Measures for Evaluating Supply Chain Performance in Transport Logistics

Kee-hung Lai[1*], E.W.T. Ngai** and T.C.E. Cheng**
**Department of Shipping and Transport Logistics, **Department of Management,*
The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong

Abstract

This study aims to investigate the construct of, and develop a measurement instrument for, supply chain performance (SCP) in transport logistics. Based on the Supply Chain Operations Reference (SCOR) model and various established measures, a measurement model and a measurement instrument for SCP in transport logistics are developed. The 26-item measurement instrument constructed to measure SCP in transport logistics, 9 for service effectiveness for shippers, 8 for operations efficiency for transport logistics service providers, and 9 for service effectiveness for consignees, is empirically tested to be reliable and valid. The findings suggest that the construct of SCP in transport logistics is multifaceted with the effectiveness and efficiency aspects of performance embedded in the measurement.

Keywords: transport logistics, supply chain, construct, performance measurement, confirmatory factor analysis

[1] Corresponding author. Department of Shipping and Transport Logistics, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong. Tel: (852) 2766 7920; Fax: (852) 2330 2704; Email: stlmlai@polyu.edu.hk

1. Introduction

The emergence of the global economy and intensified competition have led many firms to recognize the importance of managing their supply chains for fast product introduction and service innovations to the markets. For improved competitiveness, many firms have embraced supply chain management (SCM) to increase organizational effectiveness and achieve such organizational goals as improved customer value, better utilization of resources, and increased profitability (Lee, 2000).

In his seminal work on competitiveness of firms, Porter (1985) identifies customer values and costs to customers as critical elements to gain competitive advantages for a firm. The management of a supply chain encompasses these two elements, which together emphasize the importance of getting goods/services to customers at the right time, in the right place, under the right conditions, in the right quantities, and at the lowest possible costs. Porter (1985) emphasizes that, differentiation, one type of competitive advantage for a firm, is closely linked to the customer values of the product/service that can be delivered. Low cost, another type of competitive advantage, is reflected in the costs of the product/service to the customers. Christopher (1998) adds that a firm would achieve a competitive advantage by striving for excellence in both service and cost leadership. To this end, making proper performance measurement of a supply chain is necessary as it cultivates understanding between member firms in the supply chain for performance improvement (Dreyer, 2000; Fawcett and Cooper, 1998).

Traditionally, the focus of performance measurement has been on process operations within the organizational boundaries of a firm (Short and Venkatraman, 1992). In the context of SCM, performance measurement involves not only the internal processes, but also requires an understanding of the performance expectation of other member firms in the supply chain, backward from the suppliers and forward to the customers (Normann and Ramírez, 1993). Coordination between the various parties in the supply chain is key to its effective implementation (Frohlich and Westbrook, 2001).

As SCM focuses on process management beyond organizational boundaries, there is a need to measure performance for the effective management of a supply chain. Harrington (1991, p.164) states that 'If you cannot measure it, you cannot control it. If you cannot control it, you cannot manage it. If you cannot manage it, you cannot improve it'. In fact, the lack of relevant performance measures has been recognized as one of the major problems in process management (Davenport et al., 1996) and the management of a supply chain (Dreyer, 2000). Because of the different views on what should constitute supply chain performance (SCP), many firms have found it difficult to practise SCM (Beamon, 1999). A major contributing factor to this problem is that, with multiple parties having different interests, it is difficult for firms to effectively evaluate the performance of their activities on a supply chain-wide basis (Cooper et al., 1997). Consequently, firms in different parts of the supply chain tend to work to improve performance in those areas within their interest. To overcome this problem, they need a comprehensive overview of their supply chain activities and full appreciation of the impact of their performance on other member firms in the supply chain.

The objective of this study is to investigate the construct of, and develop a measurement instrument for, SCP with a focus on the intermediary component, i.e., transport logistics, in a supply chain process. A measurement instrument is a collection of measuring items applied collectively to reveal a theoretical construct, e.g. SCP in transport logistics, which cannot be assessed directly (DeVellis, 1991). Given the ambiguity in the literature and the lack of empirically validated measurement instruments for SCP, this research objective is well justified with the aim to extend SCM research to the transport logistics context. We identify the components of SCP in transport logistics, develop the measurement items and instrument, evaluate their validity using empirical data, discuss the implications of the SCP construct, and provide suggestions for using the validated measures in substantive research and practice in transport logistics.

2. Conceptual Background

SCM is concerned with managing the upstream and downstream relationships with suppliers and customers to deliver superior customer value at the least cost to the chain as a whole (Christopher, 1998). Implementation of SCM requires that the internal perspective of performance measures be expanded to include both "interfunctional" and "partnership" perspectives and avoid inward-looking and self-focused attitudes in the management approach (Holmberg, 2000). This is to be achieved by closely integrating the internal functions within a firm and effectively linking them with the external operations of member firms in the chain. To this end, an appropriate performance measurement is conducive to successful SCM implementation (Lee and Billington, 1992).

Mentzer and Konrad (1991) define performance measurement as effectiveness and efficiency in accomplishing a given task in relation to how well a goal is met. In the logistics and supply chain context, effectiveness is concerned with the extent to which goals are accomplished and they may include lead-time, stockout probability, and fill rate. Efficiency measures how well the resources are utilized, for which the measures may include inventory costs and operating costs. While many firms recognize both aspects of performance, they fail to understand them from a perspective of a balanced framework for performance measurement (Brewer and Speh, 2000). This could be disruptive for performance management in a supply chain. For instance, one firm may concentrate on operational efficiency, while the others are more concerned with service effectiveness in the supply chain. The differences in the views of SCP would lead to inconsistency in the performance measures used across member firms in a supply chain and consequently suboptimize supply chain-wide performance (Bechtel and Jayaram, 1997; Caplice and Sheffi, 1995; Gunasekaran et al., 2001).

Traditional performance measures such as profitability are less relevant for measuring SCP because they tend to have an "individual focus" and fail to consider chain-wide areas for performance improvement. Bechtel and Jayaram (1997) advocate the use of integrated measures, in addition to non-integrated measures, that motivate firms to consider chain-wide performance, rather than their own individual performance measures. An example of an integrated measure is cash-to-cash cycle that spans functional and organizational boundaries to show all member firms how the chain is performing, and fosters incentives for firms to work with others in the chain. In contrast, non-integrated measures only provide insights into potential problems within individual firms in a supply chain.

Other than integrated performance measures, there are conceptual frameworks on SCP. New (1996) presents a taxonomy for the classification of supply chain improvement. van Hoek (1998) proposes a framework at the firm's level of integration in the supply chain and the strategy adopted. Beamon (1999) develops a performance evaluation framework for manufacturing supply chains, where resources, output, and flexibility are considered necessary components for SCP. Shah and Singh (2001) provide a framework for benchmarking internal SCP. Gunasekaran et al. (2001) develop a conceptual model for SCP at three management levels. Even though there exist a variety of frameworks for SCP measurement, many companies still manage their supply chain in a way different from what their member firms desire. The main reason is that they lack agreement of goals and performance measures in their supply chain activities (Tan et al., 1999).

Among the extant SCP conceptualizations, the Supply Chain Operations Reference Model (SCOR) developed by the Supply Chain Council (c.f. Stewart, 1995) provides a useful framework that considers the performance requirements of member firms in a supply chain. The SCOR model views activities in the supply chain as a series of interlocking interorganizational processes with each individual organization comprising four components: plan, source, make, and deliver. Each of these components is considered a critical intraorganizational process in the supply chain with four measurement criteria: 1) supply chain reliability, 2) responsiveness/ flexibility, 3) costs, and 4) assets. The first two criteria deal with effectiveness-related (customer-facing) performance measures, while the other two are efficiency-related (internal-facing) performance measures of a firm. Customer-facing measures are concerned with how well a supply chain delivers products/ services to customers, e.g. delivery performance. Internal-facing measures are concerned with the efficiency with which a supply chain operates, e.g. cash-to-cash cycle time (c.f. Geary, 2001).

In line with Mentzer and Konrad (1991), the SCOR model provides an indication as to how effective a firm uses resources in creating customer value. It considers the performance expectations of member firms on both input and output sides of supply chain activities. The measurement criteria and indictors of performance measurement in SCOR across supply chain members (c.f. Stephens, 2000), shown in Table 1, provide a useful framework for developing a construct and the corresponding instrument for SCP measurement in the transport logistics context.

<< Insert Table 1 about here >>

3. SCP in Transport Logistics

Transport logistics in a supply chain is usually an intermediary that facilitates the physical flows of goods from a point of origin, i.e., shipper, to a point of destination, i.e., consignee. Firms in transport logistics perform the physical distribution function to move goods from one place to another (Coyle et al., 1996) and the business process spans organizational boundaries, encompassing shippers and consignees.

Under this conception, SCP in transport logistics involves shippers on the input side and consignees on the output side. The goal of a transport logistics service provider is to satisfy the customers (both upstream and downstream) in the chain with greater effectiveness and efficiency than the competitors. The measurement of SCP in transport logistics needs to incorporate these performance aspects to be successful. For example, cost efficiency in providing the services might be an important performance measure for a transport logistics service provider. However, this might not be desired by shippers and consignees. They would instead demand high quality and low-price delivery of shipments conforming to their requirements. Another example is that delaying shipments until carriage in full truck loads is possible may reduce the costs for organizing the delivery and improve efficiency measures for the transport logistics service provider. However, this would lead to a reduction in the service effectiveness provided to shippers and consignees. Neither performance measures alone, effectiveness and efficiency, can fully reflect SCP in transport logistics.

In this regard, SCP in transport logistics should encompass not only operations efficiency parameters, but also measures of service effectiveness (Kleinsorge et al., 1991) to meet the goals of all parties, i.e., shipper, service provider and consignee. It must not be centered only on individual functional areas, but rather on the different parties involved in the transport logistics processes and the overall SCP (Cavinato, 1992; Lee, 2000).

To this end, the SCOR model in Table 1 provides a useful framework. It represents a systematic approach to measuring performance with inputs from, and outputs to, member firms in the supply chain and considers performance assessment on a supply chain-wide basis, not just on that of an individual component, e.g. providers of transport logistics services, in the chain. This is an important point because it not only identifies both the effectiveness and efficiency aspects of performance, but also recognizes that there can be internal as well as customer-related reasons for performance measurement. Based on this, three dimensions of SCP in transport logistics are identified. These are:

- Service effectiveness for shippers (SES);
- Operations efficiency for transport logistics service providers (OE);
- Service effectiveness for consignees (SEC).

SES and SEC measure how well the activities are performed to meet the requirements of shippers and consignees, respectively. OE refers to the efficiency of a transport logistics service provider in the use of resources to perform its service activities. These three dimensions of SCP in transport logistics are congruent with the critical components for supply chain success postulated in the SCOR model. In this study, the three-factor structure of the SCP construct is tested in a first-order model, where SES, OE and SEC correlate among themselves in measuring the same construct, i.e., SCP in transport logistics, and in a second-order model, where the SCP construct is treated as a higher order model governing the covariance of the three dimensions of SES, OE and SEC.

4. Methodology

Following Churchill's (1979) paradigm for construct measurement, we first define the domain of a SCP construct in transport logistics, then operationalize the construct by developing a measurement instrument. The instrument is pre-tested, modified, and used to capture data in a cross-sectional survey of transport logistics service providers. The following paragraphs describe these processes in detail.

4.1 Domain Specification and Instrument Development

In the previous discussion, SCP in transport logistics is identified as a three-factor model. In line with SCOR, SES and SEC are customer-facing measures and concerned with the reliability (REL) and responsiveness (RES) of a supply chain process performed for shippers and consignees, respectively. These two service-oriented components are operationalized by modifying the reliability and responsiveness dimensions of the SERVQUAL instrument developed by Parasuraman, Zeithaml and Berry (1988).[1] The modified measures gauge the service effectiveness performed respectively for shippers (SES-REL and SES-RES) and consignees (SEC-REL and SEC-RES).

OE is concerned with the efficient use of resources in performing transport logistics services. In SCOR, there are two aspects of OE: cost-related and asset-related. In line with Mentzer and Konrad (1991), the cost-related aspect of OE (OE-COST) is operationalized by five broad categories of logistics performance: transportation, warehousing, costs associated with the facilities and manpower used in providing the services, order processing, and logistics administration. The asset-related aspect (OE-ASST) is developed on the basis of the three measures suggested in SCOR: cash-to-cash cycle time, utilization of facilities and manpower in providing the services, and asset turns.

A total of 26 measurement items are generated for the measurement instrument: nine for SES, eight for OE and nine for SEC as shown in Appendix A. An example is added to each item to enrich the content and improve the comprehensiveness of the item in the instrument.[2] Content validity is concerned with the extent to which a specific set of items reflects a content domain (DeVellis, 1991). Assessing content validity helps to ensure that the items used to operationalize the construct actually measure what they are supposed to measure (Churchill, 1979). We performed a content validation test by inviting some experts to review the measuring items to ensure that they are representative of our SCP conceptualization in transport logistics.[3] Several changes in the wording were made and the items were subject to further refinement in a pilot test.

4.2 Pilot Test

A pilot test was carried out to further test and refine the instrument. The pilot test was conducted with 30 postgraduate students studying a part-time Master's degree in International Shipping and Transport Logistics at The Hong Kong Polytechnic University (who were full-time transport logistics practitioners) and a convenient sample of 20 practitioners in the field.[4] A total of 32 valid responses were collected in the pilot test. Based on the 32 responses, preliminary validity of the instrument was established on the basis of two criteria: content validity[5], and construct validity from an item-to-total correlation analysis and reliability test.[6] The results of the pilot test are given in Table 2.

<< Insert Table 2 about here >>

4.3 Data Collection

To further explore the SCP construct, the final version of the questionnaire was mailed, with a covering letter and a self-addressed prepaid return envelop, to the complete sample of all 924 companies in the Schednet Asian Logistics Directory (Schednet, 2001), in which all the companies involved in transport logistics in Hong Kong are listed.[7] We used the key informant strategy to carry out the survey research (Phillips and Bagozzi, 1986). Target respondents were general managers or logistics managers of the sampled companies.[8] The questionnaire was mailed twice: one month after the first mailing, the questionnaire was again mailed to the non-respondents.

A total of 139 questionnaires were returned, but five of them were not useable because of significant data missing and incompleteness. The remaining 134 responses - 97 in the first mailing and 37 in the second mailing - represent an effective response rate of 14.5%. The profiles of the respondent companies and their characteristics are displayed in Table 3.

<< Insert Table 3 about here >>

A comparison of early (those responding to the first mailing) and late (those responding to the second mailing) respondents was carried out to test for non-response bias (Armstrong and

Overton, 1977).[9] The 26 measurement items in this study were randomly selected for a non-response bias test. We divided the 134 survey respondents into two groups based on their responses wave (first and second) and performed t-tests on the responses of the two groups. At the 5% level, there are no significant differences between the two groups in the measurement items. Although the results do not rule out the possibility of non-response bias, they suggest that non-response may not be a problem to the extent that the late respondents represent the opinions of non-respondents.

5. Results

5.1 Validity and Reliability

We first tested the measurement properties of the sub-dimensions of the SCP construct using reliability test and item-total correlation analysis, followed by confirmatory factor analysis (CFA) (Anderson, 1987; Gerbing and Anderson, 1988; Jöreskog, 1993).[10] In this study, we first developed measures based on theory and previous research (Lai et al., 2001). CFA was used to assess how well the observed variables, i.e., measurement items, reflect unobserved or latent variables, i.e., the sub-dimensions, in the hypothesized structure. A strong a priori basis warrants the use of CFA instead of exploratory factor analysis (EFA).

The reliability test and item-total correlation analysis results provided in Table 2 suggest a reasonable fit of the latent factors to the data. Cronbach alpha values for all six factors, i.e., sub-dimensions, are all greater than 0.70 and the item loadings on the factors are all acceptable, i.e., > 0.40. These tests, however, do not allow for unidimensonality[11], convergent validity[11], nor discriminant validity.[12] We proceeded to test them using CFA.

The CFA results for SES, OE, and SEC are provided in Table 4. A series of goodness-of-fit indices, i.e., CFI > 0.90, GFI > 0.90, NFI > 0.90 and RMR < 0.05, provide evidence of unidimensioality of the factors (Hair et al., 1998), though the indices for OE are marginally below the benchmark. For each of the factors, convergent validity is achieved because of the significant loading of the measurement items on their latent factors ($\lambda > 0.4$ and $t > 2$).

<< Insert Table 4 about here >>

A series of pairwise CFAs were conducted to assess the discriminant validity of the sub-dimensions using chi-square difference tests (Anderson and Gerbing, 1988).[13] This test was performed on all possible pairs of the factors and Table 5 reports the results of the fifteen pairwise tests of the factors. Discriminant validity is not achieved in some cases (SES-REL and SES-RES, SES-RES and SEC-REL). This was expected as they are the sub-dimensions of the SCP construct and are measuring a higher order latent factor, i.e., SCP in transport logistics. The significant results of the chi-square difference tests (13 out of 15) attest to the presence of discriminant validity between any two factors (Anderson and Gerbing, 1988). Upon obtaining satisfactory reliability and validity test results, we averaged the values of the measurement items for each sub-dimension and use these arithmetic means as single-indicator constructs to measure SCP in transport logistics in subsequent stages.[14]

<< Insert Table 5 about here >>

5.2 Testing First-order and Second-order Models

In the previous discussion, SES, OE and SEC are specified as a priori factors of SCP in transport logistics. In the first-order model, SES, OE and SEC are correlated measures for SCP in transport logistics. Alternatively, SCP in transport logistics may be operationalized as a second-order model[15], where the three dimensions are governed by a higher order factor, i.e., SCP in transport logistics. The results of the model estimation are shown in Figures 1 and 2.

< Insert Figures 1 and 2 about here >

The first-order model for testing the existence of SCP in transport logistics implies that SES, OE and SEC are correlated but not governed by a common latent factor. Although the χ^2 statistic is significant (χ^2 = 25.08; df = 6; $p < 0.01$), other fit indices suggest good fits for the first-order model. The GFI is 0.94, which is greater than 0.90 as recommended by Jöreskog (1993), suggesting an adequate model fit. The NFI and CFI are well above 0.90. Finally, the RMR is 0.011, which also suggests a good fit of the model to the data. In sum, the test results support the first-order model of SCP in transport logistics.

The test of the second-order model[16], illustrated in Figure 2, implies that a higher order latent factor, i.e., the overall trait of SCP in transport logistics, governs the correlations among SES, OE and SEC. The second-order model produces a χ^2 statistic of 25.08 at 6 degrees of freedom with GFI, NFI and CFI well above the 0.90 benchmark and with RMR below 0.05. The second-order loadings on SCP in transport logistics are 0.94 for SES, 0.87 for OE, and 0.97 for SEC.

We measure the efficacy of the two models by comparing the χ^2 statistics of the first-order model and the second-order model (Marsh and Hocevar, 1985). The fit indices of the two measurement models are the same[17] (χ^2 = 25.08; df = 6; GFI = 0.94; NFI = 0.96; CFI = 0.97; RMR = 0.011). An examination of the second-order model of the SCP reveals that all the lambda coefficient estimates of SES and OE and SEC, which describe the relationships or paths of the three dimensions of SCP in transport logistics, are significant. The paths between SCP in transport logistics and its underlying first-order dimensions are 0.86 for SES, 0.79 for OE, and 0.80 for SEC, respectively. All the path loadings are of a high magnitude and exhibit a significantly high t-value. Therefore, SCP in transport logistics can be conceptualized as a multidimensional measure consisting of SES, OE and SEC, and the second-order model is tenable.

6. Discussion

In this study, a SCP construct in transport logistics is developed and the instrument measuring the construct is validated. On the basis of the SCOR model, the measurement items in the instrument are classified into three a priori dimensions of SCP in transport logistics: SES, OE, and SEC. Each dimension, in turn, consists of two sub-dimensions. The measurement instrument developed in this study appears to adequately fit the data collected and the construct validity and reliability of the instrument are established with the systematic and scientific procedures used in this study.

In model testing, both the first- and second-order models provide acceptable fit. In the first-order model, SES, OE and SEC are positively highly correlated measures for the SCP. The proposed second-order model's estimated parameters are all significant, and the GFI indicates that the proposed model fits the data adequately. The unison constitutes a higher order factor that may be termed SCP in transport logistics. The implication is that firms believe that SCP in transport logistics should be multifaceted, not limited to internal processes. The existence of the second-order model suggests that SCP in transport logistics should be well-rounded, with SES, OE and SEC embedded in the measurement. Managers in transport logistics should strive to maintain a balanced focus on both effectiveness and efficiency aspects of performance management and improvement, aiming to meet the goals of the different parties (e.g. shippers and consignees) in their supply chain processes.

The multidimensional conceptualizations provide insights into the construct of SCP in transport logistics and its relationships with the underlying dimensions. First, the items and the sub-dimensions of the construct are specific to the transport logistics context. They provide direct and actionable information on SCP in transport logistics at item and sub-dimension levels. Second, conceptualization of the construct at higher levels, i.e., first and second order levels, provide managers with an opportunity to look at SCP in transport logistics at a higher level of abstraction beyond the individual item and sub-dimension tiers.

At the individual item and sub-dimension levels, managers might look at the performance for each individual item and sub-dimension and may identify areas in need of special attention. For instance, if a service provider underperforms in the SES-REL item “fulfill promises to shippers”, this would signal a need for improvement actions for that particular item. On the other hand, an analysis of the construct at a higher level of abstraction offers several potentially critical advantages. It may reveal patterns not readily revealed by studying individual items and sub-dimensions only. For instance, a service provider underperforms in certain SES items and outperforms in certain SEC items. If the items and sub-dimensions were not grouped according to the models validated in this study, managers would have no clues to identify areas for improvement or formulate strategic initiative. Performance evaluation at a higher level of abstraction helps to reveal the necessity for improvement actions in one area (e.g. SES) or prescribe a strategy for maintaining performance in another area (e.g. SEC) where the service provider may have gained a competitive edge.

7. Limitations

This study suffers from several limitations. First, the sample of respondents is all transport logistics service providers. The study assesses information only from the perspectives of transport logistics service providers. Consequently, it offers a self-reported, one-dimensional focus. The study results could be different if the data collected and the perceptions captured are from other member firms in the supply chain, e.g. shippers and consignees. In general, shippers and consignees tend to focus more on service effectiveness, and service providers tend to be more concerned with operational efficiency. Further research will benefit from testing the instrument with shippers and consignees to triangulate the findings.

Moreover, respondents are asked to report the perceived SCP of their companies as compared to the competition at a single point in time. Therefore, SCP in transport logistics on a temporal dimension cannot be measured. As a single respondent within each company provides the data for the variables, the possibility of respondent bias cannot be ruled out. Further research could enhance validity by gathering data from multiple respondents within each firm and across partner firms in the supply chain. Despite the encouraging results of the non-response bias test, the response rate of 14.5% achieved in this study, while comparable to similar studies of this nature, is relatively low. The main reason is the reluctance of respondents to complete a questionnaire that asks for performance-related data. Replications of this study with different data collection methodologies and samples are needed to address these issues.

8. Conclusions and Future Research

This study offers to practitioners a comprehensive list of 26 items for measuring SCP in transport logistics, which can be used to evaluate the status of their SCP so as to uncover improvement areas. The 26 measurement items have been empirically tested to be reliable and valid in this study. The reliability coefficient (Cronbach's alpha), measured by the 26 measurement items, for the six sub-dimensions of the SCP construct are all well above 0.70. The CFA results confirm that all the 26 measurement items significantly load on their respective latent factors. Furthermore, the extensive literature review and the validation process with experts in the field ensure that the 26 measurement items have content validity. The overall SCP construct also has acceptable construct validity as each of the six sub-dimensions significantly load on the construct with factor loadings of 0.79 or above in CFA. The results suggest that all the 26 measurement items are critical attributes of SCP in transport logistics and they form a reliable and valid measurement instrument for the construct.

Firms wishing to improve their SCP in transport logistics need to constantly monitor their performance. The validated measurement instrument can be used as a self diagnostic tool to identify areas where specific improvements are needed and pinpoint aspects of the firm's SCP that require improvement actions. On the other hand, the study contributes to the literature with a validated measurement model and a measurement instrument for SCP in transport logistics. This is an essential step for building and extending theories in SCM. For instance, research into the antecedents and consequences of SCP in transport logistics could not be undertaken without valid and reliable measures of the SCP construct.

There exists a wide scope for future research on the instrumentation issues of SCP in transport logistics. The validation of the instrument is an ongoing process and validity is established only over a series of studies that further refine and test the measures across different populations and settings (DeVellis, 1991). Development of valid and reliable measures will only be accomplished through the use and refinement of the instrument in subsequent studies. As these measures of SCP and those reported in this study are further refined, research in SCM and transport logistics management can progress into many new areas with a higher probability of producing results that are rigorous, repeatable and useful for building and confirming theories (Cooper et al., 1997).

Future research can focus more on the relationship between SCP in transport logistics and other constructs, such as competitive advantage. A conceptual model of the relationships between SCP in transport logistics and its various organizational variables or antecedents, e.g. use of information technology, and consequences, e.g. profitability, is needed. Such models can lead to a description of what affects SCP in transport logistics and how the SCP affects the bottom-line of a firm. The instrument in this study provides a means for testing such relationships. Finally, while we feel testing SCP in the transport logistics context increases the validity of the measures, we see a need to extend the study of SCP to other logistics contexts in the supply chain, e.g. port and terminal operations.

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Notes

[1] SERVQUAL is a widely accepted instrument to measure service quality across a wide variety of service domains, see Parasuraman, Zeithaml and Berry (1988, 1994) for details. There are five dimensions in SERVQUAL: reliability, responsiveness, assurances, empathy, and tangibility. The service oriented component of the SCP construct regarding reliability and responsiveness in this study are developed on the basis of the first two dimensions in SERVQUAL because of their wide acceptance and robustness in the literature.

[2] The measurement items are measured on a five-point scale, ranging from an anchor 1 = much worse than the competition, 2 = worse than the competition, 3 = same as the competition, 4 = better than the competition, and 5 = superior to the competition. Respondents were invited to evaluate the performance of their companies with respect to the items on the five-point scale. The measurement items were included in a structured questionnaire for content validation and refinement.

[3] Two neutral academics in the transport logistics field and two industry practitioners were invited to review the items to ensure the relevance and clarity of the wording for the items in the instrument. Each of the reviewers was briefed on the purpose of the study and asked to critically review the items for completeness, understandability, terminology, and ambiguity.

[4] The pilot test samples were asked to complete the questionnaire and to offer suggestions for improvement of the measurement instrument. The pilot test resulted in minor modifications to the wording and examples provided in some measurement items.

[5] Content validity is ensured because the measurement items were derived and modified from established measures, as well as from suggestions from academics and practitioners in the field. Moreover, the pilot test respondents indicated that the content of SCP in transport logistics is well represented by the items included in the measurement instrument. These procedures are entirely consistent with those required for attaining high content validity.

[6] The construct validity of the SCP scale was examined using a reliability test with the coefficient alpha computed for each of the sub-dimensions, e.g. SES-REL, and item-to-total correlation analysis. These procedures resulted in a set of items with coefficient alpha values all higher than 0.70 as recommended by Nunnally and Bernstein (1994) and all item loadings were greater than 0.50.

[7] The sample represents four broad categories of companies in the industry: sea transport, freight forwarding, air transport, third-party logistics service providers.

[8] These executives were targeted because they possess expert knowledge of SCP in transport logistics in their companies.

[9] This method is based on the assumption that the opinions of late respondents are somewhat representative of the opinions of non-respondents.

[10] The CFA was conducted using Maximum Likelihood Estimation in AMOS 4.0 (Arbuckle and Wothke 1999).

[11] Unidimensionality and convergent validity refers to the existence of one latent trait or construct underlying a set of measures (Gerbing and Anderson 1988). In CFA, the measurement items are restricted to load on their respective sub-dimensions in the SCP and the sub-dimensions are allowed to be correlated between themselves in their respective measurement models.

[12] Discriminant validity is the degree to which a dimension in a theoretical system differs from other dimensions in the same theoretical system (Churchill 1979).

[13] This was conducted by forcing measurement items of each pair of factors (sub-dimensions) into a single underlying factor, leading to a significant deterioration of model fit relative to a two-factor model. Such a result, this implies the presence of discriminant validity between the pair of factors (Bagozzi and Phillips, 1982).

[14] By using summary constructs, a complex model is simplified, and the concept of a multiple indicator is maintained (Garver and Mentzer 1999). It also reduces the model’s complexity, identification problems, and the variables to sample size ratio (Marsh and Hau 1999). This method also allows us to test the SCP construct based on a sample size of 134 respondents. Another advantage of using a summary construct is that it provides more meaningful information since it signals where potential problems in SCP may exist. For example, if SCP is not performing up to expectation, it is easier to identify the problem in one of these six sub-dimensions and to indicate where more effort should be put. Instead of concentrating on individual measurement items, this approach allows the examination of the overall theoretical SCP construct at a higher level of abstraction.

[15] In the second-order model, the correlations between the factors are denoted by a second-order factor. This alternative model explains the covariation in an alternative way (three paths in contrast to three correlations). Comparing the two models can provide further measurement efficacy (Jöreskog 1993).

[16] The second-order model is more restrictive and provides us with more information about the relationship between the higher-order SCP construct and the lower-order factors in the form of path coefficients rather than in the form of correlations. It explains the covariation among the three dimensions of SCP in transport logistics in an alternative way, i.e., same degree of freedom, three paths in contrast to three correlations.

[17] The χ^2 statistics and the related fit indices of the two models are identical because the degrees of freedom are the same when the number of first-order factors is three. The comparison indicates good model fit and no evidence of over-fitting for the second-order model compared to the first-order model. The findings suggest that the addition of a second-order factor does not significantly increase the χ^2 statistics and the model fit.

Appendix A – List of Questionnaire Items and their Codings by Construct

SES		**Service Effectiveness for Shippers**
SES – REL	1	Fulfill promises to shippers (e.g. on-time vehicle arrival; offer competitive rates) [0.59]*
	2	Solve shippers' problem (e.g. suggest best routing) [0.54]
	3	Perform services for shippers right the first time (e.g. correctly inputed B/L) [0.68]
	4	Provide services at the time promised to the shippers (e.g. on-time delivery to exhibition site; higher shipping frequency than rival companies) [0.52]
	5	Keep shippers' records accurately (e.g. correct invoice) [0.69]
SES – RES	1	Tell shippers exactly when services will be performed (e.g. location and opening hours of the depots/ container freight station (CFS)/ warehouse) [0.70]
	2	Give prompt services to shippers (e.g. special packaging for furniture/ piano etc) [0.59]
	3	Willingness to help shippers (e.g. give advice on shipping schedule or packaging; track and trace status of the cargoes shipped) [0.74]
	4	Timely response to shippers' requests (e.g. delivery/ transshipment of cargoes at short notice) [0.70]
OE		**Operations Efficiency for Transport Logistics Service Providers**
OE – COST	1	Reduce order management costs (e.g. minimize order handling through EDI) [0.75]
	2	Reduce costs associated with facilities/ equipment/ manpower used in providing the services (e.g. use IT to track and trace the status of shipped cargoes) [0.85]
	3	Reduce warehousing costs [0.74]
	4	Reduce transportation costs [0.75]
	5	Reduce logistics administration costs (e.g. build good relationships with related organizations such as customs, bureau of commodity inspection, port authority) [0.68]
OE – ASST	1	Improve the rate of utilization of facilities/ equipment/ manpower in providing the services [0.71]
	2	Improve number of cash to cash cycle time (the average days required to turn a dollar investment in facilities/equipment/manpower providing the shipping services into a dollar collected from customers) [0.82]
	3	Improve net asset turns (working capital) [0.77]
SEC		**Service Effectiveness for Consignees**
SEC – REL	1	Fulfill promises to consignees (e.g. advise arrival schedules; complaint handling) [0.64]
	2	Solve consignees' problems (e.g. provide warehousing; repackage cargoes at CFS) [0.81]
	3	Perform services for consignees right the first time (e.g. pack and remix cargoes) [0.79]
	4	Provide services at the time promised to the consignees (e.g. availability of cargoes for collection at CFS) [0.80]
	5	Keep consignees' records accurately (e.g. error-free records of consignees' addresses and opening hours) [0.70]
SEC – RES	1	Tell consignees exactly when services will be performed (e.g. advise estimated time of arrival (ETA) via fax/ mail; advise estimated time to change B/L to D/O) [0.75]
	2	Give prompt services to consignees (e.g. advise regulations regarding discharge of overweight/ over-length cargoes) [0.74]
	3	Willingness to help consignees (e.g. suggest inland routing) [0.77]
	4	Timely response to consignees' requests (e.g. transshipment arrangement) [0.73]

* Standardized loadings in CFA

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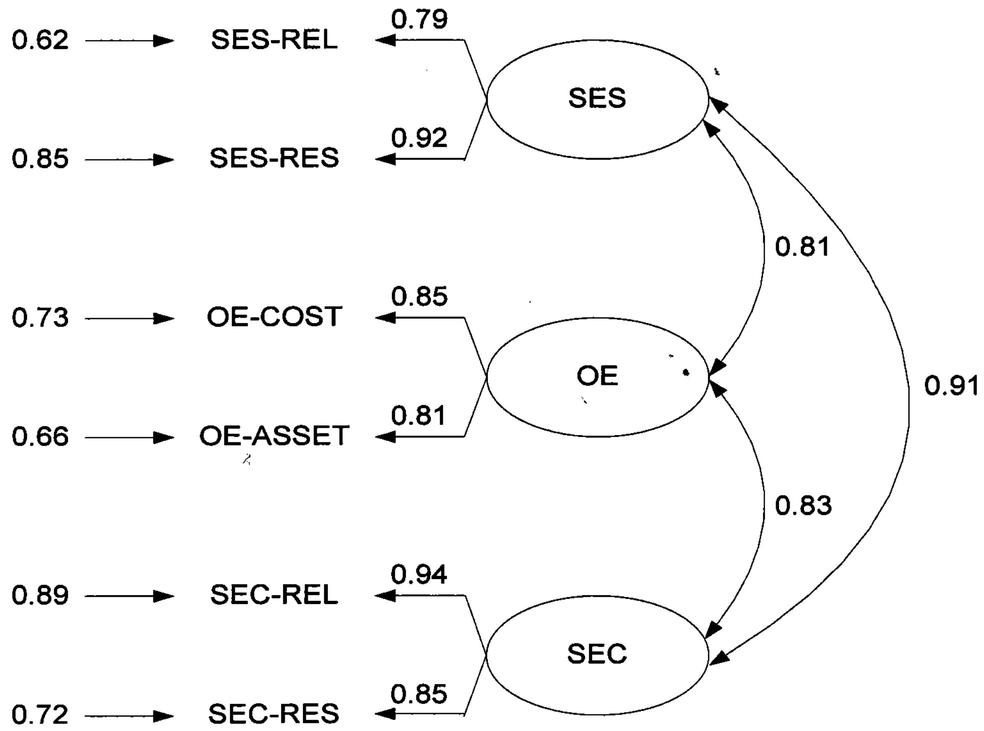
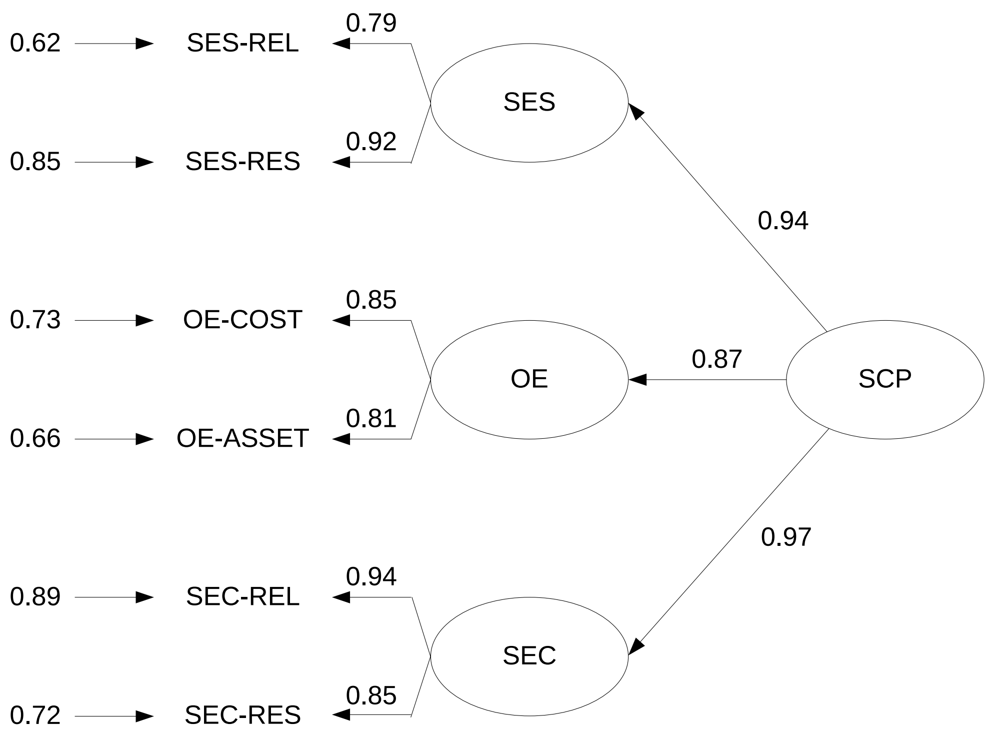


Chi Square (6) = 25.08 (P < 0.001)
Goodness of Fit Index (GFI) = 0.94
Root Mean Square Residual (RMR) = 0.011
Comparative Fit Index (CFI) = 0.97
Normed Fit Index (NFI) = 0.96

Figure 1. First-order factor model of SCP in transport logistics



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Goodness of Fit Index (GFI) = 0.94
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Comparative Fit Index (CFI) = 0.97
Normed Fit Index (NFI) = 0.96

Figure 2. Second-order factor model of SCP in transport logistics

Table 1. SCOR performance measures for a supply chain

Supply Chain Process	**Measurement Criteria**	**Performance Indicators**
Customer-facing	Supply Chain Reliability	Delivery performance
		Order fulfillment performance
		Perfect order fulfillment
	Flexibility & Responsiveness	Supply chain response time
		Production flexibility
Internal-facing	Costs	Total logistics management costs
		Value added productivity
		Return processing cost
	Assets	Cash-to-cash cycle time
		Inventory days of supply
		Asset turns

Table 2. Summary measurement results

Factors	Number of items	Mean	S.D.	Alpha	Range of Item-total correlations
SES – REL	5	4.12 (3.80)	0.52 (0.49)	0.74 (0.73)	0.45 – 0.57 (0.36 – 0.64)
SES – RES	4	4.04 (3.92)	0.48 (0.53)	0.76 (0.77)	0.46 – 0.63 (0.45 – 0.68)
OE – COST	5	3.65 (3.69)	0.73 (0.49)	0.87 (0.70)	0.62 – 0.77 (0.42 – 0.55)
OE – ASST	3	3.74 (3.65)	0.41 (0.62)	0.80 (0.79)	0.56 – 0.72 (0.58 – 0.74)
SEC – REL	5	4.03 (3.87)	0.63 (0.42)	0.86 (0.66)	0.57 – 0.75 (0.18 – 0.52)
SEC – RES	4	4.01 (3.84)	0.52 (0.46)	0.83 (0.60)	0.61 – 0.70 (0.30 – 0.61)

Note: Entries in the parentheses are pilot test results

Table 3. Profile of the respondent companies (n = 134)

Nature of Business	
Sea Transport	30 (22.4%)
Freight Forwarding	49 (36.6%)
Air Transport	2 (1.5%)
Third Party Logistics Services	53 (39.5%)
Number of Employees	
Below 100	102 (76.1%)
100 – 499	23 (17.2%)
500 – 999	1 (0.7%)
over 1,000	7 (5.2%)
Unknown	1 (0.7%)
Level of turnover (HK$)	
Below 1 million	17 (12.7%)
1-10 million	40 (29.9%)
10-100 million	45 (33.6%)
over 100 million	28 (20.9%)
Unknown	4 (3.0%)

Table 4. Results from confirmatory factor analysis model for SES, OE and SEC

Measurement Models	**Range of Standardized loadings**	**Range of t-values**	**CFI**	**GFI**	**NFI**	**RMR**	**χ^2 (d.f., prob.)**
SES			0.99	0.96	0.93	0.03	27.72 (26, P > 0.10)
SES - REL	0.52 – 0.69	4.89 - 7.47					
SES - RES	0.59 – 0.74	6.11 – 7.47					
OE			0.88	0.86	0.86	0.05	85.45 (19, P < 0.01)
OE - COST	0.68 – 0.85	7.64 – 9.73					
OE - ASST	0.71 – 0.82	7.89 – 8.22					
SEC			0.95	0.91	0.92	0.03	57.29 (26, P < 0.01)
SEC - REL	0.64 – 0.81	6.91 – 7.75					
SEC - RES	0.73 – 0.77	8.25 – 8.73					

Note: For standardized loading of individual measurement items, see Appendix A

Table 5. Discriminant validity checks: Chi-square differences

Factors	1	2	3	4	5
1. SES-REL					
2. SES-RES	1.80				
3. OE-COST	25.11	47.85			
4. OE-ASST	43.51	28.41	20.94		
5. SEC-REL	20.83	2.52	62.38	48.93	
6. SEC-RES	40.69	6.93	74.95	52.74	5.70

Note: Chi-square difference between the separate latent factors measurement model and a one latent factor measurement model (all tests = 1 *df*); $\chi^2 > 11$, $p < 0.001$; $\chi^2 > 6.7$, $p < 0.01$; $\chi^2 > 3.85$, $p < 0.05$.