Greening propensity and performance implications for logistics service providers

Abstract

Stakeholders in the logistics industry have growing concern about the damage caused by logistics operations to the environment. Logistics service providers (LSPs) have taken steps to pursue environmental objectives by involving customers in their operations. This study defines greening propensity (GP) as "involvement of customers to perform logistics activities to achieve environmental performance". We analyze survey data collected from the logistics industry in Hong Kong to address the following questions: What are the categories of greening capability in LSPs? What are the performance outcomes of LSPs' greening capability? Theoretical contributions and implications of the study results are discussed.

1. Introduction

Supply chain collaboration involves relationship development among parties in a supply chain to enhance mutual performance. Driven by growth in global production and consumption, supply chain activities have expanded in both scope and volume in recent decades. To succeed in the competition, many manufacturers and retailers dedicate resources to focus on their core businesses. Accordingly, many of them have chosen to outsource their non-core activities such as logistics operations to logistics service providers (LSPs). Due to the increase in outsourced activities at the global level, LSPs play a facilitating role for enterprises to improve their supply chain operations. Customers of LSPs (e.g., traders, manufacturers, and retailers) increasingly request more, better, and faster services in support of their global production and marketing activities (McGinnis and Kohn, 2002). Hence, it confers a competitive advantage on LSPs that provide comprehensive service menus to better satisfy customer needs (Lieb and Miller, 2002). In general, LSPs can be categorized into several types ranging from traditional freight forwarders to fully-fledged service providers. To satisfy the growing customer requirements for logistics operations, many LSPs have taken measures to broaden the scope of their services (Murphy and Daley, 2001; Murphy and Wood, 2004). LSPs provide different logistics service bundles, which we define as "a group of highly related and complementary logistics activities that enables a firm to convert its business routines into a formidable means to satisfy different logistics service needs" in this study.

On the other hand, public pressure on firms to implement environmentally friendly operations in managing their global supply chains has been on the rise (Lai et al., 2013). Green operations have become an important issue in today's business activities as participating parties in the supply chain increasingly demand striking a balance between economic gain and environmental protection (Lun 2011). Customer pressure on green operations has prompted many LSPs to cooperate with their customers and enhance their capability in greening with the aim to improve their firm performance (Lun et al., forthcoming). LSPs with a greening propensity are considered to have strong preference to perform their logistics services in an environmentally friendly manner. To adopt green operations for managing the supply chains of customer firms, LSPs need the participation of their customers to pursue environmental objectives jointly (Lai et al., 2013; Yang, 2012). In this study, we define greening propensity as "involvement of customers to perform logistics activities environmentally to achieve firm performance".

In logistics operations, better greening capability enables LSPs to deliver logistics services to their customers more efficiently. For instance, LSPs having close working relationships with their customers and understanding of customers' environmental objectives can develop efficient business routines to better serve their customers (Wong et al., 2012). Hence, it is worth studying green operations that convert inputs into outputs, which are essential to developing the green capability of LSPs. In this study, we address the following key research questions concerning green operations in the logistics industry: Do service bundles exist in logistics operations? What is the status of LSPs with a greening propensity to adopt green operations to carry out their business activities? What is the relationship between greening capability and firm performance in terms of customer satisfaction and sales growth? Based on empirical data collected from LSPs in Hong Kong, we classify service capability into several categories relative to the results of an earlier study published by Lai (2004) to examine the dynamic service capability of LSPs. In addition, we use an input/output approach to determine the greening capability of LSPs. We also examine the relationships between greening capability and customer satisfaction and sales growth using various analytical tools to illustrate the presence of greening propensity.

2. Theoretical background

LSPs involve "customers' external firms to perform logistics functions" (Lieb, 1992). Activities performed by LSPs range from the traditional arm's length outsourcing of transport services to the provision of a broad range of logistics service items. According to Lai (2004), an LSP can be broadly defined as "a provider of logistics services that performs all or part of a client company's logistics function". LSPs have received considerable attention in the last few decades (Kenmeyer et al 2003). Comprehensive reviews of LSPs have been conducted by Razzque and Sheng (1998), Skjoett-Larsen (2000), Maloni and Carter (2006), and Marasco (2008) to examine various issues pertinent to third-party logistics operations. Nowadays, LSPs offer a broad spectrum of logistics service functions. By outsourcing logistics operations to third parties, business enterprises can focus on their core strengths. Activities performed by LSPs have experienced significant growth in recent years. The annual growth in third-party logistics services in China, the US, and the rest of the world are estimated to be 25%, 10-15%, and 5-10%, respectively (Koh and Tan, 2005; Yeung et al, 2012).

According to the National Bureau of Statistics of China, the total output of the logistics industry in China had shown a significant increase from less than RMB 20 billion in 1980 to more than RMB 100 billion in 2009. The growth of logistics outputs can be examined from two aspects (Lean et al, 2014): the first one is that the logistics industry has experienced rapid development and the second one is that logistics components are broadening. The recent trend of focusing on core competence by enterprises has contributed to the rapid development of the logistics industry. To compete with rivals, business enterprises focus on their core competence with non-core logistics activities being outsourced to third parties with the aim to create competitive advantage by forming long-term relationships with LSPs (Coates and McDermott, 2002; Yeung, 2008). To enhance their core competence, business enterprises adopt a global view on logistics management and consider LSPs as partners that provide them with a broad range of logistics services (Lemonie and Dagnaes, 2003). As logistics service management is a significant research area, it is essential to investigate LSPs' green operations and their links with business outcomes.

This study uses the approach of "topology as a theory building" to examine the greening propensity of LSPs. Figure 1 shows the proposed research model that guides this study. According to Doty and Glick (1994), topology "identifies multiple ideal types, each of which represents a unique combination of the organizational attributes that are believed to determine the relevant outcome(s)". In using topology as theory, topology must meet the minimum definition of a theory. The primary criteria that a theory must meet are: (a) constructs must be identified, (b) relationships among these constructs must be examined, and (c) the relationships between dependent variables and predictors must be empirically testable. To adopt the approach of "topology as a theory" proposed by Doty and Glick (1994), we develop a theory of "greening propensity" as follows:

- Constructs in topology: We apply the tool of factor analysis to identify different logistics service bundles provided by LSPs.
- Relationships among constructs: We use the logistics service bundles provided by LSPs to serve their customers as the outputs. We adopt a stepwise approach to determine the inputs of greening capacity. Then, we apply the data envelopment analysis input-orient model to examine the transformation of inputs into outputs to determine the greening capability of LSPs.
- Relationships between constructs and predictors: In this study the constructs are greening capabilities of LSPs and the predictors are firm performance in terms of customer satisfaction and sales growth. We conduct a series of regression analysis models to test the positive relationship between the greening capability and firm performance. We expect that the results illustrate the presence of greening propensity, i.e., involvement of customers to perform logistics activities environmentally is beneficial to firm performance.

Applying the above approach, we first identify the major logistics service bundles provided by LSPs. According to Lai (2004), the logistics activities performed by LSPs include billing function, information systems management, inventory management, logistics planning, performance reporting, freight forwarding, receiving/sending shipment notices, receiving purchase or sales orders, tracking and tracking shipping information, web-based linkage, bar code scanning, label printing, purchasing and procurement, repackaging and re-labeling, assembling, and re-assembling, call center operations, customs clearance, and fleet management. It is desirable to bundle logistics activities together as a service package to meet customer needs. A logistics services bundle is a group of closely related and complementary logistics activities that enables a LSP to convert its logistics process into a formidable means for managing its logistics operations effectively to meet market needs (Lai et al, 2010). Logistics service bundles can be considered as a source of competitive advantage (Wong and Karia, 2010). Lai (2004) also classifies the services provided by LSPs into three categories, namely freight forwarding service (FFD), value-added logistics service (VAL), and technology-enabled logistics services (TEL). Based on dynamic capability theory, these logistics service bundles change over time due to changes in the competitive environment. LSPs carry out their business operations in a rapidly evolving business environment. To investigate the business operations in the logistics industry, it is essential to examine the dynamic service capability of LSPs as the requirements for logistics service bundles change over time in response to fast-changing customer requirements. To cope with the dynamic business operating environment, LSPs integrate their logistics activities to build logistics service bundles. They also re-configure their logistics service bundles over time to cope with the dynamic operating environment. Hence, LSPs create different logistics service bundles over time.

Then, we determine the service capability of LSPs. LSPs possessing higher levels of service capability can better serve their customers. Customer satisfaction is closely linked with organizational capability (Salanova et al., 2005). In response to increasing environmental concern about logistics and supply chain management (Sheu, 2008), LSPs have adopted green operations to deliver logistics services to satisfy their customer needs. To carry out green operations in supply chain management, LSPs strive to involve customers in such activities as eco-design for cargo handling, cargo transportation, and cleaner delivery. LSPs also work with their customers to pursue environmental objectives. Research on service capability and performance is often grounded in the resource-based view (RBV) of the firm. Service capability is a key component of RBV theory (Barney, 1991; Stalk et al., 1992; Peteraf, 1993). RBV argues that firms compete on the basis of their resources and capabilities (Wernerfelt, 1984). To compete, LSPs provide a number of logistics service bundles. LSPs use factor inputs to achieve desirable outcomes. Lun et al (forthcoming) propose the greening performance relativity (GPR) concept to examine the greening operations. The GPR score is a useful indicator for firms to implement green operations. The study suggests that if an LSP has a higher capability to develop business routines to perform logistics activities in an environmentally friendly manner, then its GPR score will be higher. LSPs with high GPR scores indicate that they are capable of using such business routines as eco-design for cargo handling and transportation to perform their logistics activities.

Next, we test the relationship between greening capability and performance outcomes. Evolving from RBV, the natural-resource-based view (NRBV) introduces the elements of "pollution prevention", "product stewardship", and "sustainable development" (Hart, 1995; Hart and Dowell, 2011). LSPs with a greening propensity for greening adopt "pollution prevention", "product stewardship", and "sustainable development" in performing their logistics activities. Customers' expectation for their service providers to conduct green operations also enhance the greening propensity of LSPs. LSPs with a greening propensity apply the concept of "pollution prevention" by involving customers to implement eco-design for cargo handling to reduce waste in packaging and labelling. LSPs with a greening propensity also apply the concept of "product stewardship" to expand the scope of pollution prevention by involving their customers to implement eco-design for cargo transportation and delivery. LSPs with a propensity for greening adopt green operations to maintain "sustainable development" to pursue environmental objectives. Capability is crucial for LSPs to develop efficient business routines to reap performance gains. From the short-term perspective, increase in revenue from sales growth is a desirable performance outcome. On the other hand, enhancing customer satisfaction can be a long-term objective with customer re-buy and cross-buying activities.

3. Hypothesis Development

According to RBV, LSPs can only temporarily maintain their competitive advantages because their rivals can imitate their resource features over time. To stay competitive, it is essential for LSPs to take a dynamic approach to continually enhance their capability and outperform their rivals. Teece et al. (1997) define dynamic capability as a "firm's ability to integrate, build, and reconfigure internal and external competencies to address rapid changing environment". Dynamic capability is crucial for LSPs to develop efficient business routines to reap performance gains. Capability also represents resources accumulated over time that cannot be acquired instantly (Winter 2003 and Ray et al., 2004). LSPs provide logistics services to their customers and compete

on the basis of their resources and service capability. Based on dynamic capability theory, we argue that these logistics service bundles change over time due to changes in the competitive environment. LSPs carry out their business operations in a rapidly evolving business environment.

In analyzing operations in the logistics industry, it is essential to examine the dynamic service capability of LSPs as they reconfigure their logistics service bundles over time to satisfy fast-changing customer requirements. To cope with the contemporary complex business operations, LSPs integrate their logistics activities to build logistics service bundles. They also reconfigure the logistics service bundles over time to cope with the dynamic operating environment. Hence, LSPs create different logistics service bundles over time. Bundling of logistics activities can be considered as integration of a collection of business routines to build logistics service ability, differentiating an LSP from its competitors (Jarvenpaa and Leidner, 1998; Bharadwaj, 2000). Bundling logistics activities is crucial for LSPs to deliver effective logistics services to their customers. For instance, a collection of related activities such as bar code scanning, customer-specific label printing, and re-packaging and re-labeling are required for LSPs to provide the logistics service bundles of procurement and packaging related services (PPS) to their customers. Whether LSPs can deliver the expected performance is largely dependent on how well they integrate their business activities and build logistics service bundles to service their customers. It is therefore essential to study the logistics service bundles instead of examining logistics activities in an isolated way (Bharadwaj, 2000). Further to this view, an LSP's ability can be demonstrated by its effectiveness in coordinating and redeploying the internal and external resources to deliver its logistics services (Dierickx and Cool, 1989; Sambamurthy et al., 2003; Teece et al., 1997).

Bundling logistics activities according to changing customer needs is necessary for LSPs to enhance their firm performance. The development of logistics service bundles involves the integration of highly related and complementary logistics activities to respond to the evolving business operating environment (Nath and Sudharshan, 1994). LSPs require different configurations of logistics activities to support coordination of their business activities within and across their logistics service chains (Frohlich and Westbrook, 2001; Shah et al., 2002). Compared with the provision of isolated logistics functions, there are barriers to imitating logistics service bundles. Hence, the bundling of logistics services can be considered as a scarce firm-specific resource that differentiates the logistics performance of firms (Barney, 1991). Firms deploying an extensive set of logistics service bundles are in a better position to enhance their logistics performance.

Hypothesis 1: *There are different logistics service bundles provided by LSPs.*

Capabilities are complex and embedded in firms. LSPs possessing higher levels of firm capability are more likely to attain better firm performance as they are capable of integrating their activities into bundles in a way to meet market needs. Logistics service bundles enable LSPs practise novel forms of logistics business that were previously not practical or possible (Straub et al., 2002). The resource bundles involve both internal operations of an organization and external parties such as customers (Straub and Watson, 1979). Resource bundling requires the involvement of external parties to achieve desirable outcomes (Barney, 1991), which is particularly pertinent to logistics activities as specific logistics activities serve different purposes (Singh et al., 2007) such as meeting customer expectations to provide logistics services in an environmentally friendly manner.

To pursue the objective of environmentally friendly operations, LSPs with a greening propensity may involve their customers in eco-design for cargo handling, cargo transportation, and cargo delivery.

Due to the increasing quest for environmental protection, ability in green operations has evolved as a competitive priority for LSPs to enhance their environmental and economic performance outcomes. LSPs with a greening propensity possess better company images to gain support from their business partners. Green operations can be extended to cover implementation of environmentally sustainable business routines. From the perspective of LSPs, adoption of green operations requires cooperation with parties in the supply chain to deliver environmentally friendly logistics services. According to NRBV (Hart, 1995; Hart and Dowell, 2011), the business operations of firms are constrained by and dependent on the natural environment. Therefore, it is essential for LSPs to incorporate protection of natural resources in delivering logistics-related services. In managing logistics operations, LSPs implement "pollution prevention" by involving eco-design for cargo handling to reduce waste in packaging and labelling. In terms of "product stewardship" to expand the scope of pollution prevention incorporating the nodes (e.g., warehouses and terminals to store cargo) and links (e.g., trucks and ships to link various nodes) of the supply chain, LSPs involve eco-design for cargo transportation and delivery. To maintain "sustainable development" with a focus on addressing economic and social concerns, LSPs cooperate with their customers to pursue environmental objectives. These LSPs have a propensity for greening and implementing green operations to enhance their greening capability.

Prior studies have found that the development of logistics service bundles can lead to commitment of partner firms to cooperate in managing green logistics operations and subsequently in cost and service improvements for the involved parties (Kent and Mentzer, 2003; Bakos and Brnjyolfsson, 1993). According to Collis (1994), service capability consists of two key elements: (1) it is embedded in the business routines or activities and (2) it involves the transformation of inputs into outputs inside the black box of the firm. Organizational capability governs "the efficiency in transforming factor inputs into products or service outputs". According to Collis (2004), firm capability governs the efficiency of the transformation of inputs into outputs in the black box of the firm. In the context of logistics operations, the outputs of greening capability consist of various logistics service bundles, e.g., freight forwarding and technology-enabled services (FTS), value-added logistics services (VAS), procurement and packaging related services (PPS), and planning and controlling services (PCS). Hence, the greening capability of LSPs includes the use of inputs to produce such categories of logistics service bundles as FTS, VAS, PPS, and PCS.

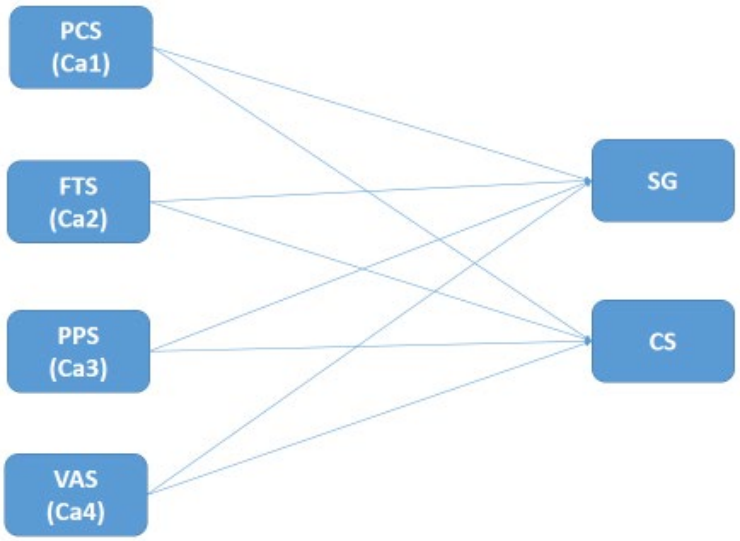
Hypothesis 2: *There are different categories of greening capability in the logistics industry*.

Organizational capability is critical for firms to gain competitive advantage. The development of greening capability meets customer expectation for environmentally friendly logistics operations. Hence, the short-term outcome of enhancing greening capability is sales growth. The long-term performance of firms depends on how efficient they manage their business operations to serve their customers (Ray et al, 2001). Satisfied customers will continually support LSPs through such behaviours as re-buying and cross-buying. Firm performance has received increasing managerial and academic attention. A key motivation for LSPs to adopt green operations is the enhancement of business performance, which consists of both customer satisfaction and sales growth.

The adoption of green operations involves the use of innovative management practices to enhance environmental performance and economic gains (Lai et al, 2013). An example of green operations is the use of eco-design to manage supply chain activities. Potential economic gains from adopting green operations include reducing waste through cooperation with business partners to meet customer expectations. The adoption of green operations also indicates LSPs' environmental commitment to fulfill customer expectations. Customer satisfaction is widely accepted as a useful indicator for evaluating long-term firm performance (Anderson and Sullivan, 1993). In managing green operations, LSPs involve their customers in such activities as eco-design for cargo handling and transportation to satisfy their customers' expectations for environmental protection. Increased competition in the logistics industry drives LSPs to focus attention on meeting customer expectations (Salanova et al., 2005). LSPs are operating in a competitive marketplace where they compete for customers and the resultant customer satisfaction (CS) enables them to outperform their competitors in the long run. Meeting customer expectations through cooperation with them also leads to sales growth (SG).

Hypothesis 3: *The greening capability of LSPs is positively associated with their firm performance in terms of customer satisfaction and sales growth*

Figure 1: Proposed research model



4. Methodology

To conduct this study, we collected data from the logistics industry in 2012. Before carrying out the mass survey, we invited 30 mangers from the logistics industry to conduct a pilot test. In the mass survey, we randomly selected a sample of 500 LSPs as target respondents from a population of 1,266 shipping firms listed in the *Shipping Gazettee*, which is a bi-weekly publication in Hong Kong. The target respondents were general operating managers. We sent a survey package with a cover letter explaining the objectives of this study, a copy of the survey questionnaire, and a pre-paid return envelope to each target respondent. After one month of the first mailing, we sent a reminder to the non-respondents. We sent a second reminder to the non-respondents two weeks

afterwards. Finally, we obtained 107 usable questionnaires. Following Armstrong and Overton (1997), we tested the mean differences in the responses between the two batches mailing to examine the non-response bias issues. The test results indicate that there are no significant differences ($p < 0.05$) in the mean values between the responses from the first and second batch mailings, suggesting that non-response bias is not a major concern.

The data collection of this study focuses on the following areas: (1) business routines of LSPs in Hong Kong based on Lai (2004), (2) the status of LSPs' involvement in cooperation with their customers in eco-design for cargo handling, transportation, and delivery, (3) the status of LSPs involvement in cooperation with their customers in pursuing environmental objectives, (4) firm performance in terms of profitability and environmental performance, and (5) firm performance in terms of customer satisfaction and sales growth. We invited the respondent to use a 5-point Likert-scale ranging from "very low" to "very high" to answer each question in the questionnaire. In addition, we collected information on number of employees and number of years in business.

To empirically test the three hypotheses, we performed the following steps:

1. Conduct a factor analysis to classify the logistics service bundles of LSPs based on their business routines
2. Use the GPR score as the input of greening capability
3. Use the logistics services bundle as the output of greening capability
4. Use data envelopment analysis (DEA) input-oriented model to calculate the DEA score and determine the greening capability
5. Conduct correlation analysis to examine the relationships between greening capability, customer satisfaction, and sales growth

5. Hypothesis Testing and Results

5.1 Testing of Hypothesis 1

To examine logistics service bundles, we used the list of logistics routines proposed by Lai 2004. Similar to the previous study by Lai (2004), we conducted factor analysis to classify these logistics business routines. We used the principal component analysis, followed by a Varimax with Kaiser Normalization, to extract factors. To purify the original list of 23 items, we eliminated those items found with a loading of 0.50 or greater on more than one factor as they are not pure factorials. Factor loading matrix of Table 3 shows the purified list of the remaining 18 items, representing four logistics service bundles. As the factor loadings on the factor loading matrix are between 0.549 and 0.792, all of these items are significant loadings. To examine the common method bias, we performed Harman's single factor test for common method variance (Chang et al., 2010). The results show that the variance of one factor is below 50%. Hence, common method variance is not an issue.

The above analysis suggests that LSPs provide four logistics service bundles: (1) freight forwarding and technology-enabled services (FTS), which perform the tasks of tracking and tracing shipments, receiving/sending shipment notifications and purchasing orders, and providing web-based linkages; (2) value-added logistics services (VAS), which include assembling and re-assembling, call centre operations, customs clearance, and fleet management; (3) procurement and

packaging related services (PPS), which consist of bar code scanning, customer-specific label printing, and repackaging and re-labeling; and (4) planning and controlling services (PCS), which carry out the activities of billing, information system management, inventory management, logistics planning, and performance reporting. The results support Hypothesis 1. Instead of providing FFD, VAL, and TEL as were found by Lai (2004), LSPs provide bundled logistic services of FTS, VAS, PPS, and PCS, indicating changes in logistics service bundles offered by LSPs over time.

Table 1: Rotated factor matrix

Item	PCS	FTS	PPS	VAS
Assembling/re-assembling				0.726
Bar code scanning			0.723	
Billing function	0.735			
Call center operations				.0782
Customs clearance				0.549
Customer-specific label printing			0.742	
Fleet management				0.617
Freight forwarding		0.645		
Information systems management	0.684			
Inventory management	0.728			
Logistics planning	0.681			
Performance reporting	0.633			
Purchasing/procurement			0.642	
Receiving/sending shipment notices electronically		0.754		
Receiving purchase or sales orders from customers electronically		0.792		
Repackaging/re-labeling			0.702	
Tracking and tracing shipping information		0.699		
Web-based linkages		0.651		

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normation.

5.2 Testing of Hypothesis 2

The next step was to determine the inputs of greening capability. To examine the status of how well LSP involve their customers for cooperation to adopt green operations, the questionnaire asked respondents to answer the following four questions to indicate the extent of customer involvement on a Likert five-point scale (1 = very low, 5 = very high): (a) customers are involved in eco-design for cargo handling, (b) customers are involved in eco-design for cargo transportation, (c) customers are involved in cleaner delivery, and (d) customers are involved in pursuing environmental objectives. We also collected LSPs' profitability and environmental performance from the respondents. Following Lun et al. (forthcoming), we took the following stepwise approach to determine the GPR as the input of greening capability:

1. Calculate the Average of Customer Involvement (ACI, i.e., average value of the four items of items of customer involvement in greening operations) in greening operations of each respondent
2. Calculate the ratio of ACI to profitability (P) of each respondent
3. Calculate the ratio of ACI to environmental performance (E) of each respondent

Organization capability focuses on the transformation of inputs into outputs. In logistics operations, LSPs deploy their resources as inputs to produce desirable outputs to meet customer requirements and market needs. In this study, we use an input-output approach to examine greening capability. The inputs are GPR scores in terms of profitability and environmental performance (i.e., ACI/P and ACI/E). Both ACI/P and ACI/E are significant resources for LSPs in cooperating with their customers to produce outputs environmentally. On the other hand, the outputs are logistics service bundles produced by LSPs to serve their customers. Table 2 summarizes the measurements of the four categories of greening capability (i.e., Ca1, Ca2, Ca3, and Ca4).

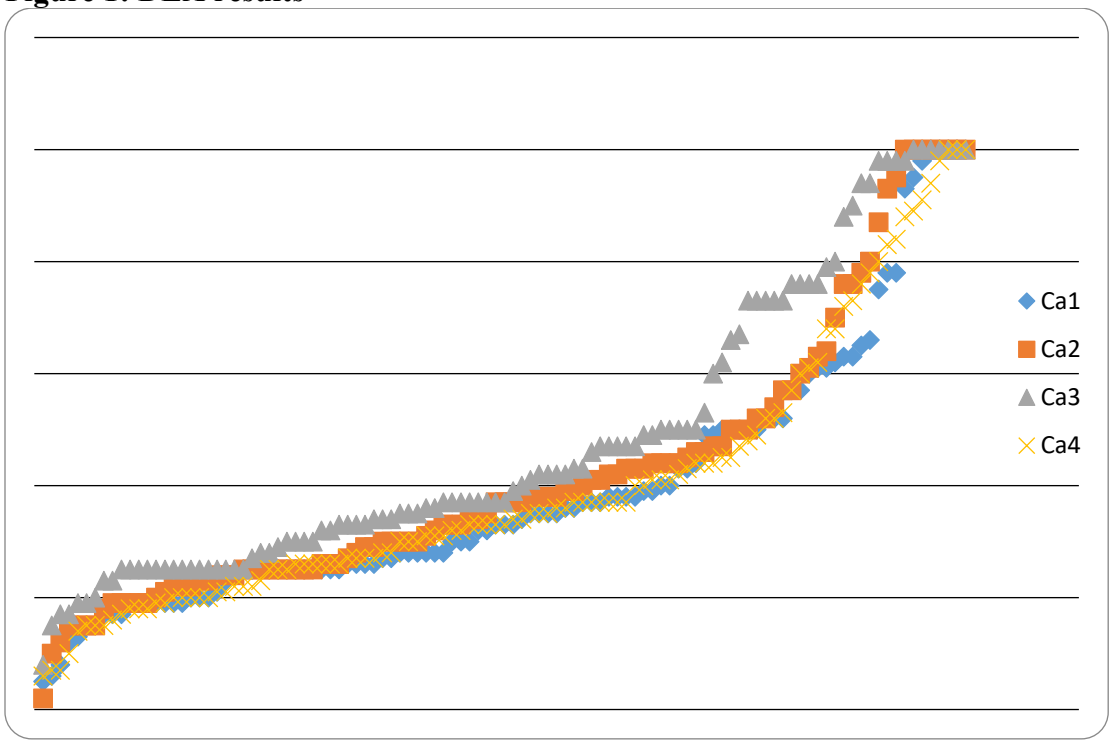
Table 2: Inputs and outputs of greening capability

Variable	Measurement	
Ca1 (PCS)	Input: 1. ACI/P 2. ACI/E	Output: 1. Billing function 2. Information systems management 3. Inventory management 4. Logistics planning 5. Performance reporting
Ca2 (FTS)	Input: 1. ACI/P 2. ACI/E	Output: 1. Freight forwarding 2. Receiving/sending shipment notices electronically 3. Receiving purchase or sales orders from customers electronically 4. Tracking and tracing shipping information 5. Web-based linkages
Ca3 (PPS)	Input: 1. ACI/P 2. ACI/E	Output: 1. Bar code scanning 2. Customer-specific label printing 3. Purchasing/procurement 4. Repackaging/re-labeling
Ca4 (VAS)	Input: 1. ACI/P 2. ACI/E	Output: 1. Assembling/re-assembling 2. Call center operations 3. Customs clearance 4. Fleet management

To measure the efficiency of the 107 respondent LSPs in converting their inputs to produce outputs, we applied the data envelopment analysis (DEA) input-oriented model. According to Cooper et al. (2007), an DEA score is defined as "the ratio of outputs to inputs of a production of an operating system". DEA assigns an efficiency score between 0 and 1. An DEA score of 1.00 represents the most efficient LSP. Relatively inefficient LSPs receive lower scores depending on how they transform their inputs into outputs. According to the results (as shown in Appendix 1), the mean values of Ca1, Ca2, Ca3, and Ca4 are 0.392, 0.421, 0.480, and 0.397, respectively. The DEA scores for Ca1, Ca2, Ca3, and Ca4 of all respondents are reported in Figure 1. The results suggest that the efficiency level of Ca3 is the highest among the four categories. In other words, LSPs are more capable in adopting green operations to produce the logistics service bundles of procurement and packaging related services (PPS) to their customers. PPS consists of such activities as bar code scanning, customer-specific label printing, and re-packaging and re-labeling. These are logistics

activities that are dependent on the natural environment to provide materials for packaging and related activities.

Figure 1: DEA results



The inputs of ACI/P and ACI/E are important for LSPs to cooperate with their customers to produce outputs (i.e., bundles of logistics services). Through the DEA approach, we identify four categories of greening capability (i.e., Ca1, Ca2, Ca3, and Ca4). The greening propensity illustrates the preference or tendency of LSPs to implement green operations in their business activities. Based on the results of the DEA analysis, Hypothesis 2 is supported as four categories of greening capability exist in the logistics industry.

5.3 Testing of Hypothesis 3

To examine the association between firm performance of LSPs and their efficiency level of managing their logistics services, we collected data on LSPs' perceptions of their customer satisfaction and sales growth. We performed correlation analysis to examine the relationship between greening capability and firm performance in terms of customer satisfaction and sales growth. Table 3 reports the results, which support Hypothesis 3 that all the four categories of greening capability are positively associated with firm performance in terms of customer satisfaction and sales growth. The results also show that customer satisfaction and sales growth are also positively associated. Among the four categories of greening capability, the correlation coefficients between Ca1 and customer satisfaction and sales growth (i.e., 0.335 and 0.486 respectively) are the highest. The results indicate that customers requesting the logistics service

bundle of planning and controlling services (PCS) to carry out the activities of billing, information system management, inventory management, logistics planning, and performance reporting expect their LSPs to implement green operations.

Table 3: Correlation matrix

	Ca1	Ca2	Ca3	Ca4	SG	CS
Ca1	1.000					
Ca2	0.880**	1.000				
Ca3	0.849**	0.885**	1.000			
Ca4	0.904**	0.932**	0.870**	1.000		
SG	0.486**	0.382**	0.328**	0.450**	1.000	
CS	0.335**	0.254**	0.207*	0.263**	0.597**	1.000

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

To further examine the influences of Ca1, Ca2, Ca3 and Ca4 on the performance indicators of sales growth and customer satisfaction, we conducted regression analyses. The results are summarized in Table 4. The results of the models 1.1, 2.1, 3.1, and 4.1 suggest that Cal, Ca2, Ca3, and Ca4 positively affect sales growth. Similarly, the results of the models 1.2, 2.2, 3.2, and 4.2 suggest that Cal, Ca2, Ca3, and Ca4 positively affect customer satisfaction. The findings illustrate that greening capability positively affects firm performance in terms of sales growth and customer satisfaction. We included the control variables of firm size (in terms of number of employees) and firm age (in terms of year of firm operations) in the regression analysis. The results confirm that firm size is a control variable in the relationship between greening capability and firm performance as the values of the adjusted R^2 of the models of 1.1a, 1.2a, 2.1a, 2.2a, 3.1a, 3.2a, 4.1a, and 4.2a are higher than those the models of 1.1, 1.2, 2.1, 2.2, 3.1, 3.2, 4.1, and 4.2. However, firm age is not a control variable influencing the relationship between greening capability and firm performance as not all the values of the adjusted R^2 of the models of 1.1b, 1.2b, 2.1b, 2.2b, 3.1b, 3.2b, 4.1b, and 4.2b are higher than those of the models of 1.1, 1.2, 2.1, 2.2, 3.1, 3.2, 4.1, and 4.2.

Table 4: Results of regression analysis

Model	Dependent variable	Independent variable (predictor)	Control variable	*R*	Adjusted R^2	*p* value
1.1	Ca1	SG	-	0.486	0.228	0.000
1.1a	Ca1	SG	Firm size	0.563	0.303	0.000
1.1b	Ca1	SG	Firm age	0.488	0.223	0.000
1.2	Ca1	CS	-	0.335	0.103	0.001
1.2a	Ca1	CS	Firm size	0.525	0.261	0.000
1.2b	Ca1	CS	Firm age	0.357	0.110	0.001
2.1	Ca2	SG	-	0.382	0.137	0.000
2.1a	Ca2	SG	Firm size	0.492	0.227	0.000
2.1b	Ca2	SG	Firm age	0.383	0.130	0.000
2.2	Ca2	CS	-	0.254	0.055	0.010

2.2a	Ca2	CS	Firm size	0.474	0.210	0.000
2.2b	Ca2	CS	Firm age	0.271	0.055	0.022
3.1	Ca3	SG	-	0.328	0.099	0.001
3.1a	Ca3	SG	Firm size	0.424	0.172	0.000
3.1b	Ca3	SG	Firm age	0.330	0.091	0.003
3.2	Ca3	CS	-	0.207	0.033	0.036
3.2a	Ca3	CS	Firm size	0.418	0.158	0.000
3.2b	Ca3	CS	Firm age	0.226	0.032	0.072
4.1	Ca4	SG	-	0.450	0.195	0.000
4.1a	Ca4	SG	Firm size	0.530	0.267	0.000
4.1b	Ca4	SG	Firm age	0.453	0.190	0.000
4.2	Ca4	CS	-	0.263	0.060	0.007
4.2a	Ca4	CS	Firm size	0.480	0.215	0.000
4.2b	Ca4	CS	Firm age	0.294	0.068	0.011

6. Conclusions

6.1 Theoretical implications

In this study we identify that LSPs provide a wide variety of logistics service activities and find that LSPs integrate these logistics service activities to create four logistics service bundles (i.e., PCS, FTS, PPS, and VAS). They offer these logistics service bundles to meet market needs. To address the rapidly changing business environment, LSPs re-configure their logistics service bundles over time. When conducting longitudinal study by using the same business routines and the same analysis tool (i.e., factor analysis), the results suggest the existence of dynamic capability as the logistics service bundles change from FFD, VAL, and TEL found in 2002 to PCS, FTS, PPS, and VAS found in 2012. In line with the notion of dynamic capability that suggests the importance of organizational practices evolution to cope with the ever-changing business environment, logistics service bundles are adjusted over time to enable LSPs to better serve contemporary customers. For example, the FFD and TEL bundles found in 2002 have evolved into the FTS bundle, which focuses on freight forwarding services with technological support. The VAL bundle found in 2002 is similar to the VAS bundle, indicating that value-added services are still important in the current logistics industry. We identify two new bundled logistics services, namely PPS and PCS, in this study. The emergence of PPS and PCS indicates the trends of outsourcing procurement-related activities and planning/controlling functions. Such resources as human capital and business operating systems are essential for LSPs to deliver services to their customers. The existence of different logistics service bundles indicates that LSPs possess various resources and LSPs provide different logistics service bundles to meet the needs of their customers. The results of this study show that logistics service bundles change over time in response to the changing requirements of the dynamic business environment.

From the perspective of RBV, LSPs compete on the basis of their service capabilities. It is essential for LSPs to provide logistics service bundles to meet their customer expectations. Extending RBV theory, NRBV includes the elements of “pollution prevention”, “product stewardship”, and “sustainable development”. LSPs with a greening propensity adopt “pollution prevention”, “product stewardship”, and “sustainable development” in performing their logistics activities. The

components of greening propensity include the implementation of "pollution prevention" by involving customers to implement eco-design for cargo handling to reduce waste in packaging and labelling, the adoption of "product stewardship" to expand the scope of pollution prevention by involving their customers to implement eco-design for cargo transportation and delivery, and the maintenance of "sustainable development" to pursue environmental objectives. Service capability governs "the efficiency in transforming factor inputs into product or service outputs". To examine the greening capability of LSPs, we collect data using four items to reflect customer involvement in green operations as a component of the input. We take a stepwise approach to determine the input value of greening capability. We use the four bundles of logistics services provided by LSPs as the output variables to examine the greening capability of LSPs. Using DEA as an analytical tool, we calculate the efficiency scores of LSPs transforming their inputs to outputs. The results show that service capability is obtained through the transformation of inputs into service outputs. The results also show that the development of greening propensity involves customers in performing logistics activities to achieve environmental performance and economic gains.

We adopt the approach of "topology as a theory building" to develop a research model and empirically test the key construct of greening propensity. The research model is empirically validated by meeting the three criteria of a theory, i.e., constructs in topology, relationships among constructs, and relations between constructs and predictors. The results support the presence of greening propensity, i.e., involvement of customers to perform logistics activities environmentally is beneficial to firm performance. The development of "greening propensity" in this study is important for future studies on greening operations. It also fills the literature gap by answering the following questions: What are the categories of greening capability in the logistics industry? What are the impacts of involving customers in greening operations? What are the relationships between greening capability and performance outcome?

6.2 Practical implications

This study uses empirical data to classify the business routines of LSPs into different logistics service bundles. Based on our results, the major logistics service bundles provided by LSPs consist of freight forwarding and technology-enabled services (FTS), value-added logistics services (VAS), procurement and packaging related services (PPS), and planning and controlling services (PCS). Compared with the findings of a previous study in 2002, the current logistics services provided by LSPs are bundled in four categories, namely FTS, VAS, PPS, and PCS. FTS involves the use of such tools as tracking and tracing shipments, receiving/sending shipment notifications and purchasing orders, and web-based linkages to provide effective information flows to carry out freight forwarding activities to support the physical flow of cargo. VAS refers to the provision of such value-added services as assembling, re-assembling, call centre operations, customs clearance, and fleet management to support customers' global supply chain management. PPS aims to support customers' procurement activities with a focus on the provision of packaging services. PCS focuses on supporting customers on their planning and controlling activities to carry out such activities as billing, information system management, inventory management, logistics planning, and performance reporting. The findings provide significant insights for LSPs to manage their business activities. To successfully provide bundled logistics services to satisfy their customers, it is essential for LSPs to assess their own strengths and weaknesses, and explore the possibility of providing a wider coverage of services to meet customer expectations. The findings of this study

provide a useful reference for LSPs to conduct an assessment of their existing logistics services and shed light on benchmarking and strategic development.

While logistics services are essential to facilitate trading activities and contribute significantly to global economic development, such activities as FTS, VAS, PPS, and PCS have been criticized for bringing environmental damage. Customers are expecting their LSPs to conduct green operations. Greening capability is essential for LSPs when making strategic decisions. In this study we use an input-output approach to determine the greening capability of LSPs. The DEA results indicate that the efficiency level of Ca3 is the highest. Ca3 concerns the provision of procurement- and packaging-related services (PPS) to meet customer needs. These logistics activities involve the use of packaging materials, which consumes natural resources and creates waste. The results of this study are aligned with the key elements (i.e., pollution prevention, product stewardship, and sustainable development) in NRBV, i.e., LSPs implement "pollution prevention" by involving eco-design for cargo handling to reduce waste in packaging and labelling, adopt "product stewardship" to expand the scope of pollution prevention incorporating the nodes (e.g., warehouses and terminals to store cargo) and links (e.g., trucks and ships to link various nodes) for cargo transportation and delivery, and maintain "sustainable development" with a focus on addressing economic and social concerns. The findings provide a good reference for LSPs with a propensity for greening to evaluate their greening capacity and make strategic greening decisions.

When investigating greening capability, its performance implication is important for logistics managers to examine. The performance of LSPs in terms of customer satisfaction and sales growth is associated with their achieving eco-efficiency in their business operations. Our results suggest that the four categories of greening capability (i.e., Ca1, Ca2, Ca3, and Ca4) are positively associated with customer satisfaction and sales growth. Our results also show a positive association between customer satisfaction and sales growth. In addition, we find that the correlation coefficients between Ca1 and firm performance in terms of customer satisfaction and sales growth (i.e., 0.335 and 0.486 respectively) are the highest. The results indicate that customers requesting bundled PCS to carry out the activities of billing, information system management, inventory management, logistics planning, and performance reporting have a higher expectation of their LSPs to implement green operations. The level of their customers' satisfaction is higher when LSPs are capable of carrying out greening operations. These customers may also support their LSPs with a greening propensity by such behaviour as re-buying. LSPs with a greening propensity also possess better company images. All these causes may contribute to the LSPs' growth in sales volume.

In addition, we examine the role of firm age and firm size in controlling the relationship between greening capability and firm performance. The results suggest that firm age does not have a significant impact on the relationship between greening capability and firm performance, indicating that all the firms, regardless of their age, are using their greening capability to enhance their firm performance in a similar manner. Furthermore, the results provide useful reference for LSPs to manage their resources and firm size to develop green capability. Bigger firms possessing more resources are in a better position to leverage their greening capability. On the other hand, the resources possessed by small firms may not be adequate for them to develop greening capability to enhance their performance in terms of customer satisfaction and sales growth. A key feature of small firms is the limitation of resources. The results indicate that it may be difficult for small

firms to develop greening capability to meet the increasing market requirements. These findings also imply that policy makers may need to take appropriate actions to facilitate small firms to enhance their greening capability for them to compete with bigger firms in the industry.

6.3 Research limitations and future research

There are three limitations of this study. First, the data were collected in 2002 and 2012 in Hong Kong. We conducted a longitudinal study to examine the evolution of service capability of LSPs. However, the longitudinal study did not cover greening capability. It is desirable to conduct future research to track the development of greening capability in LSPs. This study can also be extended to areas outside Hong Kong to examine regional differences. Second, the performance outcomes of this study focus on customer satisfaction and sales growth. Further studies may include objective data, e.g., operating costs and earnings before interest and tax (EBIT), to examine their associations with greening capability. Third, this study focuses on the greening routines in terms of customer involvement in such activities as eco-design and environmental objectives fulfillment. It is desirable for future research to examine greening routines from a holistic approach by involving transport network capability and port operations (Kai and James 2014; Lam and Gu 2013; Ng et al., 2013).

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Appendix 1: DEA Results

	Ca1	Ca2	Ca3	Ca4
1	0.05	0.02	0.08	0.06
2	0.06	0.1	0.15	0.07
3	0.08	0.12	0.17	0.07
4	0.12	0.15	0.17	0.1
5	0.13	0.15	0.19	0.14
6	0.15	0.15	0.19	0.15
7	0.15	0.15	0.2	0.15
8	0.17	0.18	0.23	0.15
9	0.17	0.19	0.23	0.16
10	0.17	0.19	0.25	0.17
11	0.19	0.19	0.25	0.18
12	0.19	0.19	0.25	0.18
13	0.19	0.19	0.25	0.18
14	0.19	0.2	0.25	0.19
15	0.19	0.21	0.25	0.19
16	0.19	0.22	0.25	0.2
17	0.19	0.22	0.25	0.2
18	0.2	0.22	0.25	0.2
19	0.2	0.23	0.25	0.2
20	0.2	0.23	0.25	0.2
21	0.21	0.24	0.25	0.21
22	0.23	0.24	0.25	0.21
23	0.24	0.24	0.25	0.22
24	0.25	0.25	0.25	0.22
25	0.25	0.25	0.27	0.22
26	0.25	0.25	0.28	0.23
27	0.25	0.25	0.28	0.25
28	0.25	0.25	0.29	0.25
29	0.25	0.25	0.3	0.25
30	0.25	0.25	0.3	0.26
31	0.25	0.25	0.3	0.26
32	0.25	0.25	0.3	0.26
33	0.25	0.26	0.32	0.26
34	0.25	0.26	0.32	0.26
35	0.25	0.26	0.33	0.26
36	0.26	0.27	0.33	0.27
37	0.26	0.28	0.33	0.27
38	0.26	0.29	0.33	0.27

39	0.26	0.29	0.34	0.27
40	0.27	0.3	0.34	0.28
41	0.27	0.3	0.34	0.28
42	0.28	0.3	0.35	0.3
43	0.28	0.3	0.35	0.3
44	0.28	0.3	0.35	0.3
45	0.28	0.31	0.36	0.31
46	0.28	0.32	0.36	0.31
47	0.28	0.33	0.37	0.31
48	0.3	0.33	0.37	0.32
49	0.3	0.33	0.37	0.32
50	0.3	0.34	0.37	0.33
51	0.32	0.34	0.37	0.33
52	0.32	0.35	0.37	0.33
53	0.33	0.37	0.37	0.33
54	0.33	0.37	0.37	0.33
55	0.33	0.37	0.39	0.34
56	0.34	0.37	0.4	0.34
57	0.35	0.38	0.41	0.35
59	0.35	0.38	0.42	0.35
59	0.35	0.38	0.42	0.35
60	0.35	0.38	0.42	0.36
61	0.36	0.39	0.42	0.36
62	0.36	0.39	0.43	0.37
63	0.37	0.4	0.43	0.37
64	0.37	0.41	0.46	0.37
65	0.37	0.41	0.47	0.37
66	0.38	0.42	0.47	0.37
67	0.38	0.42	0.47	0.37
68	0.38	0.43	0.47	0.37
69	0.38	0.43	0.47	0.4
70	0.39	0.43	0.49	0.4
71	0.39	0.44	0.49	0.41
72	0.4	0.44	0.5	0.41
73	0.4	0.44	0.5	0.41
74	0.43	0.44	0.5	0.42
75	0.43	0.45	0.5	0.43
76	0.44	0.46	0.5	0.44
77	0.49	0.46	0.53	0.44
78	0.49	0.47	0.6	0.44
79	0.5	0.47	0.62	0.45

80	0.5	0.5	0.66	0.45
81	0.5	0.5	0.67	0.47
82	0.5	0.5	0.73	0.48
83	0.5	0.52	0.73	0.49
84	0.52	0.52	0.73	0.52
85	0.52	0.54	0.73	0.52
86	0.52	0.57	0.73	0.53
87	0.57	0.57	0.76	0.57
88	0.57	0.6	0.76	0.6
89	0.6	0.61	0.76	0.61
90	0.61	0.63	0.76	0.62
91	0.61	0.64	0.79	0.68
92	0.62	0.7	0.8	0.68
93	0.63	0.76	0.88	0.72
94	0.63	0.76	0.9	0.73
95	0.65	0.78	0.94	0.76
96	0.66	0.8	0.94	0.78
97	0.75	0.87	0.98	0.8
98	0.78	0.93	0.98	0.83
99	0.78	0.95	0.98	0.84
100	0.93	1	0.98	0.88
101	0.95	1	1	0.89
102	0.98	1	1	0.91
103	1	1	1	0.94
104	1	1	1	0.98
105	1	1	1	1
106	1	1	1	1
107	1	1	1	1