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An instrument for measuring supply chain flexibility for the textile and clothing companies

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ABSTRACT

Supply chain flexibility (SCF) represents the capability of firms to respond to unanticipated changes in customer needs and competitor actions. Given the growing research interest in flexibility strategies, the development of a valid and reliable instrument to measure organizational responses toward environmental uncertainties or risks is imperative. However, no systematic and scientific research has been conducted to develop such an instrument. The present study adopts a comprehensive and rigorous procedure to develop a multi-faceted scale for SCF through an empirical investigation. The results of a confirmatory factor analysis suggest that SCF can be operationalized as a second-order factor model comprising four dimensions, namely: sourcing flexibility, operating system flexibility, distribution flexibility, and information system flexibility. A series of goodness-of-fit indices further demonstrates that this scale is internally consistent, reliable, and valid. The various findings suggested in the present study provide a more succinct picture of SCF, and the well-validated scale could be used as a basis for further research and theoretical groundwork in the field of supply chain management.

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1. Introduction

Given the ever-changing business environment, resources that have historically sustained an organization’s competitive advantage in business may no longer be viable. In today’s globalized world, competition has gone beyond the boundaries of single firms and extended across the full supply chain spectrum. It is therefore essential that supply chain members adjust and reconfigure themselves to achieve a balance between the responsiveness of their organizations and changes in the marketplace by increasing their flexibility in all operational activities. Supply chain flexibility (SCF) involves the application of supply chain resources according to marketing dynamics, and requires firms to develop cross-functional and cross-company strategies that eliminate bottlenecks and create a level of performance that allows firms to strengthen their competitive advantage in an uncertain market. From the view of supply chain management (SCM), a number of strategic options can be utilized to increase SCF; for example, multiple supplier relationships could be set up to enable organizations to find another backup supplier in case of supply breakdown, or to activate additional logistics channels if peaks (Garaveli, 2003).

Although research on flexibility is considerable and its importance has been recognized for some time, much of the research has concentrated on intra-organizational flexibility and has focused largely on manufacturing systems (e.g., Gerwin, 1993; Koste and Malhotra, 1999; Slack, 1983; Upton, 1994; Volz and O’Leary-Kelly, 2000; Gupta and Somers, 1996). Flexibility studies from the supply chain perspective, however, have thus far been limited. The lack of a theoretical basis and the wide array of measures used by individual researchers have been identified as major causes of the incomplete state of knowledge of SCF (Beach et al., 2000; Stevenson and Spring, 2007; De Toni and Tonchiglia, 1998). Given these problems, we undertook an empirical study among firms within the textile and clothing industry in China to determine how an instrument with a set of multi-item measurement scales representing the SCF construct could be developed and validated.

The remainder of this paper is organized as follows. Section 2 outlines the theoretical background based on relevant literature. Section 3 discusses the development of the scale items, and thus the research instrument, while Section 4 explains how required data was collected. In Section 5, we present the procedure for purifying the measurement models and identifying the component factors of the scales. We then report the results of a validation process for each of the component factors and a model test of the SCF scale. In Sections 6 and 7, concluding remarks are made, and theoretical

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and managerial implications are analyzed, and limitations and future research are discussed.

2. Theoretical background and literature review

For decades, flexibility as a research topic has been discussed from both economic (e.g., Devereux and Engel, 2003; Jones and Os- troy, 1984) and organizational (e.g., Boynton and Victor, 1991; Golden and Towill, 2000) perspectives. In this section, we first review the literature regarding manufacturing flexibility and the emerging studies on SCF. We then measure the inadequacy of the extant research on SCF against our objective to develop a validated SCF scale.

2.1. Manufacturing flexibility

In the area of operations management, flexibility was initially proposed for the manufacturing sector to see how manufacturers could deal with unexpected changes in their production processes, such as equipment breakdowns, variable task times, queuing delays, and re-workings (Sethi and Sethi, 1990; Dixon, 1992; Gupta and Goyal, 1989). In this regard, manufacturing flexibility concerns the degree to which an organization possesses a variety of actual and/or potential procedures, as well as the rapidity with which it can implement these procedures to increase its control capability over its environment (Bernardes and Hanna, 2009; De Leeuw and Volberda, 1996; Zhang et al., 2003). Manufacturing flexibility is typically defined in terms of range, mobility, and uniformity; specifically, it refers the various states a system can adopt, the ability to move from making one product to another, and the ability to perform comparably well when making any product within a specified range (Slack, 1983; Upton, 1994; Gupta and Somers, 1992).

The various components of manufacturing flexibility have been built up over time and presented hierarchically from shop floor to firm level. Slack (1983) described five types of manufacturing flexibility (i.e., new product, product mix, quality, volume, and delivery), while Gerwin (1993) examined seven types (i.e., mix, changeover, modification, volume, rerouting, material, and responsiveness). Later, Vokurka and O’Leary-Kelly (2000) extended these to 15 (i.e., machine, material handling, operations, automation, labor, process, routing, product, new design, delivery, volume, expansion, program, production, and market). Despite their different taxonomies, these studies all examined the principal procedures of manufacturing systems, within which strong interdependencies among many of the suggested components were found; for example, mix and routing flexibility were both influenced by the degree of machine flexibility.

2.2. Supplier chain flexibility

With inter-firm competition being extended to inter-chain competition, in which upstream suppliers and downstream distributors cooperate to deliver value to customers, the concept of flexibility needed to be expanded from manufacturing to supply chain scenarios. This required "inter-functional" and "partnership" perspectives, and an avoidance of approaches that were inward-looking and self-focused (Holmberg, 2000). The concept of SCF was then proposed and has been studied ever since (e.g., Beamon, 1998; Duclos et al., 2003; Vickery et al., 1999; Das, 2011; Lummus et al., 2003) contend that SCF refers to the promptness of a supply chain in responding to customer demand and the degree to which it can adjust its speed, destinations, and volume in response to various market changes. The Supply Chain Council (2006, p.7) also came up with a performance-based definition of SCF: "The agility of a supply chain in responding to marketplace changes to gain or maintain competitive advantage." Several studies have adopted the approach of relating components found in the literature on manufacturing flexibility to the wider context of the supply chain. Vickery et al. (1999) outline five components of SCF from an "integrative, customer-oriented perspective": namely, volume flexibility, product flexibility, distribution flexibility, access flexibility, and new product introduction flexibility. Among these components, the first two are related to manufacturing systems, the next two are used to investigate marketing, and the last is related to new product research and design. However, although these studies attempt to extend the investigative boundary from a single department/process to multiple departments/processes, they remain focused on the internal perspective of a particular firm.

Other research has contributed to the flexibility literature by focusing on internal issues inherent at the plant or firm level, together with a wider range of external processes, including sourcing, procurement, and logistics (Stevenson and Spring, 2007). Garavelli (2003) and Sánchez and Pérez (2005) examined two main aspects of SCF: process flexibility and logistics flexibility. Process flexibility concerns the number of product types that can be manufactured at each production site, regardless of where they are located. Logistics flexibility refers to the different logistics strategies that can be adopted to release a product into a marketplace or to procure a component from a supplier. Similarly, Swafford et al. (2006) proposed a three-dimensional SCF that includes procurement/sourcing flexibility, manufacturing flexibility, and distribution/logistics flexibility.

2.3. SCF scale - a research gap

SCM and flexibility may have been among the leading concerns of operations management in recent years, but the studies that focus on SCF remain inadequate (Garavelli, 2003; Gong, 2008). One major limitation of the previous studies is that most of them have been conducted within the confines of a single firm, thereby neglecting other important aspects of a supply chain, especially those related to upstream suppliers and downstream distributors. Consequently, the proposed flexibility options are incapable of including the multiple interdependencies that exist among supply chain partners. Another restriction of existing research is its lack of insight into the application by organizations of information technology (IT) to adapt to changing circumstances. Because of the important role of information systems in a supply chain, the inclusion of IT in the study of SCM is inevitable.

Furthermore, a comprehensive and widely accepted theoretical framework for measuring SCF has yet to be formulated (Bernardes and Hanna, 2009; De Toni and Tonchia, 1998). Without a reliable and well-validated scale, it is impossible to adequately measure the flexibility of a supply chain in responding to the fickle demands of today's market or to compare the level of flexibility of one supply chain with that of another (Stevenson and Spring, 2007). Moreover, it is difficult to understand how flexibility affects a supply chain's performance and/or other organizational attributes. It was therefore our intention to study the basic nature of SCF and to integrate its various dimensions to form a reliable and well-validated measurement scale. We anticipate that through a comprehensive and rigorous validation process, a well-defined measurement model and a highly validated research instrument can be obtained, which can be applied to empirical studies and, in turn, may generate substantive theories. Particularly, our results can be of help in providing a means for measuring the intensity of flexibility for the companies in the textile and clothing industry.

3. Development of a research instrument for SCF

The methodology we used to develop the research instrument for SCF followed the recommendations outlined by Churchill.
(1979). The conceptualization and operationalization of the SCF construct and its component factors are discussed in this section, while the processes and results of the model test are reported in Sections 4 and 5.

3.1. Defining the domain of SCF

Notwithstanding its limitations, previous literature has provided us with a theoretical and operational basis for the conceptualization of SCF. Synthesizing the definitions in the extant literature (Koste and Malhotra, 1999; Lumnus et al., 2003; Sánchez and Pérez, 2005; Sawhney, 2006; Sethi and Sethi, 1990; Swafford et al., 2006; Fredericks, 2005), we define SCF as "the capability of an organization to respond to internal and external changes in order to gain or maintain a competitive advantage". We also maintain that SCF is a multifaceted concept with four flexibility dimensions, which are needed by supply chain participants to develop superior responsiveness in order to meet the challenges of a volatile marketplace (Duclos et al., 2001).

The first dimension of SCF is sourcing flexibility (SF), which we define as the availability of qualified materials and services and the ability to effectively purchase them in response to changing requirements (Duclos et al., 2003; Lumnus et al., 2003). In general, sourcing comprises the pre-activities of an enterprise's core business. These activities provide crucial links between supplier firms and buyer firms and result in the procurement of materials, components, products, or services to support the buyer firm's daily business (Lumnus et al., 2003; Swafford et al., 2006; Tachiakiwa and Giménez, 2009). The major determinant of SF is how well a firm can manage its upstream supply flows.

The second dimension of SCF is operating system flexibility (OSF), which we define as the ability to exploit the use of obtained resources to produce a range of products and services effectively in order to meet various market demands. In other words, it is the ability to provide qualified products with a wide range of features, mixes, and volumes according to various customer specifications (D' Souza and Williams, 2002; Koste et al., 2004; Sethi and Sethi, 1990). OSF enables firms to produce needed products timely through setup time reduction, cellular manufacturing layouts, preventive maintenance, and/or quality improvement efforts (Koste and Malhotra, 1999; Sarfer et al., 1994; Shewhulk and Moodie, 1998). The key determinant of OSF is a firm's ability to produce products in response to the demands of its clients. At the plant level, OSF can be predicated on machining, labor and materials management, and process routing flexibilities.

Distribution flexibility (DF), the third dimension, refers to a company's ability to control the movement and storage of materials, components, finished goods, and/or services under constantly evolving marketplace conditions (Duclos et al., 2003; Swafford et al., 2006). DF facilitates production and marketing by smoothing the flow of incoming materials and outgoing products (Lin and Shaw, 1998). It is promoted by the close coordination of upstream and downstream operations along the supply chain (Vickery et al., 1999). The primary determinant of DF is the ability of a firm to manage its distributors, warehouses, loading capacity, and other distribution facilities effectively and efficiently.

Finally, information system flexibility (ISF) represents the ability of the organization's information system to adapt to changing circumstances, especially in situations of unexpected disturbance (Duclos et al., 2003; Fredericks, 2005). With the physical flow of products across different supply chain echelons, relevant information should be transferred frequently and accurately across each involved party. Lucas and Olson (1994) believe that IT affects system flexibility in three ways: by changing or blurring the boundaries of an enterprise's system; by reducing working time in the system and connecting time among different organizations; and by enhancing working properties and rhythm. The key component of ISF relates to the capability of an organization to set up an effective information system to support the operations and communications among different internal functions/departments and external trading partners (Lee and Whang, 2000).

3.2. Generation of scale items for evaluating SCF

In line with the literature reviewed in Section 2 and the four dimensions of SCF identified above, this subsection describes how we identified the measurement items for each factor component of SCF. An initial set of 38 items was generated by the authors, including five items for SF, five items for OSF, five items for DF, and three items for ISF, to capture the theoretical and conceptual domain of SCF (see Table 1).

Sourcing flexibility (SF) is determined by the ability of the purchasing function to manage available suppliers and to influence these suppliers' performance in providing quality materials and services. In this regard, we believe that a firm who has more and greater variety of supply sources, has wider range of materials/components/products available from the major suppliers, and has the ability to add and remove suppliers freely; it might be more competent to secure a smooth supply flow to support their daily operations (Lumnus et al., 2003; Swafford et al., 2006). For example, if a firm can easily find new suppliers, the risk of production halt caused by an interruption of necessary materials is greatly reduced. Inter-firm uncertainties are then minimized.

Operating system flexibility (OSF) is used to examine the operational processes of a supply chain, especially in manufacturing. We expect that the greater a firm's ability to vary its output volumes, to develop new products, to change products and services mix, and to adjust manufacturing facilities and processes; the greater its ability to reorganize production agilely and to produce products that meet the evolving standards of customer demand, production design, process technology, and materials supply (Koste et al., 2004; Pagell and Krause, 1999; Sawhney, 2006; Sethi and Sethi, 1990; Gopin and Somers, 1996). For example, if a firm can easily control its production capacity, then it can reduce or increase its output quickly to deal with sudden changes in market demand.

Distribution flexibility (DF) is used to examine the process of delivery of goods and supplies among member firms of a supply chain. We anticipate that if a firm wants to enhance its flexibility in delivery, it should have more available warehouses, loading capacity, and other distribution/logistics facilities; have the ability to change these facilities' functional structure, delivery modes, and schedules, and have less restrictions to add or remove distributors and/or logistics providers (Swafford et al., 2006). For example, having relationships with a variety of carriers for each delivery mode ensures that product delivery will not be adversely affected when the primary carrier is unable to meet delivery requirements.

Information system flexibility (ISF) is the fourth dimension of SCF and is operationalized by the use of IT to facilitate information sharing across multiple functions and departments and with other members along the supply chain (Lee and Whang, 2000). If a firm's information system has the ability to support transportation and distribution, inventory management, and other logistical and operational activities, then the firm can respond more quickly to the market (Lee, 2000; Lee and Whang, 2000; Fredericks, 2005). For example, an integrative information system linking members along the entire supply chain enables members to make timely responsive decisions in accord with the sales conditions from the shop floor of frontline retailers. Therefore, a supportive information system reduces uncertainties in the supply chain and contributes to overall SCF.
Table 1
Initial measurement items for supply chain flexibility and their references.

<table>
<thead>
<tr>
<th>Labels</th>
<th>Measurement items</th>
<th>Related studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sourcing flexibility (SF)</td>
<td>Number of available suppliers</td>
<td>Swafford et al. (2006)</td>
</tr>
<tr>
<td>SF-1</td>
<td>Range of products and services provided by major suppliers</td>
<td>Swafford et al. (2005)</td>
</tr>
<tr>
<td>SF-3</td>
<td>Range of suppliers that provide major materials/products</td>
<td>Lumusse et al. (2003) and Swafford et al. (2006)</td>
</tr>
<tr>
<td>SF-4</td>
<td>Ability to add and remove suppliers</td>
<td>Lumusse et al. (2003) and Swafford et al. (2006)</td>
</tr>
<tr>
<td>SF-5</td>
<td>Ability to change suppliers to satisfy changing requirements</td>
<td>Lumusse et al. (2003) and Swafford et al. (2006)</td>
</tr>
<tr>
<td>Operating system flexibility (OSF)</td>
<td>Output volumes the firm can produce</td>
<td>Koste et al. (2004), Pagell and Krause (1999) and Sawhney (2006)</td>
</tr>
<tr>
<td>OSF-1</td>
<td>Range of new products or services</td>
<td>Koste et al. (2004) and Sethi and Sethi (1990)</td>
</tr>
<tr>
<td>OSF-2</td>
<td>The firm can change its production every year</td>
<td>Koste et al. (2004) and Sethi and Sethi (1990)</td>
</tr>
<tr>
<td>OSF-3</td>
<td>Ability to change output volumes</td>
<td>Gupta and Saverio (1996) and Koste et al. (2004)</td>
</tr>
<tr>
<td>OSF-4</td>
<td>Ability to change products and services mix</td>
<td></td>
</tr>
<tr>
<td>OSF-5</td>
<td>Ability to adjust manufacturing facilities and processes</td>
<td></td>
</tr>
<tr>
<td>Distribution flexibility (DF)</td>
<td>Number of warehouses, leading capacity, and other distribution facilities</td>
<td>Swafford et al. (2006)</td>
</tr>
<tr>
<td>DF-1</td>
<td>Ability to add or remove carriers or other distributors</td>
<td>Swafford et al. (2006)</td>
</tr>
<tr>
<td>DF-2</td>
<td>Ability to change warehouse space, leading capacity, and other distribution facilities</td>
<td>Swafford et al. (2006)</td>
</tr>
<tr>
<td>DF-3</td>
<td>Ability to change delivery modes</td>
<td>Swafford et al. (2006)</td>
</tr>
<tr>
<td>DF-4</td>
<td>Ability to change delivery scheduling</td>
<td></td>
</tr>
<tr>
<td>DF-5</td>
<td>Information system flexibility (ISF)</td>
<td></td>
</tr>
<tr>
<td>ISF-1</td>
<td>Support of information systems in transportation and distribution management</td>
<td>Lee (2000) and Lee and Whang (2000)</td>
</tr>
<tr>
<td>ISF-3</td>
<td>Support of information systems across multiple functions and departments</td>
<td>Lee (2000) and Lee and Whang (2000) and Fredericks (2005)</td>
</tr>
</tbody>
</table>

3.3. Item review and sorting

After the domain for SCF has been identified, the construct definitions can be formally converted into measurable scales. In general, the goal of this task is to ensure that the items used to operationalize the construct actually measure what they are supposed to measure (Churchill, 1975). In this study, we invited seven experts to review the measurement items so as to identify potential problems resulting from ambiguous or poorly defined scale operationalization. These experts included two academics in the SCM field and five senior industry practitioners. We then made amendments according to the comments we received.

We also adopted a sorting procedure to examine whether the meaning associated with each measurement item was the same for both the research team and the targeted respondents (Segars and Grover, 1998). This procedure was essential because the instrument we were developing for measuring SCF was rather new and its measurement scales were not yet well established or well validated. Indeed, this procedure could provide a powerful means of confirming the underlying structure of such a complex variable and establish content validity for the scale. To carry out the sorting process, we developed an instrument that included three parts: a construct description, a random item list, and a set of sorting instructions.

The construct description explaining the concepts of the four component factors of the SCF was presented on a single page, with a single paragraph for each factor. The random list of the 18 initial measurement items was recast in the form of single sentences and printed on a page separate from that of the construct description. The sorting instructions, which were provided on the cover page, asked the respondents to read the construct description carefully and group the 18 items within the four dimensions according to the definitions in the construct description. Seven potential participants were invited to help us conduct this item sorting process. They were also encouraged to indicate any indeterminable matches, comment on ambiguity or lack of clarity in wording, and suggest changes.

Item placement ratios were used to assess the content validity of the measurement items and the initial reliability of the proposed constructs (Moore and Benbasat, 1991). We computed respondents' responses using the frequency with which each item was correctly associated and matched with its intended construct. As Table 2 shows, all placement ratios of items within each target construct exceeded the recommended level of 70% (i.e., SF = 91%, OSF = 89%, DF = 89%, and ISF = 90%), and an overall placement ratio reached the level of 89% (Hair et al., 2006). This confirmed the adequacy of the scale items for capturing the pre-specified factor components of the SCF scale. Consequently, we deemed no further analysis was necessary for item refinement or redevelopment, and adopted all items as measures of their associated constructs.

3.4. Development of questionnaire and pilot test

In the questionnaire, the 18 measurement items were assessed using a 7-point Likert-type scale, ranging from 1 (completely...
disagree to 7 (completely agree). Since the present study was administered among Chinese informants, the questionnaire was first translated from English into Chinese and then back-translated from Chinese into English to ensure that all items in the Chinese version meant the same as in the English version. Prior to conducting the large-scale postal survey, we carried out a pilot test to check and refine the measurement instrument. This pilot test was conducted among 25 respondents through a convenience sample; five were part-time MBA students at the Hong Kong Polytechnic University who were practitioners in the field of SCM, and the other 20 were senior supply chain executives of textile and clothing manufacturers in China. These respondents were asked to indicate the extent to which they agreed with each item and provide suggestions for improving the content and format of the questionnaire. This pilot test resulted in some minor modifications to the wording and several editorial issues related to the questionnaire format. No serious problems were reported by these respondents in filling out the questionnaire.

4. Data collection

After the final refinement of the research instrument, we conducted a postal survey to collect data from the industry for validating the conceptual framework of the SCF scale.

4.1. Selection of textile and clothing industry as a case

We collected the data for the survey study exclusively from companies involved in the textile and clothing industry in mainland China. The focus on such a single industry was based on the following considerations. First, a single industry eliminates noise from a number of potentially confounding factors, such as macroeconomic conditions, the competitive environment, the complexity of production processes, and the volatility of market demand. Second, in a single-industry design, a smaller sample size is sufficient for making comparisons across identified cases (Dixon, 1992).

Third, the textile and apparel industry is a typical consumer-driven industry with product demands (e.g., fibers, yarns, and garments) being determined mostly by the demands of the final consumers. This derived demand results in a strong relationship between the supply chain and the market. China is an important market for the textile and clothing industry, and the domestic market demand in China has made China the world's largest exporter and manufacturer of textiles and clothing.

The single-industry design does, however, have weaknesses as well. One is that the results are not necessarily generalizable (Dess et al., 1989). Nonetheless, though many processes, required techniques, and equipment are unique to the industry, textile and apparel supply chains also share numerous difficulties and opportunities with other industries. The variety in product characteristics—such as standard yarn and basic apparel versus fancy yarns and fashion apparel—results in variations in supply chain characteristics, such as customer demand, complexity of manufacturing processes, and product distribution. In this regard, we believe that selecting this single industry as a case for the present study is appropriate; yet we also recognize the need to have diversified samples to compare across cases.

4.2. Survey administration

We used the Directory of Chinese Enterprises (China Community Net, 2007) issued by the Ministry of Commerce of the People's Republic of China as the sampling framework. Companies under the categories of garment, knitting, and crocheted textile, chemical fiber, fur and leather, home textile, and apparel, and yarn and thread were included in the survey. The target respondents were the senior staff within their respective firms, with titles such as chief executive, vice president, director, director of supply chain or operations, general manager, plant manager, and production manager. These informants were preferred because of their knowledge in operations and strategic management of the supply chain. To encourage more responses and enhance the reply quality, we promised each potential participant a copy of the survey results.

The second round of mailing was sent out to those non-respondents one month after the first round. In cases an undeliverable questionnaire was received, a replacement form was added. A total of 1,330 firms were mailed to and 207 returned questionnaires were received, with 156 from the first mailing and 51 from the second. Fifteen were unusable because of significant missing data or incompleteness. The remaining 192 responses accounted for 14.44% of the total number of mailed questionnaires. Table 3 displays the profiles of the informants and their companies. One way to examine non-response bias is to test for statistically significant differences between the earlier (those responding to the first mailing) and later (those not responding to the second mailing) waves of returned questionnaires (Armstrong and Overton, 1977). For this study, we performed a t-test to examine the differences among the 28 scale items between the two groups. The results showed no significant difference at the 0.05 level, suggesting that the non-response bias was negligible.

5. Data analysis and results

As developed from previous literature, each item in the scale presented in Table 1 represents an a priori measurement model of the theoretical construct of SCF. Given the theory-driven approach to construct development, the analytical framework of confirmatory factor analysis (CFA) in structural equation modeling (SEM) provides an efficient means of assessing the consistency of measurement across scale items and of the pre-specified model with its associated network of theoretical concepts (Joreskog, 1993). In this regard, we adopted CFA to test and confirm the measurement model of the SCF scale. The following subsections report the results of the model specification and purification; the descriptive statistics regarding the scale characteristics; a statistical validation process including the testing of unidimensionality, reliability, convergent validity, and discriminant validity; and the comparison of the efficacy of alternative competing models for confirming the final measurement model for SCF.

5.1. Model specification and purification

To develop a reliable, valid, and parsimonious scale for SCF, we first specified and purified the measurement models for each component factor. The modification index (MI) is a useful tool for detecting model misspecification (Byrne, 2001); that is, a value of 3.84 or greater in an MI indicates that the chi-square ($\chi^2$) would statistically be significantly reduced if the coefficient was estimated (i.e., freed) (Hair et al., 2006). In this process, the analysis results of the MI across the paired tests suggested that six items (SF-4, SF-5, OSF-1, DF-1, DF-2, and IF-3) had high cross-loadings with other factors they were not supposed to measure and were thus deleted. Cross-loadings might be attributed to a statistical artifact; therefore, removing offending items to improve the $\chi^2$ value and to permit one item load on one factor should be done with caution so as not to violate the theory. In the deletion process, we scrutinized the concept and nature of each of these problematic items.
and deleted them one by one according to the magnitude of the MI values. Consequently, the number of items was reduced from 18 to 12, ending with 3 items for SF, 4 items for OSF, 3 items for DF, and 2 items for ISF. This re-specified model was analyzed in the later stages in an attempt to develop a measurement model for SCF. Indeed, this purification process made the structure of the component factors simpler and clearer, and enabled the interpretation of the factor concepts easier.

5.2. Scale characteristics

As shown in Tables 4 and 5, the mean values of the 12 measurement items range from 4.08 to 5.85, standard deviations from 1.314 to 1.954, and inter-item correlations from 0.002 to 0.790. Considering the results of the mean values, we found that the most important item within the SF dimension was SF-1 (mean = 5.85, SD = 1.240), implying that firms aiming at a higher level of flexibility should develop more potential suppliers. In this way, they can adjust their partnership easier with various suppliers and achieve greater responsiveness in cases of unexpected environmental disturbance. The key item in the OSF dimension was OSF-2 (mean = 5.51, SD = 1.314), suggesting that those firms with higher ability to manage production of a wide variety of new products can more easily meet demands from the ever-changing fashion market. Likewise, the ability of a firm to change delivery modes (DF-4) (mean = 4.58, SD = 1.497) is an important indicator of DF, confirming that firms with higher ability to strategically control and adjust their delivery modes might provide better service for their clients, particularly in a globally dispersed market. For ISF, the ability of a firm's IT system to support information flow in transportation and distribution management (ISF-1) (mean = 4.33, SD = 1.794) was perceived as most important. This suggests that a flexible information system should be able to supply sufficient and accurate information for logistical operations so as to enhance a firm's agility in meeting the volatile market demand, in turn, improving its overall SCF and thus outperforming its competitors.

5.3. Validation of component factors

Prior to testing the overall measurement model for SCF, we conducted a series of validation tests for unidimensionality, reliability, convergent validity, and discriminant validity to examine the properties of the four proposed component factors of the SCF. The results of all of these tests should be satisfied to achieve construct validity (Hair et al., 2006).

5.3.1. Testing for unidimensionality

Unidimensionality is defined as the existence of one construct underlying a set of items (Gerbing and Anderson, 1988). The aim of testing for unidimensionality is to assess how well the identified measurement items reflect their respective latent variables. This testing process is fundamental in a validation process and should hence be undertaken before other tests (Garver and Menteer, 1999). In this study, we tested the unidimensionality of each component factor by analyzing the alpha scores, the item-total correlations, and the results of a principal component analysis (PCA) in the exploratory factor analysis (EFA) (Williams et al., 2009). In Table 4, all Cronbach's alpha values are higher than or close to 0.7 and all the item-total statistics are greater than or approach 0.5. For the EFA, results show that the factor loadings of the observable items onto their respective component factors are all over 0.70, while the eigenvalue for each factor is greater than 1. The total variance explained is above 60%. All these exhibit evidence of unidimensionality for each component factor of the SCF.

5.3.2. Testing for reliability

Reliability is the degree to which measures yield consistent results (Peter, 1979). In the current study, we first checked item reliability in light of the square multiple correlations (SMC) by squaring the regression loadings of each item onto the latent construct it represents. Then, we calculated the composite reliability (CR) and average variance extracted (AVE) estimates to confirm the scale reliability based on the two following formulas (Fornell and Larcker, 1981).

Table 4

<table>
<thead>
<tr>
<th>Items</th>
<th>Descriptive</th>
<th>SF-1</th>
<th>SF-2</th>
<th>SF-3</th>
<th>SF-4</th>
<th>SF-5</th>
<th>SF-6</th>
<th>SF-7</th>
<th>SF-8</th>
<th>SF-9</th>
<th>SF-10</th>
<th>SF-11</th>
<th>SF-12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>5.85</td>
<td>5.45</td>
<td>5.27</td>
<td>5.51</td>
<td>5.35</td>
<td>5.22</td>
<td>4.80</td>
<td>4.89</td>
<td>4.58</td>
<td>4.08</td>
<td>4.33</td>
<td>4.27</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>1.240</td>
<td>1.345</td>
<td>1.994</td>
<td>1.314</td>
<td>1.300</td>
<td>1.423</td>
<td>1.520</td>
<td>1.450</td>
<td>1.497</td>
<td>1.830</td>
<td>1.794</td>
<td>1.721</td>
<td></td>
</tr>
<tr>
<td>Reliability</td>
<td></td>
<td>0.552</td>
<td>0.518</td>
<td>0.485</td>
<td>0.525</td>
<td>0.699</td>
<td>0.647</td>
<td>0.586</td>
<td>0.608</td>
<td>0.626</td>
<td>0.700</td>
<td>0.700</td>
<td></td>
</tr>
<tr>
<td>Cronbach's alpha</td>
<td>0.593</td>
<td>0.796</td>
<td>0.796</td>
<td>0.796</td>
<td>0.796</td>
<td>0.796</td>
<td>0.796</td>
<td>0.796</td>
<td>0.796</td>
<td>0.796</td>
<td>0.796</td>
<td>0.796</td>
<td></td>
</tr>
<tr>
<td>EFA</td>
<td>Factor loading</td>
<td>0.847</td>
<td>0.769</td>
<td>0.577</td>
<td>0.712</td>
<td>0.827</td>
<td>0.744</td>
<td>0.748</td>
<td>0.870</td>
<td>0.846</td>
<td>0.735</td>
<td>0.516</td>
<td>0.918</td>
</tr>
<tr>
<td>Eigenvalue</td>
<td>1.575</td>
<td>3.785</td>
<td>1.855</td>
<td>1.061</td>
<td>13.126</td>
<td>31.346</td>
<td>15.660</td>
<td>8.823</td>
<td>0.907</td>
<td>0.907</td>
<td>0.907</td>
<td>0.907</td>
<td></td>
</tr>
<tr>
<td>Total variance explained (cumulative)</td>
<td>0.8807</td>
<td>0.8807</td>
<td>0.8807</td>
<td>0.8807</td>
<td>0.8807</td>
<td>0.8807</td>
<td>0.8807</td>
<td>0.8807</td>
<td>0.8807</td>
<td>0.8807</td>
<td>0.8807</td>
<td>0.8807</td>
<td>0.8807</td>
</tr>
</tbody>
</table>

Note: Total number of firms = 192
Table 5

Inter-item correlations and violations of discriminant validity.

<table>
<thead>
<tr>
<th>Items</th>
<th>Inter-item correlations</th>
<th>ISF-1</th>
<th>ISF-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF-1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>SF-2</td>
<td>.498**</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>SF-3</td>
<td>.420**</td>
<td>.586**</td>
<td>1</td>
</tr>
<tr>
<td>OSF-2</td>
<td>.171*</td>
<td>.243**</td>
<td>.242**</td>
</tr>
<tr>
<td>OSF-3</td>
<td>.211*</td>
<td>.242**</td>
<td>.240**</td>
</tr>
<tr>
<td>OSF-4</td>
<td>.333**</td>
<td>.386**</td>
<td>.321**</td>
</tr>
<tr>
<td>OSF-5</td>
<td>.143*</td>
<td>.158**</td>
<td>.219**</td>
</tr>
<tr>
<td>DF-2</td>
<td>.110</td>
<td>.209**</td>
<td>.233**</td>
</tr>
<tr>
<td>DF-4</td>
<td>.094</td>
<td>.205**</td>
<td>.238**</td>
</tr>
<tr>
<td>DF-5</td>
<td>.013</td>
<td>.145**</td>
<td>.197</td>
</tr>
<tr>
<td>ISF-1</td>
<td>.010</td>
<td>.054</td>
<td>.062</td>
</tr>
<tr>
<td>ISF-2</td>
<td>.069</td>
<td>.115</td>
<td>.925</td>
</tr>
</tbody>
</table>

*Correlation is significant at the 0.05 level (2-tailed).
**Correlation is significant at the 0.01 level (2-tailed).

\[
CR = \frac{(\sum r^2)}{(\sum r^2 + \sum (1 - \lambda_i^2))}
\]

\[
AVE = \frac{\sum r^2}{(\sum r^2 + \sum (1 - \lambda_i^2))}
\]

where \( r \) is the standardized loading for each observed variable and 1 - \( \lambda_i \) is the error variance associated with each observed variable.

SMC is a measure of the strength of the relationships of the individual items to their respective latent variables, while the CR score reflects the internal consistency of a set of measures, and the AVE estimate illustrates the overall amount of variance in the indicators accounted for by the latent construct (Garver and Mentzer, 1999; Bolten, 1989). In general, an SMC greater than 0.3, a CR greater than 0.7, and an AVE greater than 0.5 indicate sufficient reliability for a construct (Garver and Mentzer, 1999; Fornell and Larcker, 1981; Segars, 1997). As Table 6 shows, all score values for SMC, CR, and AVE exceed the recommended threshold requirements, implying that each component factor is sufficiently reliable.

5.3.3. Testing for convergent validity

Convergent validity refers to the existence of one latent trait or construct underlying a set of measures (Anderson et al., 1987). To check for this, we first compared the correlations at item level. If the lowest correlation of a particular item within each component factor is significant at p < 0.01, convergent validity exists (Koufteros et al., 1998). In Table 5, the results show that the lowest correlations for each item in each component factor are all greater than or very close to 0.40 and are significant at the 0.01 level. These indicate initial evidence of good convergent validity.

Further, we checked the parameter estimator and the overall fit of each measurement model (Garver and Mentzer, 1999). In CFA, measurement items are restricted to significant loadings on their respective constructs to demonstrate sufficient convergent validity (Hair et al., 2006). As Table 6 shows, the regression weights of the measurement items range from 0.901 to 0.557, all being over 0.50 and significant at the 0.05 level. The model summary statistics also show that all the p values of the \( \chi^2 \) of the component factors are higher than 0.05 and statistically insignificant, while all the normed \( \chi^2 \) (i.e., \( \chi^2/df \)) are lower than 3.00. A series of goodness-of-fit

Table 6

Measurement properties of the component factors of SFC.

<table>
<thead>
<tr>
<th>Component</th>
<th>Item</th>
<th>Regression weight</th>
<th>Item reliability (SMC)*</th>
<th>Scale reliability (CR and AVE)**</th>
<th>Model summary and fit indices†</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF</td>
<td>SF-1</td>
<td>.736</td>
<td>.542</td>
<td>CR = 0.7985</td>
<td>( \chi^2(1) = 0.009 ) (p = 0.925)</td>
</tr>
<tr>
<td></td>
<td>SF-2</td>
<td>.577</td>
<td>.458</td>
<td>AVE = 0.5585</td>
<td>( \chi^2/df = 0.049 )</td>
</tr>
<tr>
<td></td>
<td>SF-3</td>
<td>.576</td>
<td>.322</td>
<td></td>
<td>GFI = 1.000; AGFI = 1.000; CFI = 1.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RMR = 0.005; RMSEA = 0.000</td>
<td></td>
</tr>
<tr>
<td>OSF</td>
<td>OSF-2</td>
<td>.614</td>
<td>.377</td>
<td>CR = 0.8720</td>
<td>( \chi^2(2) = 4.007 ) (p = 0.135)</td>
</tr>
<tr>
<td></td>
<td>OSF-3</td>
<td>.825</td>
<td>.581</td>
<td>AVE = 0.6332</td>
<td>( \chi^2/df = 2.004 )</td>
</tr>
<tr>
<td></td>
<td>OSF-4</td>
<td>.739</td>
<td>.596</td>
<td></td>
<td>GFI = 0.949; AGFI = 0.945; CFI = 0.991</td>
</tr>
<tr>
<td></td>
<td>OSF-5</td>
<td>.549</td>
<td>.421</td>
<td></td>
<td>RMR = 0.049; RMSEA = 0.072</td>
</tr>
<tr>
<td>DF</td>
<td>DF-3</td>
<td>.799</td>
<td>.638</td>
<td>CR = 0.8427</td>
<td>( \chi^2(1) = 0.372 ) (p = 0.542)</td>
</tr>
<tr>
<td></td>
<td>DF-4</td>
<td>.787</td>
<td>.619</td>
<td>AVE = 0.5468</td>
<td>( \chi^2/df = 0.372 )</td>
</tr>
<tr>
<td></td>
<td>DF-5</td>
<td>.557</td>
<td>.310</td>
<td></td>
<td>GFI = 0.959; AGFI = 0.952; CFI = 1.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RMR = 0.086; RMSEA = 0.096</td>
<td></td>
</tr>
<tr>
<td>NSF</td>
<td>NSF-1</td>
<td>.881</td>
<td>.775</td>
<td>CR = 0.7981</td>
<td>( \chi^2(1) = 0.233 ) (p = 0.631)</td>
</tr>
<tr>
<td></td>
<td>NSF-2</td>
<td>.901</td>
<td>.812</td>
<td>AVE = 0.8753</td>
<td>( \chi^2/df = 0.233 )</td>
</tr>
</tbody>
</table>

* Threshold for SMC (>0.3), CR (>0.7), AVE (>0.50).
† Threshold for p-value of \( \chi^2 > 0.050 \), \( \chi^2/df > 3.000 \), GFI (>0.80), AGFI (>0.80), CFI (>0.90), GFI (>0.90), RMR (>0.10), RMSEA (<1.0).
indices, namely, CFI, GFI, and AGFI are greater than the threshold level of 0.9; and RMSEA and RMSEA are lower than 0.08. All these reveal stronger evidence for the existence of convergent validity; that is, the observed indicators are good representatives of their respective latent constructs (Hair et al., 2006).

5.3.4. Testing for discriminant validity

Discriminant validity represents the degree to which a dimension in a theoretical system differs from other dimensions in the same system (Churchill, 1979). In the present study, we used three tests to confirm the discriminant validity of the four component factors of the SFC: (1) correlation comparison (Koufteros et al., 1998), (2) the pair-construct test (Segars and Grover, 1998), and (3) the AVE versus shared variance test (Farrell, 2010).

We checked the initial discriminant validity by comparing the lowest correlation for a particular item and any other items within the same factor (within-factor correlations) with the correlations of that item and all items outside the factor (between-factor correlations) (Koufteros et al., 1998). If the within-factor correlation was less than any between-factor correlation, then a violation would have occurred. In examining the correlation matrix in Table 5, we found no violation to this rule among the 106 possible comparisons. Initial evidence of discriminant validity was thus supported.

In the pair-construct test, we compared the \( \chi^2 \) values of each of the unconstrained models, which estimated (or freed) the correlation between a pair of constructs of the four component factors of SFC, with the nested constrained models, which fixed the value of the construct correlation to one (Segars and Grover, 1998). If there was a significant \( \chi^2 \) difference between the two models, the unconstrained model would be a better fit for the data and thereby support the existence of discriminant validity. Table 7 shows the results of this test, in which the \( \chi^2 \) differences range from 5.378 to 28.875 and all are significant at the 0.05 level, providing further evidence of discriminant validity.

Finally, we examined the discriminant validity by comparing the AVE of each construct with the shared variance between constructs. Shared variance is the amount of variance that one construct is able to explain in another construct (Farrell, 2010). It is represented by the square of the correlation between any two constructs. Discriminant validity can be supported if the AVE for each construct is greater than its shared variance with any other construct. Table 7 shows that all AVE estimates of SF, OSF, DF, and ISF are higher than each of the shared variance values between each pair of constructs. Such results provide further evidence of confirming the discriminant validity of the four component factors of SFC (Farrell and Larcker, 1981).

5.4. Developing and testing the overall measurement model for SFC

To achieve our ultimate goal of proposing a reliable and valid measurement model for SFC, we set up five alternative competing models (see Fig. 1) based on the approach of Xia and Lee (2005). Likewise, we examined the model fitness in line with the conceptualization of the SFC construct using CFA in SEM. The five models are as follows: (1) a null model in which all measures were uncorrelated to one another; (2) a model in which all measures were loaded onto a single first-order factor; (3) a model in which the measures were loaded onto four uncorrelated first-order factors; (4) a model in which the measures were loaded onto four correlated first-order factors, and (5) a model in which the four first-order factors were loaded onto a second-order factor of SFC. These models were tagged as Model 1 to Model 5, respectively.

Table 8 shows the results of these five competing models. Models 1, 2, and 3 were unacceptable because most of their goodness-of-fit indices failed to meet the threshold criteria. In contrast, we could preliminarily accept Models 4 and 5, namely, the correlated four-factor first-order model and the four-factor second-order model, because all fit indices satisfy the threshold criteria. The results of the estimation of these two models are also shown in Figs. 2 and 3, respectively.

For the correlated four-factor first-order model, the scales of SF, OSF, DS, and ISF are correlated but not governed by a common latent factor, yet all the model summary statistics and the goodness-of-fit indices suggest a sound fit for it. The \( \chi^2 \) statistic is 51.41 (df = 48; p = 0.342) and is insignificant at the 0.05 level; normal \( \chi^2 \) is 1.071, well below 3.00. Meanwhile, CFI (0.958), GFI (0.958), and AGFI (0.932) are all higher than 0.9, and RMR (0.102) and RMSEA (0.019) are below or close to 0.1. For the four-factor second-order model, the test results illustrate that a higher-order latent factor, that is, the overall trait of SFC, governs the correlations among the constructs of SF, OSF, DF, and ISF. The \( \chi^2 \) statistic is 61.563 (df = 50; p = 0.127) and normalized \( \chi^2 \) is 1.231. The goodness-of-fit indices of CFI (0.954), GFI (0.951), AGFI (0.932), RMER (0.147), and RMSEA (0.035) all meet or are close to the threshold criteria. As a whole, the four proposed factors fit the dataset well and that the two measurement models can represent the scale of SFC.

To compare the efficacy of these two acceptable models, we continued to check the values of the consistent Akaike information criterion (CAIC), which is an assessment for improvement over competing models. In general, lower CAIC values reflect the model with better fit (Millont and Duckitt, 2004). The results in Table 8 show that the CAIC of the second-order model (258.773) is lower than that of the correlated first-order model (259.134), suggesting that the second-order model possesses better parsimony. Subsequently, we checked the target (T) coefficient, which is a comparison of the \( \chi^2 \) statistics of the lower-order model and the higher-order model (Marsh and Hocevar, 1985). This coefficient has a ceiling value of one, with a higher value implying that the relationship among lower-order factors is sufficiently captured by the higher-order factor (Segars and Grover, 1998). In our study, the T coefficient is rather high (0.835), indicating that

### Table 7

<table>
<thead>
<tr>
<th>Pairs</th>
<th>Pair-construct test</th>
<th>( \chi^2 ) Difference</th>
<th>AVE vs shared variance test*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \chi^2 ) Values</td>
<td></td>
<td>SF</td>
</tr>
<tr>
<td></td>
<td>Constrained model</td>
<td>Unconstrained model</td>
<td></td>
</tr>
<tr>
<td>SF with SF</td>
<td>46.126 (df = 14)</td>
<td>20.997 (df = 13)</td>
<td>25.129***</td>
</tr>
<tr>
<td>SF with DF</td>
<td>33.774 (df = 9)</td>
<td>9.952 (df = 8)</td>
<td>24.212***</td>
</tr>
<tr>
<td>SF with ISF</td>
<td>33.568 (df = 5)</td>
<td>4.623 (df = 4)</td>
<td>28.927***</td>
</tr>
<tr>
<td>OSF with DF</td>
<td>35.020 (df = 14)</td>
<td>9.444 (df = 13)</td>
<td>25.576***</td>
</tr>
<tr>
<td>OSF with ISF</td>
<td>19.278 (df = 9)</td>
<td>8.189 (df = 8)</td>
<td>11.089**</td>
</tr>
<tr>
<td>DF with ISF</td>
<td>12.485 (df = 5)</td>
<td>2.076 (df = 4)</td>
<td>10.409*</td>
</tr>
</tbody>
</table>

* Comparison are below the diagonal, shared variances are above the diagonal, and AVE estimates are presented on the diagonal.

** \( \chi^2 \) difference is significant at the 0.05 level.

*** \( \chi^2 \) difference is significant at the 0.01 level.
the second-order model does not drastically increase the $\chi^2$ value; that means no serious negative effect on the model fit.

In essence, the second-order model is a more parsimonious representation of the observed covariances, i.e., four paths in contrast to six correlations. It is also more restrictive and provides added information about the relationships between the higher-order construct and the lower-order factors in the form of path coefficients (i.e., the $\gamma$ of SF = 0.57, OSF = 0.91, DF = 0.40, and ISF = 0.39) rather than in the form of correlations (i.e., the $\gamma$ of SF-OSF = 0.54, SF-DF = 0.32, SF-ISF = 0.06, OSF-DF = 0.33, OSF-ISF = 0.37, and
Table 8
Model fit test of the five alternative models.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Threshold</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\chi^2$</td>
<td>-</td>
<td>0.00</td>
<td>401.377</td>
<td>.00</td>
<td>514.069</td>
<td>61.563</td>
</tr>
<tr>
<td>df</td>
<td>-</td>
<td>0</td>
<td>54</td>
<td>0</td>
<td>48</td>
<td>50</td>
</tr>
<tr>
<td>$p$-Value</td>
<td>(&gt;.050)</td>
<td>.560</td>
<td>-</td>
<td>-</td>
<td>.342</td>
<td>.127</td>
</tr>
<tr>
<td>$\chi^2$/df</td>
<td>(&gt;.10)</td>
<td>7.583</td>
<td>-</td>
<td>1.971</td>
<td>1.211</td>
<td></td>
</tr>
<tr>
<td>CFI</td>
<td>(&gt;.90)</td>
<td>1.000</td>
<td>.519</td>
<td>1.000</td>
<td>.995</td>
<td>.984</td>
</tr>
<tr>
<td>GFI</td>
<td>(&gt;.90)</td>
<td>1.000</td>
<td>.741</td>
<td>1.000</td>
<td>.988</td>
<td>.993</td>
</tr>
<tr>
<td>NFI</td>
<td>(&gt;.90)</td>
<td>.000</td>
<td>.034</td>
<td>.000</td>
<td>.192</td>
<td>.147</td>
</tr>
<tr>
<td>RMR</td>
<td>(&gt;.10)</td>
<td>.0242</td>
<td>.185</td>
<td>.0242</td>
<td>.019</td>
<td>.035</td>
</tr>
<tr>
<td>RMSEA</td>
<td>(&gt;.10)</td>
<td>468.085</td>
<td>558.557</td>
<td>486.085</td>
<td>239.134</td>
<td>238.773</td>
</tr>
</tbody>
</table>

Inner factor correlations
- SF -- OSF = .54
- SF -- DF = .32
- OSF -- DF = .63
- OSF -- ISF = .33
- DF -- ISF = .29

Standardized regression weights:
- SF -- SF = .57
- SCF -- OSF = .51
- SCF -- DF = .40
- SCF -- ISF = .32
- SCF -- ISF = .28

DF-ISF = 0.29). A further examination of this second-order model also reveals that all path loadings between SCF and its underlying first-order factors are significant and of high magnitude. Consequently, the hypothesis that SCF can be conceptualized as a multidimensional measure consisting of SF, OSF, DF, and ISF, and that it is governed by a second-order latent variable, can be confirmed. We therefore accept this four-factor second-order model as a "truer" representation of the model structure of the SCF scale.
6. Conclusion and discussion

An important agenda within the study of flexibility in SCM has been the development of a validated SCF scale. In the present study, we developed a conceptual model for SCF on the basis of the extant research and empirically assessed and confirmed an instrument for measuring the construct of SCF. We classified the identified measurement items into four dimensions: that is, SF, OSF, DF, and ISF. With a comprehensive and rigorous validation process, the measurement scales of these sub-constructs were shown to be adequate from the collected dataset. In the model test, both correlated four-factor first-order and four-factor second-order models were well established. In the former model, most of the component factors of SCF were correlated with statistical significance; the latter model captured these correlations and “explained” them using a higher-order construct, which is an integrative latent representation of SCF. In essence, SCF is a multidimensional concept manifesting the processes of sourcing, manufacturing, distribution, and information management, as well as the interactions of these processes (Swafford et al., 2006).

From the results of the present study, some important insights can be obtained. First, the study adds the concept of flexibility to the previous approach, which focused on the perspective of a single firm in the manufacturing sector (Bernardes and Hanna, 2009; De Leeuw and Volberda, 1996; Sethi and Sethi, 1990; Zhang et al., 2003), by considering collaboration and integration within the supply chain, which involves both suppliers and customers. Second, the present study, to the best of our knowledge, is the first to take a systematic and scientific approach to developing a reliable and well-validated scale and instrument for SCF. We feel sure that our effort to develop such a scale and instrument will facilitate future research, particularly in developing usable hypotheses and in communicating empirical results in the field of SCM.

Third, because the important role of IT in SCM has been increasingly emphasized (Lee and Whang, 2000), we added a new construct of ISF to widen the concept of SCF, and we expected a significant interaction between it and the other three dimensions in our proposed conceptual framework. However, an insignificant correlation between ISF and SF was found. Such a countercyclical finding could simply be an outcome of our respondents, or alternatively, it could indicate that the sharing of information with supply chain partners is more applicable within internal operating systems or with downstream customers rather than upstream suppliers. In view of the important role of suppliers in today’s competitive business environment (Gunasekaran and Ngai, 2009), it is essential that organizations set up an efficient and robust information system to facilitate information flow along the full spectrum of the supply chain.

Fourth, the existence of the second-order model suggests that an organization’s SCF is a multifaceted, interactive, synergistic process rather than a single entity. For organizations that are aiming to improve flexibility in managing supply chain operations, this measurement instrument could be used as a self-diagnostic tool to identify areas that require specific improvements, and to pinpoint those aspects that call for immediate action. Supply chain managers should always maintain a well-balanced focus on the different aspects of SF, OSF, DF and ISF to achieve a high level of overall SCF.
7. Limitations and future research

Establishing a valid and reliable scale for SFC contributes to a better understanding of the nature and role of SCM. However, the present study has some limitations. First, it focuses only on the textile and clothing industry in China; thus, a wider scope of research merits further attention. More studies are needed to refine, validate, and test the proposed instrument across different industries and settings. Second, future research could also focus on examining the relationships between SFC and other organizational attributes, such as perceived environmental uncertainties or supply chain performance. The instrument developed in the present study provides a basis for these explorations. Third, the unit of analysis of this study is a focal firm rather than a specific supply chain. This unit of analysis has enabled us to focus only on organization-wide patterns of SFC. Thus, readers should be aware of this when interpreting the results.

All in all, our study adds to the body of knowledge regarding SFC by offering a Valuabilization tool to measure the intensity flexibility in various aspects of an organization. We believe that future qualitative or quantitative studies that collect data from different members in a specific supply chain might provide more informative results. We also expect additional new approaches to generating and managing SFC on the basis of a more critical investigation into industrial practices and an intensive review of the existing literature, which would enrich both theoretical and managerial development. With further refinement of the measures, research in SFC could progress into new areas that may have a higher probability of building and confirming substantive theories.

References


