipping industry. Based on conceptualisation of GSP in an earlier study and survey data collected from 107 shipping firms, we develop, refine, and test a six-dimensional GSP measurement scale specifically for evaluating GSP implementation in the sea transportation context. The six GSP dimensions include company policy and procedure (CPP), shipping documentation (SD), shipping equipment (SE), shipper cooperation (SC), shipping materials (SM), and shipping design for compliance (SDC). We construct two measurement models at first- and second-order levels for evaluating the implementation of GSP and validate them by confirmatory factor analysis (CFA). The empirical findings suggest that both of the measurement models for evaluating GSP implementation are reliable and valid. This study makes a novel contribution to the shipping literature by empirically developing and validating the construct of GSP implementation. Practically, we contribute a validated measurement scale useful for shipping companies to evaluate the strengths and weaknesses of their greening efforts and identify areas for improvement.

Keywords: shipping; environmental management; construct measurement; confirmatory factor analysis; CFA.

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1 Introduction

Public concerns over environmentally friendly operations and resource conservation in the shipping sector have been on the rise. Shipping refers to cargo movement between two or more geographic locations in all modes including air, land, and sea transportation. As ships serve more than 80% of the world trade by volume (UNCTAD, 2011), sea transportation is the most popular shipping method by traders. Considering the global importance of seaborne trade, this study defines shipping as cargo movement by ships with intermodal connections and specifically investigates green shipping practices (GSP) in sea transportation. Shipping facilitates global trade but generates environmental pollution (e.g., CO_2 emission, and oil spill). While most shipping research studies focus on cost saving and service enhancement in order to achieve productivity gains, the environmental management aspect of shipping operations remains largely unexplored in the literature (Lun et al., 2011). Due to the escalating environmental awareness in business, the shipping industry is increasingly expected to take environmental responsibility such that shipping operations and processes become more environmentally friendly in serving world trade. In response, shipping firms pursue GSP in hope of mitigating the environmental damages caused by their activities (Yang, 2012). This study defines GSP broadly as *"the handling and distribution of cargoes in an environmentally sustainable way with a view to reducing waste creation and conserving resources in performing shipping activities"*.

Industrialisation and globalisation have bolstered international trade and the total seaborne trade had tripled from 1990 to 2011 (UNCTAD, 2011). Although shipping by maritime routes causes relatively less pollution compared with other transportation modes, it can significantly harm the environment due to its enormous industry scale, and shipping activities can damage the environment in multiple ways, e.g., consumption of natural resources (e.g., fuel consumption), emissions of greenhouse gases (GHG) (e.g., CO_2), and discharge of waste from vessel operations (e.g., ballast water and oil). In view of a growing emphasis on environmental protection as part of corporate social responsibility, shipping firms have begun to recognise the importance of 'greening' their activities in serving the global community through their role in supporting international trade (Lun et al., 2012a).

The intensifying community and consumer pressures on environmentally responsible operations have prompted shipping firms to implement GSP as means for greening their operations. For instance, many mega carriers such as OOCL, Hapag-Lloyd, and CMA CGM value the potential performance benefits of environmental management and embrace GSP as a part of their operations strategy to seek sustainable growth in business. Meanwhile, due to stricter regulations mandating environmentally responsible practices [e.g., the International Maritime Organization (IMO) International Convention for the Prevention of Pollution from Ships], shipping firms are expected to effectively integrate environmental concerns into their daily operations. They find it advantageous to pursue proactive environmental-based operations such as GSP to cope with institutional pressures (e.g., stricter regulatory requirements), which will intensify in the years ahead.

To advance knowledge in the emerging but neglected research topic of green shipping, it is desirable to understand the construct of GSP implementation and develop an empirically validated measurement scale for evaluating implementation GSP in shipping firms. Measurement is a fundamental activity of science and is usually associated with other scientific questions (DeVellis, 1991). Specifically, performance measurement is the process of measuring actual outcomes or the end goal of performance, as well as the means of achieving those outcomes as represented by in-process measures (Harbour, 2009). Therefore, an absence of measurement scales for evaluating the scale and scope of shipping firms in greening their activities is a potential barrier to their effective implementation of GSP.

Shipping embraces all the activities concerning the movement of cargoes among different parties within a transportation chain, whereby the activities involve the integration of upstream shippers and downstream consignees (Lun et al., 2010). Therefore, implementation of GSP needs coordination of internal functions within a shipping firm and the external operations of partner firms, e.g., shippers, consignees, logistics services provides, intermodal transport operators, and other trade related firms, along the transportation chain. However, stakeholders, such as shippers, consignees, and carriers, tend to emphasise the performance areas that serve their best interest. For instance, carriers may focus on operational efficiency, while shippers are more concerned with service effectiveness along the same transportation chain (Lai et al., 2002). The differences in the views of GSP would lead to inconsistency in the performance measures valued by different member firms and compromise chain-wide performance as a consequence. Given the divergent viewpoints on GSP, it would be difficult for shipping firms, as well as the different parties involved, to effectively evaluate the performance of their practices on a chain-wide basis.

Upon conducting a literature search on environment-based shipping practices, we find a serious lack of tools for evaluating the implementation of GSP. Furthermore, the extant studies concerning environmental management practices in the shipping discipline are mostly descriptive in nature with little empirical evidence about the aspects of GSP that are implemented in shipping firms. This study sets out to fill this research gap by investigating the construct of, and developing a valid and reliable scale and related items as an evaluation instrument for, GSP implementation to benefit the shipping industry in terms of improving the environmental dimension of their operations. Further, to identifying the components of GSP implementation, we also discuss the management implications of the GSP construct and provide suggestions for research and practice of environmental management in the shipping industry. In the rest of this paper, we first introduce the conceptual background of this study in Section 2. We then discuss the methodology used to develop and validate the GSP implementation construct in Section 3. We present the results of this study in Section 4, followed by a discussion of the results in Section 5. In Section 6, we conclude the paper by summarising the findings, discussing their implications, presenting the limitations, and identifying future directions for this important topic in shipping research.

2 Conceptual background

GSP implementation is increasingly recognised as an important management approach to help lessen the environmental damages caused by shipping activities. GSP are concerned with handling and distributing cargoes in a sustainable way, taking account of such environmental issues as waste reduction and resource conservation in shipping management. Shipping activities involve coordination with various parties along the transportation chain. The nature of such operations suggests that the effective implementation of GSP necessitates cross-functional cooperation rather than being confined to a single organisational unit. For example, GSP require cooperation with equipment suppliers for the selection of environmentally friendly shipping facilities (Wong et al., 2012). Examples include eco-labelling of resources such as shipping crates and totes for reuse, cooperation with equipment suppliers on environmental objectives, and environmental audits of suppliers' internal management systems. Cooperation with customers and shippers on eco-design in cargo handling and shipments is also highly desirable. This includes customer involvement in cleaner delivery such as enforcement of programmes for recycling, vehicle idling, packing waste collection, and using green packing materials.

Different interpretations of GSP can lead to inconsistency in performance evaluation, which compromises the implementation outcomes. GSP have been conceptualised in various ways, ranging from the perspective of natural science to technological advancement, as well as business management. The former conceptualisation considers

GSP as means helpful for shipping firms to ease the damages caused by their operations to the natural environment. Corbett et al. (2007) and Eyring et al. (2010) examined emission-related atmospheric problems arising from shipping activities and they explained the association between vessel operations and atmospheric pollution consequences (e.g., global warming, acid rain, and climate changes). Their studies analyse the adverse environmental impacts brought by shipping activities with recommendations suggested to mitigate the relevant issues. Yang (2011) investigated the toxicity and ecological risks in the marine environment associated with shipping management. The study covers various aspects of pollution generated by shipping operations, which include ballast water discharge, exhaust emissions, and oil pollution. In addition, he carried out a toxicology assessment to evaluate the severity of environmental impact caused by chemical leakage from hull during operations. Toxic chemicals such as tributyltin (TBT) (i.e., a typical anti-fouling paint) are commonly found in raw materials for vessel construction, where the leakage of such chemicals can result in severe ecological impact.

Alternatively, GSP are sometimes considered as breakthroughs and advancements in shipbuilding technologies with a focus on cost reduction and productivity improvement through effective use of energy, while minimising shipping-caused environmental damages. Coupled with technological advancement, we have seen the use of modifications of vessel engine systems, application of chemical tracers, and use of alternative fuels for vessel operations as means to green the shipping activities. All these initiatives are adopted with the aim to reduce the environmental harm caused by shipping navigations (Corbett and Fischbeck, 2002; Eyring et al., 2010; Viana et al., 2009). The environmental and financial consequences of technological advancement for shipping operations have become popular research topics in the literature (e.g., Viana et al., 2009).

Meanwhile, GSP implementation is often associated with behavioural changes to run and manage shipping companies such as continuous improvements of vessel operation procedures. Two groups of researchers have investigated the association between vessel speed and emission level (Corbett et al., 2009; Lindstad et al., 2011). They built mathematical models to correlate vessel speed, profit, and CO_2 emissions, and both studies found that vessel speed reduction would effectively reduce CO_2 emissions, while maintaining profitability. From the commercial perspective, shipping firms have also begun to adopt new business practices for improving the environmental performance of their operations. For example, CMA CGM has introduced the ‘eco-speed’ programme to reduce the speed of its vessels. Mitsui O.S.K. Lines (MOL) has implemented a newly established system called ‘ECO SAILING’ and Maersk has developed the Voyage Efficiency System (VES). OOCL has launched a fuel saving programme to cut down GHG, especially CO_2. These practices highlight that shipping firms focus on the most environmentally friendly operations in order to minimise fuel consumption while striving to optimise vessel performance. GSP are also a viable management approach to satisfy the escalating environmental expectations and requests of stakeholders of shipping firms. The greening of shipping operations can help fulfil various voluntary environmental requirements such as ISO 14000 certification and ISM Code. There exist various models to fulfil the environmental purposes in shipping operations. For instance, Celik (2009) developed an Integrated Environmental Management System (IEMS) for the shipping industry. The model is developed by integrating the analytic hierarchy process (AHP) and fuzzy axiomatic design (FAD) concepts. Shipping firms may use the model to establish the managerial and operational interface on environmental management issues to comply with the requirements of the ISM Code and ISO 14001 standard simultaneously.

The importance of GSP for the shipping industry is obvious, but measures for evaluating GSP implementation remain inconclusive. Based on an earlier exploratory research (Lai et al., 2011), we empirically investigate the environmental concerns of shipping firms; in particular, we develop the construct and measurement of GSP implementation in this study. Specifically, we classify the GSP implementation of shipping firms for reducing waste creation and conserving resources into six dimensions. These GSP implementation dimensions in shipping operations are useful for shipping firms to yield environmental as well as productivity benefits. Shipping firms may use these different aspects of environmental shipping operations to identify improvement areas in their own operations for achieving eco-efficiency. We summarise the six GSP implementation dimensions below:

1. *Company policy and procedure (CPP):* CPP is concerned with corporate commitment to a vision of sustainability. Indicators include a firm's support to attain environmental compliance to enhance environmental performance.
2. *Shipping documentation (SD):* SD focuses on promoting reductions in resource utilising such as paper for documenting shipping activities.
3. *Shipping equipment (SE):* SE advocates the use of eco-design for such SE as cartons and pallets. This also extends to collaboration with suppliers to use environmentally friendly SE to pursue environmental objectives.
4. *Shipper cooperation (SC):* SC concerns cooperation with shippers in eco-design for cargo operations.
5. *Shipping materials (SM):* SM emphasises reducing, recycling, and reusing SM. It also extends to the environmental design of packaging materials, e.g., packaging and cartons.
6. *Shipping design for compliance (SDC):* SDC seeks to take measures in compliance with such environmental requirements as energy saving, reuse of SE, reduction of environmental damage, and recycling and recovery of waste.

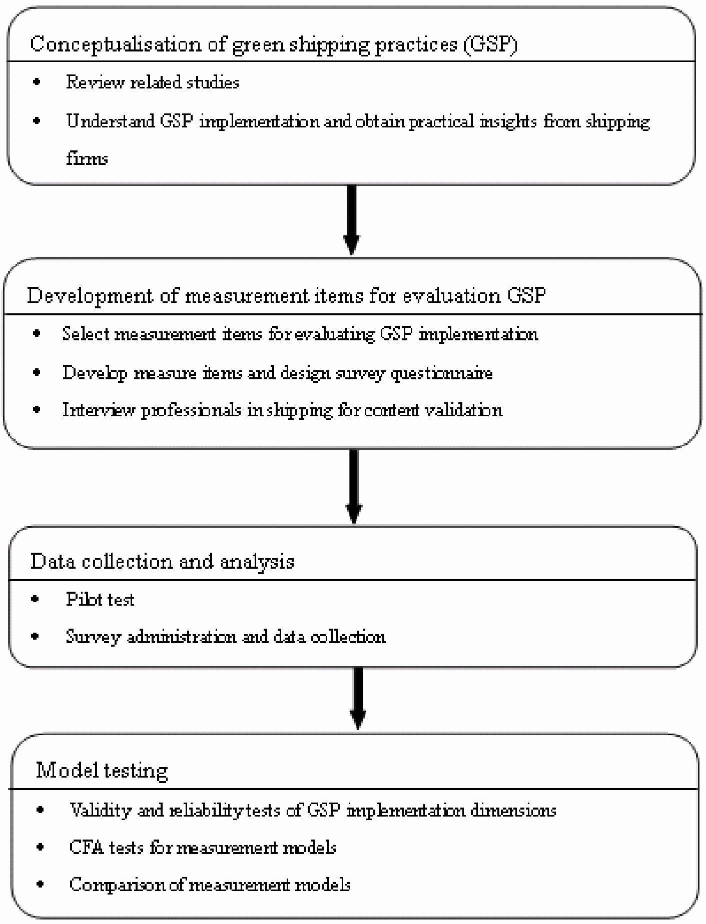
Based on the above conceptualisation, we examine two models of GSP implementation in this study. We test the six-factor structure of the GSP construct in a first-order model, where CPP, SD, SE, SC, SM, and SDC correlate among themselves in measuring the same theoretical construct, i.e., GSP implementation, and in an alternative second-order model, where we treat the construct as a higher order model governing the covariance of the six dimensions of GSP implementation.

3 Methodology

3.1 Developing the GSP implementation construct

In developing a measurement instrument for evaluating GSP implementation, we followed the standard guidelines to ensure the key components of validity with respect to content, discriminant, convergent, and nomological validity (Bagozzi et al., 1991). Using the inputs from an earlier study (Lai et al., 2011), together with the insights from 12 professionals in an international shipping forum, we generated a list of 31 items on GSP that are considered important for implementation by shipping firms: six for CPP, five for SD, six for SE, four for SC, five for SM, and five for SDC, where the items are summarised in Appendix. These items are measured on a five-point Likert scale, where 1 = very low, 2 = low, 3 = moderate, 4 = high, and 5 = very high, to measure the extent to which the GSP were implemented in the company. We conducted a content validation test by inviting experts in the shipping industry to review the measuring items, so as to ensure that they are representative of our conceptualisation of GSP implementation. We invited five shipping logistics experts from academia and five industry practitioners to review the questionnaire to ensure the relevance and clarity (i.e., face validity) of the descriptions for each item in the measurement scale. We explained to the experts the purpose of our study and asked them to comment on the items for completeness, understandability, terminology used, and ambiguity. We made several changes to improve the wording after the expert review and refined the questionnaire items in a pilot test.

Figure 1 Research process



We initially pilot tested the measurement scale for evaluating GSP implementation with 30managers attending a postgraduate master's programme in international shipping and transport logistics. The pilot test sought their feedback with a view to improving the wording and seminal meanings of individual measurement items for content validity. Subsequently, we organised the refined measurement items collectively as a measurement scale in the form of survey questionnaire for administering to a sample of shipping companies to capture the status of GSP implementation in the shipping industry. To evaluate the construct of GSP implementation, we carried out CFA tests to examine the measurement properties of GSP implementation, followed by a comparison of the test results of two alternative measurement models to evaluate the GSP implementation construct. Figure 1 summarises the methodology that guides the research process of this study.

3.2 Data collection

We identified a sample of 500 shipping companies from a population of 1,266 shipping companies listed in *Shipping Gazette*, a biweekly magazine published by the shipping industry in Hong Kong. We employed the key informant strategy to carry out the survey research. The target respondents were general operations managers of the sampled companies. Each target respondent received an initial mailing, which consisted of a covering letter explaining the purposes of the study, a copy of the questionnaire, and a postage-paid return envelope. Approximately one month later, we sent a second mailing identical in content to the initial one to the non-respondents, followed by a reminder letter two weeks after the second mailing. We received a total of 107 usable questionnaires, yielding a valid response rate of 21.4%.

3.3 Non-response bias and common method variance

We examined non-response bias by comparing the responses from the first mailing of the questionnaire with the responses from the second mailing by testing for the mean differences in the six dimensions of GSP implementation (Armstron and Overton, 1977). We found no significant differences (i.e., $p > 0.05$) in the mean value of the six dimensions between the early and late respondents. Although the test results do not rule out the possibility of bias due to non-response, they suggest that such a problem should not be an issue for this study to the extent that the late respondents represent the opinions of the non-respondents.

Common method variance might be a threat in this study due to the cross-sectional and key-informant research design. We therefore checked for such problem in three steps. First, we divided the survey questions into different sections based on the position of their respective variables in the model, e.g., dependent and independent (Podsakoff et al., 2003). Second, following prior studies on environmental management and shipping, we conducted the Harman's one-factor test to ensure that no single factor accounts for the majority of covariance between the independent and dependent variables. The factor analytic results indicate that no one factor explains more than 40% of the total variance, which suggests that common method variance should not be a problem for this study. Lastly, we followed Lindell and Whitney's (2001) guideline to test if there is a relationship between a marker variable (i.e., the variable that is theoretically not related to any variable in this study) and the six dimensions of GSP implementation. We used type of firm ownership as the marker variable and we found no significant relationship between it and the GSP implementation dimensions, so the potential threat due to common method bias was not apparent.

4 Results and discussion

4.1 Reliability test

Before proceeding to conduct various multivariate tests, we first examined the skewness and kurtosis scores of each item to ensure there is no serious deviation from the normality assumption (Hair et al., 2010). All of these scores fall within the range of –2 to +2 (skewness: –0.90 to 1.10; kurtosis –0.94 to 1.18), suggesting no violation of the normality assumption and the data quality is assured.

To assess the measurement properties of GSP implementation, we first conducted the reliability test and corrected item-to-total correlation (CITC) analysis, followed by confirmatory factor analysis (CFA). We used CFA to assess how well the observed variables reflect unobserved or latent variables. Table 1 summarises the Cronbach's alphas for the six dimensions and the CITC results. All the six factors of GSP implementation have a Cronbach's alpha and composite reliability greater than the recommended threshold value of 0.70 (Fornell and Larcker, 1981; Nunnally and Berstein, 1994) and all the CITC results are greater than 0.50 (Churchill, 1979), except for the item Shipper Cooperation (SC2), which has a CITC result of 0.33. While the CITC analysis assesses how well all the items are highly correlated if they belong to the same domain of concept, we eliminated SC2 for further analysis because this item is not highly correlated with the rest of the measurement items underpinning their respective constructs. Also, upon careful examination of its content, shippers tended not to involve eco-design in transportation, rendering this item inappropriate as part of the SC construct.

4.2 Convergent and discriminant validity

We next performed a CFA using the maximum likelihood estimation with AMOS 18.0. We used a multiple of goodness-of-fit indices to evaluate the fit of the factor structure of the CFA. The criteria of these indices for evaluating fitness are: comparative fit index (CFI) > 0.9, incremental fit index (IFI) > 0.9, root mean square residual (RMR) < 0.1, and normal fit index (NFI) > 0.9 (Hu and Bentler, 1999). Table 1 summarises the goodness-of-fit indices for the CFA. To test the convergent validity of the measurement scale, we followed Fornell and Larcker (1981) and calculated the AVE values. The AVE of each construct exceeds the recommended minimum value of 0.5, which indicates convergent validity. The significant loading of the measurement items on their latent factors ($\lambda > 0.4$ and $t > 2$) provides further support for convergent validity. We also followed Fornell and Larcker (1981) to test discriminant validity. The square root of AVE of each construct is greater than the correlation between any pair of them. This suggests that the relationship between the measurement items of their respective construct is greater than the relationship of the measurement items across constructs. This result provides evidence of discriminant validity.

Table 1 Results of reliability, CITC, and CFA

Green shipping practices	*Cronbach's alpha*	*Range of CITC*	*CFI*	*IFI*	*RMR*	*NFI*	*χ^2 (df) (all with $p < 0.001$)*	*Range of standardised loadings*	*Range of t-values*	*Composite reliability*	*AVE*
CPP	.92	.61–.86	.96	.96	.03	.95	33.16(8)	.42–.92	3.44–7.16	.91	.62
SD	.93	.71–.89	.98	.98	.04	.97	13.23(5)	.71–.94	8.85–15.51	.93	.74
SE	.96	.81–.92	.94	.94	.07	.93	62.95(8)	.75–.98	10.92–28.11	.95	.69
SC	.94	.87–.90	-	-	-	-	-	.91–.95	3.49–16.62	.94	.85
SM	.90	.59–.86	.98	.98	.04	.97	12.91(4)	.51–.89	5.72–16.11	.90	.63
SDC	.96	.86–.90	.96	.97	.03	.96	26.25(5)	.88–.93	13.86–15.81	.96	.77

We conducted a series of χ^2 difference tests between nested CFA models for all pairs of constructs to assess the discriminant validity of the constructs to examine the degree to which each construct and its measurement items are different from another construct and its measurement items (Churchill, 1979). We compared the χ^2 between the constrained model, where the correlations between two constructs are constrained to 1.0, and the unconstrained model, where the two constructs vary freely (Bagozzi et al., 1991). Table 2 summarises the χ^2 of the unconstrained and constrained models. Significant χ^2 differences between all pairs of constructs indicate discriminant validity.

Table 2 Discriminant validity checks: χ^2 differences

Factor		*1*	*2*	*3*	*4*	*5*
1	CPP					
2	SD	10.23***				
3	SE	9.22***	13.46***			
4	SC	9.08***	20.92***	8.13***		
5	SM	12.35***	25.63***	6.49*	12.53***	
6	SDC	5.96*	17.58***	6.18*	7.92**	5.58*

Notes: χ^2 difference between the separate latent factors measurement model and a one latent factor measurement model (all test =1 df); ***p < 0.001, **p < 0.01, *p < 0.05.

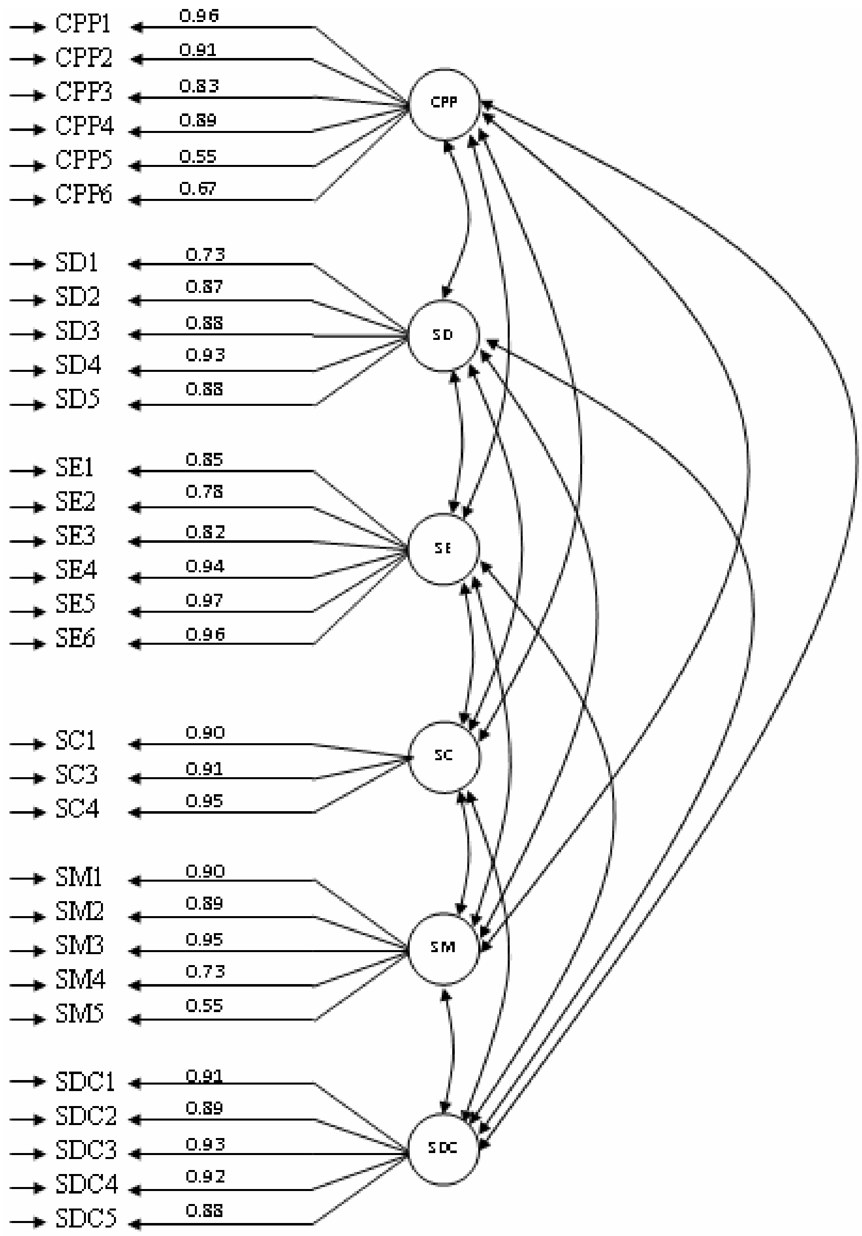
Table 3 Results of CFA on green shipping practices

Construct	*Direction*	*Indicator*	*Standardised loading*	*t-value*	*p*
GSP	→	SC	.80	-	-
GSP	→	SD	.57	4.78	.00
GSP	→	SE	.86	7.47	.00
GSP	→	CPP	.64	6.22	.00
GSP	→	SM	.77	7.02	.00
GSP	→	SDC	.84	7.72	.00

4.3 First-order and second-order models

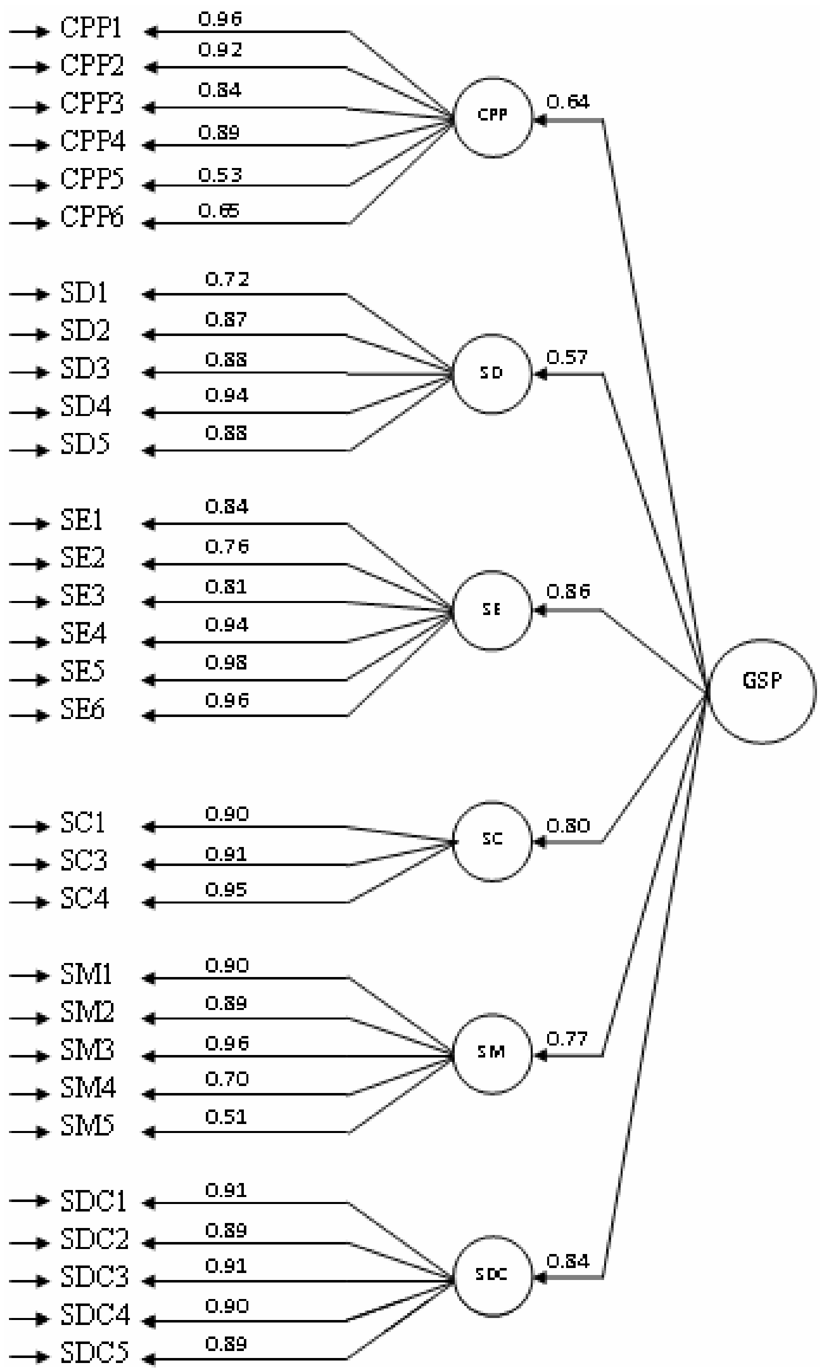
Having achieving satisfactory reliability and validity results, based on the concept of multiple dimensions of the GSP implementation construct, we tested if the construct should be a more parsimonious measure as a second-order level construct consisting of sub-dimensions including CPP, SD, SE, SC, SM, and SDC. We conducted three tests to compare the first-order (χ^2 = 933.42, df = 390, CFI = 0.86, IFI = 0.86, RMR = 0.1) (see Figure 2) and second-order (χ^2 = 762.68, df = 393, CFI = 0.90, IFI = 0.90, RMR = 0.1) models as shown in Figure 3, which are found to be almost identical. The second-order model is more restrictive and provides more information about the relationship between the higher-order GSP implementation construct and the lower-order factors in the form of path coefficients rather than correlations. This result suggests that the second-order model is a better predictor of GSP implementation. Moreover, the first-order constructs load significantly onto the second-order construct at p < .05 with λ ranging from .57 to .86, providing support for the presence of the second-order model. Lastly, we compute the target coefficient value (*T*) (Marsh and Hocevar, 1985) and found *T* = 0.82, which is close to the theoretical upper limit of 1.0. This result indicates that the second-order construct accounts for 99% of the traits of the first-order constructs, providing further support for the presence of the second-order model. Table 3 summarises the CFA results on the GSP implementation construct.

Figure 2 First-order factor measurement model for GSP implementation



Notes: Chi square (390) = 933.42 ($p < 0.001$), RMR = 0.1, CFI = 0.86, IFI = 0.86.

Figure 3 Second-order factor measurement model for GSP Implementation



Notes: Chi square (393) = 762.68 ($p < 0.001$), RMR = 0.1, CFI = 0.90, IFI = 0.90.

4.4 Nomological and predictive validity test

To test for nomological validity of the GSP implementation scale regarding its ability to perform as expected in a network of well-established causal relationships and measures, we placed it within a nomological network of performance outcomes associated with different extents of GSP implementation. We developed the performance measures on the basis of Lai et al. (2002, 2010) for evaluating logistics performance in terms of cost (i.e., profitability, sales growth, and operations cost reduction) and service (i.e., customer satisfaction, unforeseen problem-solving ability, and environmental performance) improvements over the last three years.

We used SEM to test the relationships between GSP implementation and logistics performance in the nomological network. The hypothesised model was supported, suggesting nomological validity of the GSP implementation scale. GSP implementation in shipping firms is significant and positively related to their cost reduction (β = .46, $p < 0.01$) and environmental performance (β=.62, $p < 0.01$). The predictive power of the model is also good as the model explains a good portion of the variance in cost reduction ($R^2 = 0.22$) and service performance ($R^2 = 0.38$).

5 Discussion

In this study we develop the construct of GSP implementation and validate the measurement scale for evaluating the dimensions of GSP implementation. The measurement items underpinning the scale for GSP implementation are classified into six dimensions: CPP, SD, SE, SC, SM, and SDC. Among the 31 items validated in the survey study, the construct of GSP implementation adequately fits into the data collected, excluding item SC2. This item was eliminated due to a lack of correlation with the rest of the measurement items underpinning their respective constructs. We further discovered that shippers tend not to involve in transportation eco-design as a part of their GSP implementation. In the model testing, both the first- and second-order models are validated while the second-order model is considered to be a better predictor, which indicates that the GSP construct should be treated as a higher order model governing the covariance of the six dimensions encompassing CPP, SD, SE, SC, SM, and SDC. In the first-order model, CPP, SD, SE, SC, SM, and SDC are correlated measurement factors for GSP implementation. The second-order model's estimated parameters are all significant and it is more restrictive with the provision of more information about the relationship between the higher-order GSP implementation construct and the lower-order factors in path coefficients in addition to the correlating relationships. Thus, the second-order model appears to be a more appropriate predictor for studying GSP implementation. This result reflects that the consideration of GSP implementation should be multifaceted, which should not be limited to any individual item. GSP implementation should cover all the six identified dimensions validated in this study (i.e., CPP, SD, SE, SC, SM, and SDC). A lopsided focus on one dimension while neglecting the other dimensions can be devastating for overall performance outcomes because of the complementary nature of GSP implementation. The multidimensional conceptualisation of the GSP implementation model provides insights into the construct of GSP implementation and its relationships with the underlying dimensions. First, the items and sub-dimensions of the construct are specific to the context of the shipping industry, so they provide direct and actionable suggestions for GSP implementation. Second, conceptualisation of the construct at a higher level assists shipping firms to observe GSP implementation at an advanced level of abstraction beyond the individual items. At the individual item level, shipping companies may consider GSP implementation for each single item with a view to identifying areas in need of specific attention. The measurement items validated in this study provide shipping firms with a systematic guideline to evaluate their strengths and weaknesses in GSP implementation and also identify the areas that require improvement actions.

6 Conclusions

6.1 Findings

This study advances knowledge in the literature on assessing the construct of GSP implementation by providing a validated 30-item measurement scale for the practical use of shipping firms to evaluate the different facets of environment-based shipping practices. The empirical results suggest that all the 30 measurement items are critical attributes of the six underlying factors of GSP implementation. Shipping firms wishing to improve their GSP need to constantly monitor their implementation progress. On the practical side, shipping firms can use the six dimensions of GSP as a check list to help them to yield environmental benefits. The validated measurement scale can be used as a self-diagnostic tool for shipping firms to identify whether certain areas of their environmental efforts should receive more attention and require additional improvement efforts. This study provides a useful reference for shipping firms to understand GSP and the breadth and depth of their implementation. In view of the growing environmental awareness of customers, shipping firms can competently cope with such pressure by implementing GSP, which is conducive to environmental performance improvement and cost reduction. Shipping firms can benefit from the implementation of GSP by catering to customer expectations through promoting materials recycle programmes (i.e., a focus on SM) and customer cooperation programmes (i.e., a focus on SC). Coupled with increasingly stringent environmental-related regulations, the importance of GSP for shipping firms to balance their productivity with environmental performance is highlighted. The validated GSP construct and the measurement scale provide assessment tools for shipping firms to assess and identify deficiencies in their GSP implementation that call for improvement actions. Shipping firms can use the evaluation results obtained from using the tools to plan their assessment, reporting, and monitoring mechanisms for GSP implementation.

6.2 Limitations and future research

Our developed measures for evaluating GSP implementation are not without limitations. First, the sample of respondents was selected from shipping firms and the study assesses information only from the perspective of sea transportation. Consequently, it offers a self-reported, one-dimensional focus. The study results could be different if the questionnaire data are collected from other transportation modes (e.g., air, land, and rail) and stakeholders (e.g., shippers and consignees) within the transportation chain. Further research will benefit from testing the instrument with different parties in the transportation chain to triangulate the findings. Second, we focus on developing the measures for evaluating GSP implementation without a more in-depth investigation of the resulting performance outcomes. Further empirical research examining the performance implications of GSP implementation and the relative impacts of the six dimensions of GSP implementation on different performance measures including cost, customer satisfaction, employee motivation, environmental, financial, productivity, market, and supply chain coordination are encouraged (Wong et al., 2009a, 2009b, 2011). Moreover, a wider consideration of GSP implementation should be incorporated to provide a more comprehensive framework incorporating institutional factors such as the pressures from customers and legal requirements (Lai and Wong, 2012; Wong et al., 2011). Richer insights can be generated if future studies are conducted across different cultural and social settings (Lai et al., 2012), which will help generalise the findings and understand the influences of cultural and social contexts on the development of GSP implementation. Further research can focus on the measurement models for GSP performance improvement after the implementation has matured. The causal links between the antecedents to and consequences of GSP implementation and their moderation and mediation effects are worthy of further investigation. Finally, the contributions of GSP implementation to the development of logistics service capability and the sustainable growth of shipping firms are promising topics to extend this line of research (Lun et al., 2012b; Lun and Browne, 2009). We hope that our validated construct and measurement scale for evaluating GSP implementation can serve as a springboard for further studies and a useful reference for shipping firms to better improve the environmental dimension of their operations. For a standard measure to emerge from future research, our validated scale can serve as a baseline measure for comparison and benchmarking across studies in shipping and logistics.

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Appendix

Measurement scales

Factors	*Measurement items*	
Company policy and procedure (CPP)	1	Senior management support for GSP *(CPP1)*
	2	Mid-level management support for GSP *(CPP2)*
	3	Cross-departmental support for GSP *(CPP3)*
	4	Company policies in support of environmental protection *(CPP4)*
	5	Environmental management systems such as ISO 14 001 in support of GSP *(CPP5)*
	6	Corporate environmental performance report in support of GSP *(CPP6)*
Shipping document (SD)	7	Shipping instructions are handled electronically *(SD1)*
	8	Invoices are handled electronically *(SD2)*
	9	Notifications of paid invoices are handled electronically *(SD3)*
	10	Bills of lading are handled electronically *(SD4)*
	11	Environmental guidelines for handling shipping documents *(SD5)*
Shipping equipment (SE)	12	Eco-design for shipping packaging *(SE1)*
	13	Eco-design for shipping cartons *(SE2)*
	14	Eco-design for shipping pallets *(SE3)*
	15	Eco-design for cargo containers *(SE4)*
	16	Cooperation with equipment suppliers to pursue environmental objectives *(SE5)*
	17	Design of shipping equipment to meet environmental standards *(SE6)*
Shipper cooperation (SC)	18	Shippers are involved in eco-design for cargo handling *(SC1)*
	19	Shippers are involved in eco-design for cargo transportation *(SC2)**
	20	Shippers are involved in pursuing environmental objectives *(SC3)*
	21	Shippers are involved in cleaner delivery *(SC4)*
Shipping materials (SM)	22	Reduction in packaging materials *(SM1)*
	23	Improvement in design of packaging materials *(SM2)*
	24	Improvement in packaging procedures *(SM3)*
	25	Recycling used packaging such as cartons *(SM4)*
	26	Sale of used packaging such as cartons *(SM5)*
Shipping design for compliance (SDC)	27	Compliance for energy saving shipping equipment design *(SDC1)*
	28	Compliance for shipping equipment reuse *(SDC2)*
	29	Compliance for recycling of waste *(SDC3)*
	30	Compliance for recovery of waste *(SDC4)*
	31	Compliance for reducing environmental damages *(SDC5)*

Notes: A five-point Likert measurement scale: 1 = 0–20% very low; 2 = 21–40% low; 3 = 41–60% moderate; 4 = 61–80% high; 5 = 81–100% very high.
*SC2 was eliminated from the study because this item was not highly correlated with the rest of the measurement items underpinning their respective constructs (i.e., CITC of .33).