SUPPLY CHAIN INNOVATION: CONCEPTUALIZATION, INSTRUMENT DEVELOPMENT, AND INFLUENCE ON SUPPLY CHAIN PERFORMANCE

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Abstract A supply chain (SC) is seen as a source of competitive advantage, and SC innovation has become a critical research topic in business-to-business marketing and production. However, the main obstacle to empirical research on SC innovation is a lack of validated and well-developed scales to measure it. Therefore, developing a measurement scale for the SC innovation construct is necessary. This paper describes the development and validation of a third-order SC innovation scale based on the collection of primary quantitative and qualitative data. SC innovation was then operationalized as a multidimensional construct with three aspects, namely, marketing, technology development, and logistics-oriented innovation activities, resulting in 31 measurement items. The developed SC innovation scale applies to the textile and apparel industry primarily. Business-to-business marketers can apply this empirically validated scale to evaluate their SC innovation efforts and identify areas for improvement.

Practitioner Points

- By applying the framework developed for SC innovation in this study, managers can define the specific areas and elements of SC innovation that they need to manage and consider.
- SC innovation was operationalized as a multidimensional construct with three aspects, namely, marketing, technology development, and logistics-oriented innovation activities, resulting in 31 measurement items.
- The measurement scale developed for SC innovation can become a benchmark for practitioners' evaluation of the effectiveness of SC innovation.

Keywords Supply chain innovation, Supply chain research, Instrument development, Scale validation, Measurement model, Empirical study

1. INTRODUCTION

Innovation refers to the development and implementation of ideas (Edmondson, 2003; Alexander and Knippenberg, 2014), which is critical to organizational success and is often cited as an important competitive resource for firms (Roussel et al., 1991; Cooper et al., 1998; Chao and Kavadias, 2008). Craighead et al. (2009) highlighted that the supply chain (SC) is now considered a source of competitive advantage. Well-managed innovation processes among firms in an SC network result in innovations that enhance SC effectiveness (Roy et al., 2004). Bello et al. (2004) explained that SC innovation includes new investment and the distribution of a set of activities to SC members to maximize revenue through greater service effectiveness and lower costs, thereby achieving more joint profits through greater operational efficiency.

SC innovation has received increasing scholarly attention in the business-to-business marketing domain because of its potential to influence organizational outcomes, such as economic prosperity, service effectiveness, and operational efficiency (Coltman et al., 2010; Isaksson et al., 2010; MacCarthy et al., 2016; Kim and Chai, 2017). Kusi-Sarpong et al. (2018) further argued that SC innovation affects sociocultural and environmental issues. However, few studies have focused on the conceptualization of the SC innovation construct (Bello et al., 2004; Lee et al., 2011), and no research has explored the development of instruments to operationalize this construct (Wong and Ngai, 2019).

Therefore, the theoretical motivation for this study was to provide valuable insights to both researchers and practitioners who deal with SC innovation. Inconsistencies in the conceptualization and operationalization of SC innovation in the literature have resulted in slow progress in its study (Chen and Paulraj, 2004). There is thus a need for valid and reliable instruments to evaluate SC innovation, especially as firms rely increasingly on innovation to help them compete efficiently and effectively (Govindarajan and Kopalle, 2006). Therefore, this study focused on the development of a survey instrument for SC innovation, and the resulting insights contribute to the literature on SC innovation.

SC innovation is regarded as a complex construct that is strengthened by cooperative ties and joint product development between buyers and suppliers (Flynn et al., 2010; Inemek and Matthyssens, 2013). SC stakeholders are becoming increasingly involved in the innovation process, particularly in the area of SC. A key component of SC innovation in this context is the management of inter-organizational relationships among partners. Jajja et al. (2018) introduced the term SC integration to refer to strategic collaboration with key SC partners to achieve the efficient and effective management of inter- and intra-organizational activities involving joint decision making and the flow of finance, information, services, and products. SC integration also refers to the degree to which a firm deploys its capacities and resources collaboratively with channel partners (Liu et al., 2016). The goal of SC integration is to offer higher value to customers; transfer capital, information, services, and products more efficiently; and make decisions that lower costs (Lii and Kuo, 2016). However, research on SC innovation remains limited (Lavastre et al., 2014). In this study, we examined key aspects of SC innovation as a basis for conceptualizing and operationalizing the construct.

We developed a reliable and valid instrument to empirically evaluate a firm's SC innovation using data collected from the apparel and textile industry. According to Moon et al. (2012), using a single industry removes the noise from potentially confusing elements, such as complex manufacturing processes, macroeconomic conditions, volatile market demand, and the competitive environment. Although the processes, equipment, and techniques are unique and specific to the industry, the apparel and textile SC presents more challenges and opportunities than other industries, such as the variety of new products, impulse buying, fluctuating demand patterns, low predictability, and short product life cycles. Moreover, effective SC innovation is essential to improve SC performance in the apparel and textile industry.

The way in which SC innovation benefits firms remains relatively unexplored empirically (Hazen et al., 2012; Ageron et al., 2013). How can an organization measure its SC innovation? More importantly, what is a suitable metric that not only assesses SC innovation but also gives managers insight into problem areas? The need for an empirically valid and reliable instrument to measure SC innovation to answer these questions is increasing as firms depend more heavily on innovation to be competitive. However, despite the various definitions of SC innovation proposed by scholars (see Bello et al., 2004; Roy et al., 2004; Arlbjorn et al., 2011), few studies have discussed the conceptualization of SC innovation as a construct. Additionally, no studies have attempted to develop measurement scales to operationalize this construct (Wong and Ngai, 2019).

2. REVIEW OF SC INNOVATION

2.1. Resource-based view (RBV), dynamic capabilities view, and SC innovation

RBV. The widely advocated resource-based view (RBV) theory (Barney, 1991; Barney, 2001) refers to all of the resources of a firm (Priem and Butler, 2001), and contends that firms with valuable, scarce, and non-substitutable resources obtain a sustainable competitive advantage. Among a firm's resources, scholars consider the internal technology resource base to be the main driver of innovation (Hoskisson et al., 1999; Hitt et al., 2001; Benner and Tripsas, 2012). Firms can also obtain complementary capabilities and resources from their SC partners to promote innovation (Zimmermann et al., 2016; Shou et al., 2018). Scholars have used the RBV to describe how firms can increase their competitive advantage and enhance their capabilities through collaboration (Adams and Graham, 2017). From the RBV perspective, external stakeholders are resources that can provide valuable knowledge for a firm (Kazadi et al., 2016). Firms are motivated to share resources with business-to-business partners for exploitative purposes, and gain leverage and develop existing resources and knowledge to reach their performance goals (Adams and Graham, 2017). Researchers recognize knowledge sharing as a key relational norm in business-to-business relationships (Amit and Schoemaker, 1993), and knowledge creation as relying on collaboration among business-to-business partners (Adams and Graham, 2017). These findings have been widely discussed in the innovation literature, and the RBV assumes that the resources of a firm, whether tangible or intangible, provide an advantage that significantly determines its position relative to other firms (Lavastre et al., 2014).

Dynamic capabilities view. Innovation is one of a firm's dynamic capabilities (Schilke et al., 2018). Based on Schumpeter's (1934) theory of innovation-based competition, the dynamic capabilities view refers to a firm's ability to build, combine, and reconfigure its knowledge and resources to cope with environmental uncertainty (Teece et al., 2007; O'Reilly and Tushman, 2008). Ancona et al. (2001, p. 658) further explained that dynamic capabilities "are rooted in the streams of innovation—in simultaneously exploiting and exploring."

Although the RBV states that firms must develop capabilities to gain a competitive advantage and overcome difficulties, capabilities are not clearly delineated in changing environments. In addition, there is no clear explanation of how and why firms gain a competitive advantage in an uncertain environment. Previous studies have shown that the dynamic capabilities view can be seen as an extension of the RBV (Wernerfelt, 1984; Barney, 1991). The dynamic capabilities view fills a gap in the RBV theory by organizing the capabilities and resources that deal with situation-specific changes (Eisenhardt and Martin, 2000) and considering contingency characteristics. To succeed in the global market, firms must simultaneously create variations through exploratory innovation and explore current resources and technologies to ensure efficiency (March, 1991; Teece, 1997; Yalcinkaya et al., 2007).

2.2. Review of the SC process

The SC process is a major element of SC management (Potter et al., 2011). Key SC processes include product development and commercialization and customer service management (Lambert and Cooper, 2000). Radical product innovations tend to initiate the demand for new SC processes, production, and service delivery, therefore increasing a firm's process innovation propensity (Piening and Torsten, 2015).

Each business partner in the SC process should understand the strategic and systemic implications of coordinated activities within the chain to obtain balanced and improved performance of the SC and its member firms (Min et al., 2007). For example, the marketing function requires not merely fulfilling orders but full integration into the SC process (Brindley and Oxborrow, 2014). Technology in the SC process improves internal operations and provides immediate communication and efficiencies with suppliers (Robinson and Malhotra, 2005). Logistics is the part of the SC process that controls, plans, and implements the effective flow, efficient services, and storage of goods and relevant information from the points of origin to consumer consumption (Lambert and Cooper, 2000).

2.3. Definition of SC innovation

SC innovation has been defined as "a change (incremental or radical) within the SC network, SC technology, or SC process (or combinations of these) that can take place in a firm's function, within a firm, in an industry or in a SC in order to enhance new value creation for the stakeholder" (Arlbjorn et al., 2011, p. 8). SC innovation includes changes in services, processes, or products and technological improvements in procedures and processes that increase customer satisfaction and efficiency (Roy et al., 2004; Seo et al., 2014). For example, UPS, FedEx, and DHL innovated and improved their logistics-related processes, while Apple, Samsung, and Microsoft included SC innovation in their global SC (Golgeci and Ponomarov, 2013).

SC innovation can also be defined as a set of complex processes implemented to meet customer requirements and cope with environmental uncertainty by using new technologies to improve organizational processes (Lee et al., 2011). An example is Dell, with its closed-loop recycling system that uses 11.7 million pounds of recycled plastics in its new products (Kahn, 2018). In addition, SC innovation connects flexibility and business model integration within the SC (Ahl et al., 2018). Another important role of SC innovation is to increase the speed and breadth of information flow and improve information channels for better service quality (Kwak et al., 2018). Chang et al. (2019) suggested that customer response, inventory, and product manufacturing processes can all benefit from SC innovation. For example, SC innovation focuses on market demand, increasing customer value propositions (Flint et al., 2008). Another example is the ability of logistics firms to adopt innovations to increase the bottom line for shippers (Wagner, 2008).

Whatever its definition, the problems related to SC innovation are varied and multiple. In this context, Wong and Ngai (2019) pointed to the growing need for valid and reliable instruments to evaluate SC innovation, as firms rely increasingly on innovation to help them compete efficiently and effectively. In this study, we conceptualized and developed an empirically valid and reliable instrument for measuring SC innovation.

3. CONCEPT, FRAMEWORK, AND INSTRUMENT DEVELOPEMNT

The conceptualization of SC innovation and the development of the survey instrument followed the three phases of scale development recommended by Chin et al. (1997) and the 10-step procedure proposed by MacKenzie et al. (2011). Various methodological strategies were integrated in the construct conceptualization, measurement scale development, and validation (Straub, 1989; Straub et al., 2004; DeVellis, 2016). As shown in Figure 1, the initial phase was developmental. We conducted a comprehensive review of SC innovation from the literature to gain an initial understanding of innovation and to help us define and identify the main themes (see Appendix A). We then extended the review by Wong and Ngai (2019) from 1999–2017 to 2020 (see Appendices C, D, and E). From this review, we created three sub-constructs, namely, marketing-oriented innovation activity (MOIA), technological-development-oriented innovation activity (TDOIA), and logistics-oriented innovation activity (LOIA). We then constructed a content database of SC innovation studies (see Appendix F) and their sub-constructs (see Appendix G). Finally we constructed a comprehensive taxonomy of the SC innovation construct (see Appendix H) with nine dimensions and three measurement scales. The measurement items and initial questionnaire are presented in Table 1.

The second phase was exploratory. An initial questionnaire was pre-tested with focus group discussions and card sorting exercises. This allowed us to check the understandability of the questions and clarify and reformulate some of the questions so that our questionnaire could be understood by various stakeholders in the SC innovation process of the apparel and textile industry. Next, our initial measurement scale was administered as a questionnaire in a scale pretest and pilot test. The reliability, validity, and factor structure of each scale were then tested. Based on these results, the instrument was structured, tested, and purified.

The final phase was confirmatory. Reinforced by a solid theoretical background, the refined questionnaire was administered to a new sample, and the convergent, discriminant, and nomological validity were assessed. By the end of this phase, 298 SC professionals had been surveyed to measure SC innovation. The three phases of the study were executed over one and a half years. In the following sections, we describe in detail the stages of the development and validation of the measurement scale.

<<Inert Figure 1 about here>>

3.1. Conceptualization of SC innovation

Although aspects of SC innovation have been recognized for decades (e.g. Desbarats, 1999), researchers have taken different perspectives on the construct (Lee et al., 2011). For instance, many related disciplines have influenced the theory of SC innovation, including SC collaboration (Soosay et al., 2008), SC risk (He, 2017), cultural competitiveness (Hult et al., 2002), value chain strategies (Jayaraman and Luo, 2007), ego network innovation (Carnovale and Yeniyurt, 2014), SC integration (Vickery et al., 2003), and strategic supply management (Yeung, 2008).

In addition, members of different functional areas in the same firm (process development, marketing, information technology, logistics, etc.) hold different views of SC innovation. For example, Desbarats (1999) articulated six perspectives on SC innovation, and Isaksson et al. (2010) described three. Third, firms may display different patterns of innovation depending on their organizational context (Bello et al., 2004; Yaibuathet et al., 2008; Huo et al., 2013). Finally, researchers do not agree on the level of analysis at which SC innovation is enacted (Sarkis, 2012). In light of these discrepancies, identifying the operational definitions of SC innovation that are most useful for research and practice is essential.

According to Eisenhardt and Martin (2000), dynamic capabilities are strategic organizational routines that enable firms to reach new resource configurations to create and adapt to market changes. Product development routines are an example of dynamic capabilities recognized in the literature (Eisenhardt and Martin, 2000; Wheeler, 2002). Bello et al. (2004) defined SC innovation as a combination of technology and information technology development, combined with new marketing and logistics procedures to improve service effectiveness, revenue, joint profits, and operational efficiency. According to this definition and the dynamic capabilities view, SC innovation comprises three main innovation activities: MOIA, TDOIA, and LOIA. A conceptual definition of SC innovation was evaluated through content analysis of the literature on SC innovation. Techniques were applied to concisely describe and systematically analyze the content of the literature. The content analysis was used to support the current theory on the definition of SC innovation by Bello et al. (2004), which presents three SC innovation sub-processes. In addition, the content analysis revealed further key activities of SC innovation.

A comprehensive view of SC innovation can help researchers to analyze and identify areas of investigation. The major studies on SC innovation from 1999 to 2017 are shown in Appendix B, which classifies the reviewed articles by author, year, and theme. We applied the framework of Ngai et al. (2009) to evaluate and select articles during our literature review. As shown in Figure SF1, this framework had three phases: an online database search, initial classification of journal articles by the first researcher, and independent verification of the classification by the second researcher.

First, seven well-known online journal databases (i.e., Science Direct, IEEE Transactions, Ingenta Journals, Emerald Fulltext, Business Source Premier, Academic Search Premier, and ABI/INFORM Database) were selected. As the review focused on core academic research, we excluded conference papers, newspapers, dissertations, theses, textbooks, unpublished papers, and newspapers. This confined our literature review to papers referenced by the abovementioned databases. We selected the articles using the keyword "supply chain innovation," which produced approximately 3,000 articles.

Using the definition of Bello et al. (2004), we extracted the following domains from the list of related studies: MOIA, TDOIA, LOIA, service effectiveness, economic prosperity, and operational efficiency. In addition, we extracted articles on environmental protection and social responsibility using the definition of Lee et al. (2011), highlighting that SC innovation can help to ensure environmental protection and product safety. These eight domains were selected owing to their frequent recurrence in the SC innovation literature (Wong and Ngai, 2019). During the screening process, we eliminated journal articles that did not focus on SC innovation and articles that were listed twice. All selected articles were written in English. Overall, 155 articles were selected from 32 journals and each article was reviewed thoroughly and analyzed by two independent researchers to reduce bias. Each reviewer offered his/her views on the theme in each article, such as (1) demographics; (2) organizational action; (3) outcomes; (4) output. Finally, each article was classified by authors and publication year, and a framework was developed accordingly.

No single measurement instrument is able to satisfy all perspectives. Obtaining an appropriate measure and definition of the concept can only be temporary with such a complex and emerging subject. Although the definition of an emerging concept such as SC innovation may not be entirely effective (Lee et al., 2011), our research effort makes a contribution toward this goal. In addition, reviewing, testing, and developing a measurement sample to adequately represent significant perspectives is beneficial for the field.

Given the diversity of the available definitions, it is necessary to interpret and explain the basis on which the definitions were operationalized into measures. After considering the different perspectives applied by theorists to categorize the SC innovation concept, we focused on four typical perspectives (see Appendix B): demographics, organizational actions, outcomes, and output. Templeton et al. (2002) examined four arguments in favor of centralizing operationalization efforts from the perspective of social action, which we used for our organizational action perspective: 1) it accesses the levels of analysis that are active during SC innovation; 2) it provides a means of evaluation for members of the organization to formulate SC innovations; 3) it has the greatest potential for use in SC innovation research; and 4) it currently has a cumulative tradition of acceptance in the field. All of these justifications are intended to facilitate managerial practices in SC innovation.

The ontological specification process (Templeton and Snyder, 1997) was used in the content analysis of the literature review. It consisted of four steps: 1) select the theme; 2) designate concepts for the entire construct; 3) transmit to a reusable method; and 4) use of concepts in labeling source. Accordingly, the definition of SC innovation was determined

(Wong and Ngai, 2019) and incorporated into the conceptual definition of this study as follows:

SC innovation refers to a set of innovative actions (marketing-oriented innovation activities (MOIA), technological-development-oriented innovation activities (TDOIA), and logistics-oriented innovation activities (LOIA)) within the SC that intentionally or unintentionally influence positive SC changes.

3.2. Developing a framework for SC innovation

Our aim was to identify all innovation activities that comprise SC innovation and lead to increased SC performance. The literature has acknowledged that more SC innovation is needed for firms to develop better SC performance with their SC partners (Roy et al., 2004; Henke and Zhang, 2010; Modi and Mabert, 2010). However, what constitutes SC innovation and the structure of this construct has not been clearly defined.

The three categories of innovation activity identified in sub-section 3.1, MOIA, TDOIA, and LOIA, each include different areas of innovation activity. First, we constructed a content database of SC innovation studies (see Appendix F). The literature was found to offer a rich source of measurement indicators. Most previous studies have determined the concept of SC innovation as a function of the research question. For example, Allred et al. (2011) focused on customer orientation; Jayaram and Pathak (2013) emphasized market knowledge acquisition; Chiou et al. (2011) focused on product innovation; Acharya et al. (2019) emphasized information management; Beltagui et al. (2020) focused on innovation orientation; Cheng et al. (2014) emphasized IT infrastructure; Jin et al. (2014) focused on logistics flexibility; Dai et al. (2019) emphasized logistics innovation, and Carter and Jennings (2002) highlighted logistics social responsibility. Therefore, our conceptualization encompassed all of these different areas of SC innovation.

Our first step in developing a measurement scale comprised coding and extracting the measures from existing articles in accordance with the three types of innovation activity, i.e.

MOIA, TDOIA, and LOIA. Two coders who were not connected to the project classified the existing measures according to the nine identified components. They were free to code a given measure into one or more of the nine components, or into a "not-applicable" domain that would be re-evaluated if additional components emerged. The level of simple agreement across coders was 0.73, and the more conservative Cohen's kappa was $\kappa = 0.69$, indicating substantial interrater reliability (Landis and Koch, 1977). Disagreements were resolved mutually and the allocations are illustrated in Appendix F.

We then constructed a presentation of the sub-constructs from the previous literature (see Appendix G). Organizing the literature by theoretical base shows that SC innovation is a third order construct, with each of the three domains comprising three underlying elements. The majority of studies (89.8%) used only one of the three domains (e.g., MOIA focus: Chen and Pauraj (2004); TDOIA focus: Cheng et al. (2014); LOIA focus: Flint et al. (2005)). However, the literature was skewed toward TDOIA: among the 59 papers in our sample, 13 (22.0%) involved MOIA, 21 (35.6%) involved TDOIA, and 19 (32.2%) involved LOIA. Information management (11 papers, 20.0%) was the most frequently addressed element of SC innovation, whereas customer orientation (4 papers, 7.3%), innovation orientation (4 papers, 7.3%), logistics social responsibility (4 papers, 7.3%), and market knowledge acquisition (4 papers, 7.3%) were least addressed. No studies addressed all three domains, and only a few included two domains: 3 papers (5%) addressed both TDOIA and LOIA, 2 papers (3.4%) considered both MOIA and LOIA, and 1 paper (1.7%) included both MOIA and TDOIA. The results are quantitatively described in Appendix G.

Our proposed taxonomy was thus built by organizing and integrating the suggestions from various studies of innovation activity by SC professionals, each of which used a variety of labeling, coverage, categories, and frameworks, as shown in Appendix H. Our literature review revealed a gap, in that no papers have studied all components of MOIA, TDOIA, and LOIA, as shown in Appendix G. Thus, on the basis of the sub-construct elements of MOIA, TDOIA, and LOIA determined from the content database of SC innovation studies (Appendix F), we developed a comprehensive taxonomy of SC innovation. This taxonomy could be considered a superset of previous work in the area to date that brings a new structure and organization to the items proposed by the literature. Our proposed taxonomy comprises the three broad categories of MOIA, TDOIA, and LOIA, each of which is further divided into three specific areas of innovation activity. One of these categories has the ability to communicate efficiently and work effectively with the other party and partly understand what the other party does, thereby enabling them to successfully collaborate with another party. Our literature review of the content of the SC innovation studies (Appendix F) exposed three underlying components of MOIA, which can be categorized into customer orientation, market knowledge acquisition, and product innovation. Similarly, TDOIA can be categorized into information management, innovation orientation, and IT infrastructure flexibility, and LOIA into logistics flexibility, logistics innovation, and logistics social responsibility. These nine categories were used in this study. The next section discusses the components of the taxonomy.

Step One—Construct definition

According to MacKenzie et al. (2011), the first step in the development of a survey instrument is to develop a conceptual definition of the constructs. Indeed, significant measurement errors will occur during the testing phase if the focal constructs have no detailed and precise conceptualization (DeVellis, 2016). In this study, our proposed taxonomy involved nine specific areas of innovation activity arranged under three categories: MOIA, TDOIA, and LOIA. MOIA represented new marketing procedures, TDOIA included information and related technology development, and LOIA covered new logistics procedures, as specified in the literature (Bello et al., 2004; Wong and Ngai, 2019). The following sections illustrate the elements of the taxonomy.

3.2.1. Marketing-oriented innovation activities (MOIA)

The first dimension, MOIA, was defined as innovative marketing-related services and inspirational customer research that meets customer requirements (Desbarats, 1999; Chen and Paulraj, 2004). Desbarats (1999) stated that marketing has a core strategic responsibility of the customer–supplier relationship. Supplier integration and collaboration play a significant role in SC innovation. Thus, when suppliers are not aligned with innovation, firms are unlikely to achieve SC innovation (Jajja et al., 2017). Firms develop their SC innovation upstream and internally for this purpose (Ageron et al., 2013).

MOIA included:

1) Customer orientation

2) Market knowledge acquisition

3) Product innovation

Customer orientation. Customer orientation refers to sufficient understanding of customers to provide them with excellent value at all times (Wang et al., 2016). Jean et al. (2012) emphasized that customer orientation is strategically critical for business innovation. In addition, Chen and Pauraj (2004) noted that the main purpose of business is to meet the needs of customers, which is also the main purpose of marketing. Customer orientation helps to develop processes for customer satisfaction and increase understanding of customer expectations (Allred et al., 2011). Consequently, it improves firm creativity to meet the needs of customers (Jean et al., 2012).

Market knowledge acquisition. Market knowledge acquisition refers to an external knowledge integration mechanism to capture, interpret, and deploy a firm's knowledge base

(Zhou and Li, 2012). It stimulates the absorption of important knowledge from external market sources, which include both competitors and customers (Jean et al., 2012). Market knowledge acquisition helps to increase knowledge identification via explorative learning (Zhou and Li, 2012), while innovative ideas are likely to arise from the arrival of new information of foreign origin. The integration of downstream and upstream knowledge in an SC occurs via various processes over time and is likely to influence different areas of product development (Jayaram and Pathak, 2013).

Product innovation. Product innovation refers to a firm's ability to develop new services and products to meet customer expectations (Damanpour and Gopalakrishnan, 2001). Firms focus on the needs of their customers and develop value-added services and better products to meet their needs (Melnyk et al., 2009). Product innovation is a multi-disciplinary process, and although "all functional interfaces are important in the product development process, the R&D–marketing interface is one of the most critical" (Gupta et al., 1986, p. 7). One example is the refining of a current product design to reduce its negative environmental impact (Chiou et al., 2011). Zhang et al. (2002) further explained that product innovation positively contributes to design improvement and manufacturing flexibility. Firms must constantly innovate and quickly bring these innovations to the market to meet customer demand for new products and beat the fast pace of technology (Koufteros et al., 2007).

3.2.2. Technological development-oriented innovation activities (TDOIA)

The second dimension, TDOIA, was defined as the creation of new knowledge and technical skills that can help develop new products and services for customers (Lee et al., 2011). Storer et al. (2014) highlighted that SC innovation often involves collaborative relationships and partnerships that can be mutually beneficial, especially with regard to the application of industry-led and industry-wide innovation, such as information systems and new technologies. In addition, Vanpoucke et al. (2009) stated that IT has a direct effect on coordination and leads to SC innovation. Indeed, IT has a positive influence on process innovation and has been identified as a key element of SC innovation (Sanders, 2005; 2008). According to the literature, the success of SC networks is highly dependent on the long-term commitment of SC members and their ability to share the risks associated with process design, joint service/product design, and SC innovation (Harland et al., 2003; Wakolbinger and Cruz, 2011).

We identified three areas of innovation activities in TDOIA based on the literature:

1) Information management

2) Innovation orientation

3) IT infrastructure flexibility

Information management. Information management refers to the process of distributing, protecting, processing, storing, collecting, defining, and identifying information (Olaisen, 1990). It involves the management and availability of relevant and timely information (Devaraj et al., 2007). Prajogo et al. (2018) pointed out that a large amount of external and internal information can be captured by firms through information technology. When firms possess sufficient technical know-how or can access this knowledge economically or easily, they are likely to achieve logistical and technological innovations (Claycomb et al., 2005). A good example of applied corporate information management is improving information availability through big data analytics to enhance the provision, exploration, availability, assessment, and discovery of information and data (Kache and Seuring, 2017).

The application of information technology also affects coordination. Indeed, current processes can be improved incrementally throughout their operation, directly influencing operational coordination (Sanders, 2008). The literature has shown that the uptake of information technology leads to increased information exchange between SC partners, resulting in process innovation and SC restructuring, accompanied by the production of more customer-specific, more diverse, and less expensive products (Vickery et al., 2003; Yu et al., 2017).

Innovation orientation. Innovation orientation represents a firm's tendency to change and its openness to new things through the use of new skills, technologies, administrative systems, and resources (Chen et al., 2011). Hurley and Hult (1998) pointed out that innovation orientation is a critical factor in overcoming barriers and reinforcing a firm's capability to successfully implement new developments. Customers prefer services and products that "generate the greatest interest and provide the greatest performance, features, quality, and value for money – in short, technological superiority" (Berthon et al., 1999, p. 37). Berthon et al. (1999) further noted that "managers in firms that enact a technological innovation orientation devote their energy towards inventing and refining superior products" (p. 37). According to Zhou et al. (2005), innovation orientation affects organizational innovation. Golgeci and Ponomarov (2013) argued that innovation orientation accounts for innovation adoption and outputs. Firms with a greater capacity for innovation achieve higher performance and a competitive advantage (Hurley and Hult, 1998).

IT infrastructure flexibility. IT infrastructure flexibility refers to a set of firm resources to provide future information technology usage and high-speed development (Cheng et al., 2014). The flow of information between SC partners can be accelerated to create IT infrastructure and business value (Li and Ye, 1999; Bharadwaj, 2000; Byrd and Turner, 2001; Bhatt et al., 2010). Apart from being vital to a firm's ability to use information technology competitively (Duncan, 1995), IT infrastructure flexibility allows for the innovative rethinking of key business processes (Broadbent et al., 1999). Moreover, the performance of inter-organizational innovation can be enhanced by IT infrastructure flexibility between partners through the integration of geographically separated systems and the sharing of resources (Cheng et al., 2014).

3.2.3. Logistics-oriented innovation activities (LOIA)

The third dimension, LOIA, is defined as logistics-related services that are new and useful to a specific target audience. Innovation improves operational efficiency (the internal audience) and better serves customers (the external audience; Flint et al., 2005; Grawe, 2009). Logistics provide firms with time and space utilities, guarantee the necessary amount of goods at the right time and place, and reduce organizational slack. They require close, coordinated, and intensive information exchange between SC partners (Chen and Paulraj, 2004). Eschenbacher et al. (2011) noted that SC innovation processes are examples of inter-organizational and distributed innovation processes (DIPs) coordinated by an SC hub and often executed by a large firm. Moreover, logistics service providers assume a new role in service SCs through the innovative combination of generic digital manufacturing and conventional logistics services (e.g., the F-18 Super Hornet; Holmstrom and Partanen, 2014). Benetton, Whirlpool, and Hewlett Packard (HP) even significantly modified their current SC practices as part of their disruptive SC innovation project (Hult et al., 2010).

We identified three areas of innovation activities in LOIA from the literature:

1) Logistics flexibility

2) Logistics innovation

3) Logistics social responsibility

Logistics flexibility. Resource-based logistics flexibility refers to a firm's ability to quickly respond to customer needs for service, support, and delivery (Zhang et al., 2002). Prater et al. (2001) further described it as a firm's procurement system to efficiently, quickly, and accurately adapt to different delivery and receipt requests. It involves managing information and material flows between firms and their SC partners (Yu et al., 2017). According to Claycomb et al. (2005), flexibility helps firms adopt innovation. Jin et al. (2014) pointed out that logistics flexibility promotes innovation in supplier interactions and leads to greater competitive performance. A good example is the launching of reverse logistics and marketing waste management systems to improve performance (Richey et al., 2005; Melnyk et al., 2010). However, the competitive advantages formed by innovative processes and novel products disappear rapidly without the support of logistics and production (Teece, 1986).

Logistics innovation. Logistics innovation refers to novel interventions designed to explain the mechanisms and achieve specific ends through which logistics-related innovation has been adopted and introduced in practice successfully, diffusing to other parties beyond the originators and offering economic value. (Tanskanen et al., 2015). Studies by Lee et al. (2011), Manuj et al. (2014), and Tanskanen et al. (2015) have shown that other stakeholders (e.g., suppliers) should be included in logistics innovation. In addition, Wagner (2008) pointed out that external and internal R&D is related to logistics innovation. Flint et al. (2008) further suggested that there is a positive correlation between a firm's overall performance, innovation performance, learning process, and logistics innovation.

Value is generated through the design and delivery of logistics processes to meet new customer demands (Melnyk et al., 2009). Claycomb et al. (2005) pointed out that logistics innovations improve significantly when technologies become more routinized and better understood. Good examples are Holcim's track-and-trace Personal Digital Assistant and DHL Exel Supply Chain's Radio Frequency Identification technology, leading to efficient and effective internal processes (Wagner and Sutter, 2012).

Logistics social responsibility. Logistics social responsibility refers to socially responsible logistics management (Carter and Jennings, 2002). Ciliberti et al. (2008) suggested that logistics social responsibility focuses on "socially responsible management of the SC under a cross-functional perspective" (p. 89). It is a method of combining sustainability with SC processes (Mejías et al., 2016). Hall (2006) pointed out that "customer firms invest in environmental supply chain innovation because suppliers with poor environmental practices can expose the customer firm to high levels of environmental risks" (p. 233). Gruchmann and Seuring (2018) further stated that "From a sustainability perspective, logistics service providers should actively use their experiences from logistics social responsibility practices to further develop sustainably logistics services" (p. 1268). Ciliberti et al. (2018) identified 252 socially responsible purchasing practices (p. 95), and Piecyk and Bjorklund (2015) suggested a number of measures for logistics social responsibility, such as health and safety, workplace diversity, environment, and employee training. Similarly, Carter and Jennings (2002) recommended that ethics and human rights be included as dimensions of logistics social responsibility.

Thus, our proposed three-level model of firm SC innovation consists of three categories of innovation activity, MOIA, TDOIA, and LOIA, each with three components. Appendix J summarizes the first-order constructs and definitions, while Appendix K summarizes the second- and third-order constructs and definitions.

3.2.4. Effects on SC performance

SC innovation can potentially influence organizational outcomes related to social responsibility, environmental protection, economic prosperity, service effectiveness, and operational efficiency (Bello et al., 2004). Agarwal et al. (2007) further explained that SC performance can be increased by improving the level of service. However, no empirical study has examined the relationship between these areas of innovation activity and SC performance.

Roy et al. (2004) stated that SC innovation can be implemented by the sharing of processes among the many firms in the SC network, particularly innovative activities that can enhance the effectiveness of the SC, leading to a competitive advantage for the firms involved. In addition, Kroes and Ghosh (2010) suggested that a firm's SC performance has a positive and intuitive effect on business performance. Baum et al. (2010) further argued that when a firm innovates, its competitive advantage and profits increase compared with other firms in the industry. Thus, firms are likely to engage in various types of innovation activity to achieve higher levels of SC innovation, positively influencing SC performance. In this study, the contribution to SC innovation of the different types of innovation activity was tested through their SC performance.

3.3 Development of the SC innovation measurement instrument

Step Two—Measure development

After clearly defining the constructs of interest, the next step in the survey instrument development procedure was the creation of items to develop and refine a measurement scale (MacKenzie et al., 2011). Scale development is an important step in empirical research on business-to-business marketing (Menor, 2000; Stratman and Roth, 2002). In some cases, the refinement and iterative design of multi-item scales are also used to investigate the constructs. The validity of a scale depends on the implementation of reliable measures (Churchill and Iacobucci, 2006), and the relationships among different operational concepts can only be empirically estimated using valid and reliable measurement scales. Our objective was to measure the three second-order constructs discussed in sub-section 3.2 by creating or locating a valid and reliable multi-item measurement scale. In addition to the definition of SC innovation, a list of first-order constructs describing SC innovation activities in firms was included in the taxonomy (see Appendix H). These items were applied to produce the original statements of the instrument, based on the literature review, with extensions in multiple areas. To ensure that the definition of SC innovation was consistent with the views on SC innovation by various stakeholders, an open-ended elicitation procedure was conducted before generating the items (Netemeyer et al., 2003). Below are the different steps followed to measure content validity throughout the survey instrument development process. Appendix I illustrates the demographics of the respondents and their firms.

Focus group discussion. We followed Davis's (1989) approach to focus group discussion.

We invited 10 participants, including six SC professionals with over 10 years' experience in the apparel and textile industry and four researchers with expertise in innovation and SC management to join a focus group. Throughout the group discussion, we 1) received feedback on the clarity, format, questions, and length of the draft and the instructions for the initial questionnaire; 2) identified low-ranking, inapplicable, or redundant items; 3) increased clarity by rewording certain items (i.e., face validity); and 4) allowed participants to independently rank the 64 items according to the closeness of their meaning to the underlying SC innovation factors by applying the nominal group technique (Stewart and Shamdasani, 2014). The 64 items were initially developed to capture the most essential aspects of the constructs outlined in Appendix J. After the focus group discussion, the initial set of 64 items was reduced to 48 items by eliminating low-ranking, inapplicable, and redundant items. Face validity was also enhanced by rewording certain items, resulting in a set of 48 items.

Card sorting exercise. To evaluate the extent to which the 48 items tapped the nine SC innovation factors and therefore supported construct validity, a card sorting exercise was conducted with the help of six judges (Moore and Benbasat, 1991; Hinkin, 1998). The initial phase of the exercise involved three SC professionals with over 10 years' experience in the apparel and textile industry and three researchers with expertise in innovation and SC management. None of the judges were aware of the content of our study. Each judge received a randomly sorted list of the 48 items and nine SC innovation factors (together with their definition) printed on 4 x 6 inch index cards. They were guided to individually assign each item to one of the nine factors or to an "uncertain" category if they were unsure of the best placement. After completing the sorting process, the judges explained why they put cards in the "uncertain" category (if applicable). For example, they all had difficulty with certain items because of confusing and ambiguous wording. To demonstrate, the item "Firms with SC innovation are technologically reputable" was ambiguous because it tapped other factors in the SC innovation framework, and the item "Firms with SC innovation help customers set high expectations" was too general to fit any of the nine proposed SC innovation factors. Accordingly, we eliminated 12 items that at least four of the six judges found confusing or ambiguous, resulting in 36 items. The average hit ratio was 0.85 among the nine SC innovation factors, and the average Cohen's kappa for good construct validity was 0.83 (Cohen, 1960).

The next phase of the card sorting exercise was to identify higher-order constructs in the construct conceptualization. We used a card sorting procedure similar to that of previous studies (Hoehle and Venkatesh, 2016). Constructs with similar characteristics and a common theme should be theoretically extracted and identified at a higher level (Edwards, 2001; MacKenzie et al., 2011). According to MacKenzie et al. (2011), it is essential that this step be completed once all constructs have been defined and conceptualized. We reviewed the literature for each identified first-order construct and carefully evaluated them (see Appendix J) based on their conceptual similarities. We discussed the characteristics of each construct and whether removing any of them would alter the domain of the construct (MacKenzie et al., 2011). Four new judges—two SC professionals with over 10 years' experience in the apparel and textile industry and two researchers with expertise in innovation and SC management—helped to identify the conceptual similarities between the constructs. Again, none of the judges were aware of the content of our study. Each judge received nine cards, each with a first-order construct name and its definition (see Appendix J) as determined in the previous step of the survey instrument development process. The card sorting results were then discussed and compared with the higher-order constructs determined by us. After thorough discussion between ourselves, our views matched those of the judges, and three second-order constructs were identified to represent the aggregations of the nine identified first-order constructs. Meanwhile, we also considered whether the second-order constructs could be represented by a third-order construct, i.e., a high-level abstraction (Rindskopf and Rose, 1988; Wetzels et al., 2009). By referencing previous studies (Bello et al., 2004; Wong and Ngai, 2019), we concluded that each second-order construct represented an area of SC innovation, and that it was useful and necessary to form a third-order construct. This was also based on the literature (Bello et al., 2004). Appendix K shows all of the conceptualized second- and third-order constructs and their definitions.

Step Three—Content validity assessment

Content validity refers to the degree to which a measurement scale represents all domains of a construct (Straub et al., 2004; Lewis et al., 2005; MacKenzie et al., 2011). According to MacKenzie et al. (2011), researchers must review two important areas when evaluating the content validity of a measurement scale: 1) are the items, as a set, collectively representative of the entire content domain of the construct? and 2) is each individual item representative of a specific area of the content domain of the construct? Unfortunately, in the field of SC innovation, no previous study has discussed the development of survey instruments to operationalize this construct (Wong and Ngai, 2019).

The original draft of the questionnaire included 36 questions about the participants' perceptions of the presence of SC innovation practices in their firm. The response categories of the measurement scale were as follows: 1 = Strongly disagree, 2 = Disagree, 3 = Slightly disagree, 4 = Neutral, 5 = Slightly agree, 6 = Agree, and 7 = Strongly agree. In addition, the initial questionnaire collected information on demographic variables such as job function, work experience, education level (individual data), and firm (organizational data).

Step Four—Measurement model specification

The next step in our survey instrument development process was the specification of the measurement model (MacKenzie et al., 2011). This focused on the relationships among the first-, second-, and third-order constructs and the specification of the links between the indicators and the constructs. Given the multidimensionality of the SC innovation construct, SC innovation was modeled as the higher-order construct of our survey instrument in a reflective-formative way (see Figure SF2; Ringle et al., 2012). The model assessed was a third-order construct model, with formative measures for the second- and third-order constructs and reflective measures for the first-order construct. At the first-order construct level, we modeled the measurement items as reflective of their areas of innovation activity, as they were caused by the measurement items (Chin, 1998a). In addition, the measurement items were strongly correlated with each other, supporting the fact that they represent the underlying constructs (Gefen et al., 2000, Becker et al., 2012). To decide a construct's directionality at the second- and third-order construct levels, MacKenzie et al. (2011) suggested the use of formative modelling if changes in one dimension would be linked with a change in the focal construct. In thinking through the relationship between the second-order constructs and SC innovation, we concluded that the three dimensions were the defining characteristics of SC innovation. For example, an increase in the level of MOIA would be reasonably associated with an increase in the overall innovation of an SC, and similar arguments could be made for all second-order constructs. Therefore, SC innovation should be modeled formatively (Petter et al., 2007). The same rationale was applicable between the first- and second-order construct levels. Thus, higher-order constructs were modeled as formative, indicating that they were the sum of, or formed by, innovation activities at the lower level (see Figure SF2).

Step Five—Scale pretest

Having specified the measurement model, the next step in the survey instrument development process was to pretest the instrument (MacKenzie et al., 2011). Based on grounded theory (Glaser and Strauss, 1967), exploratory qualitative research was conducted by pretesting the questionnaire. First, we consulted three academic professionals from the Hong Kong Polytechnic University to verify the validity of the appearance, format, organization, and content of the initial questionnaire. Then, we consulted two shipping managers, three sales managers, two IT managers, two production managers, and one director, all of whom had relevant knowledge of the apparel and textile industry. To improve the questionnaire, the participants were invited to comment on the terminology, understandability, content, format, and the ease and speed of completion. In addition, they were asked to identify any questions they felt should be deleted or added to the questionnaire. They were also invited to make recommendations for improvement.

Step Six—Scale purification

MacKenzie et al. (2011) recommended refining and purifying a survey instrument using pretest data. The measurement properties of the survey instrument in this study were evaluated using statistical tests on the pretest data, such as evaluating the reliability and validity of the individual indicators and removing weak indicators.

First, a pilot test was conducted to evaluate and purify the instrument after receiving the pretest revisions. The revised questionnaire was then e-mailed to 15 SC professionals in the apparel and textile industry, who were asked to complete the questionnaire and make suggestions for improvement.

The content validity of the survey was then evaluated quantitatively using a variant of the procedure (Lawshe, 1975). This technique used a content evaluation panel composed of SC professionals with knowledge of the SC innovation concept being measured. The content evaluation panel consisted of 15 individuals (different from the pilot test participants) from the apparel and textile industry. A copy of the revised measurement scale was sent to the panelists, and they were asked to rate each SC innovation activity on a 3-point scale: essential = 3, important (but not essential) = 2, not relevant = 1. After receiving their feedback, the content validity ratio (CVR) was computed for each measurement item based on the data by applying the formula

$$CVR = (n - N/2)/(N/2),$$

where N is the number of participants and *n* is the frequency count of the number of participants rating an item as important (but not essential) = 2 or essential = 3.

Compared with Lawshe (1975), who only used the “essential” response category to calculate the CVR, we applied a less stringent standard (Lewis et al., 1995), i.e., both “essential” and “important (but not essential)” response categories were taken as positive indicators of the items corresponding to SC innovation. The participants who did not rate a given item were excluded from the calculation of the content validity ratio for that item. Appendix L reports the CVRs and means of the items based on Lawshe’s (1975) procedure in a content validity index.

Following Lawshe’s (1975) procedure, the content validity ratio for each item was tested for statistical significance at the 0.05 level, i.e., where over 85% of panelists rated it as either “important” or “essential.” Consequently, 31 of the 36 items were considered significantly valid and remained in the final version of the questionnaire, and the other 5 (MOIA-b, MOIA-d, TDOIA-i, LOIA-e, and LOIA-f) were removed. Table 1 summarizes the scale items in the final questionnaire and the supporting literature.

<<Inert Table 1 about here>>

4. DATA COLLECTION

Step Seven—New sample data collection

Following MacKenzie et al. (2011), once the scale had been refined, pretested, and problematic indicators eliminated, the purified scale needed to be re-examined using new data collected from a fresh sample. We thus conducted an online panel survey in the apparel and textile industry to validate the conceptual framework for measuring SC innovation.

4.1. Selection of apparel and textile firms in China

For several reasons, we collected our survey data exclusively from firms in the apparel and textile industry in China. According to Wong and Ngai (2019), most previous research on SC innovation has focused on developed areas such as North America and Europe, thus our study represents one of the few attempts to explore this construct in East Asia. China is also the world's largest manufacturer and exporter of apparel and textiles, partly due to the rapid growth of its domestic market (Fong and Dodes, 2006). Most apparel and textile firms have relocated their production operations to China in recent decades to reduce production costs, making China the world's leading apparel and textile supply center (Moon et al., 2009). According to the World Trade Organization (2016), China's exports amounted to US$106 billion for textiles and US$161 billion for clothing, indicating an enormous market size.

4.2. Apparel and textile SC levels

Our literature review in sub-section 3.1 (see Appendix B) shows that most research on SC innovation has focused on upstream suppliers (62.6%), with far fewer studies of downstream customers (8.4%) or both upstream suppliers and downstream customers (29%). Gao et al. (2017) explained that SC innovation focuses primarily on manufacturing because of its core function of value creation. Indeed, the apparel and textile SC is multidimensional (Chan et al., 2017), complex (Jones, 2002), and lengthy (Bruce and Daly, 2011). It is customer-driven, with final customer demand determining product demand (garments, yarns, and fibers; Moon et al., 2012). Chan et al. (2017) proposed that the garment SC includes a trading sector (wholesalers, agents, and retailers) and a production sector (fibers, textiles, garments, and accessories). More recently, apparel agencies have been added to the SC as the outcome of the growing globalization of the industry (Popp, 2000).

Our aim was to investigate SC innovation from a holistic perspective; therefore, our data were collected from firm managers at different levels of the SC (Skippari et al., 2017). Figure SF3 describes the five main levels or categories of the SC structure, namely, fabric and textile producers, apparel manufacturers, apparel agencies, brand owners, and retailers. We further identified fabric and textile producers and apparel manufacturers as upstream suppliers, whereas apparel agencies, brand owners, and retailers were downstream customers. This wide variety in the sample allowed us to explore different patterns and generalize the results in the industry.

4.3. Survey administration

We used the online research service QQ Survey (Quality and Quick) China to collect our data. A recent study showed that 55.8% of China' population use the Internet (CNNIC, 2018). QQ Survey was selected for its active and large online survey community in China (Lyu et al., 2017; Lyu et al., 2018), in which nearly 5.1 million panelists had participated by 2019 (www.1diaocha.com). Compared with traditional online sampling, QQ Survey provides several important features, such as (1) control of recruitment and participant selection; (2) complete anonymity of the sample; (3) motivation to visit the recruitment location; and (4) incentive disbursement through built-in payment systems. It also enables the rapid and inexpensive gathering of a large amount of data with rich demographic diversity and high quality.

The original measurement scale was developed in English as it was adapted from the literature in English. A professor in the field of business-to-business marketing in China helped to translate the scale into Chinese to ensure the reliability of the questionnaire (Zhao et al., 2011). Several questions were reworded to suit China's business-to-business marketing practices and enhance the accuracy of the translation. Then, a Hong Kong professor in the field of business-to-business marketing back-translated the questionnaire into English, as all of the data collection analysis procedures were conducted in Chinese. Afterwards, an associate professor in the field of business-to-business marketing in China helped verify the translation against the original English version for accuracy. The bilingual version of the questionnaire was used in Hong Kong and a Chinese version in mainland China (Zhao et al., 2008). After completing the translation process, the questionnaire was linked to the QQ Survey agent website. The survey objective and participant recruitment requirements were described at the beginning of the survey. We emphasized that (1) the study only focused on the apparel and textile industry, thereby only individuals with SC-related experience in the industry were eligible to participate; and (2) the data collected by the questionnaire would be used for academic purposes only and accessible exclusively to the parties involved in the research. In addition, the questionnaire was conducted on an anonymous basis to comply with the privacy and confidentiality requirements. Moreover, as SC innovation might have been a new concept for some participants, a cover page clearly explained what SC innovation is and how and why it is applied in SC, to ensure that each participant had a basic understanding of SC innovation. At the beginning of the survey, a screen question was set up to filter out participants who failed the quality check questions, so that they were excluded from the analysis (Wetzels et al., 2009). Of the 1,400 invitations sent, 338 responses were obtained, a response rate of 24.1%. No missing data were found in the returned questionnaires as the web page prohibited this. After eliminating systematic variance due to social bias in the participants' responses (Boyer and Pagell, 2000), 298 usable responses were obtained. The valid response rate was 21.3%, which met the recommended minimum rate of 20% for empirical studies (Malhotra and Grover, 1988).

As China is vast with different levels of economic growth across regions (Zhao et al., 2008; Huo et al., 2014; Chavez et al., 2017), we strategically chose 10 industrial cities to provide economic and geographic diversity to the sample pool. Shanghai (in the Yangtze River

Delta) and Guangzhou (in the Pearl River Delta) have the highest and second highest GDP per capita in China, and both have the highest level of economic reform and marketization (Zhao et al., 2006; 2008). In addition, several industrial agglomerations of apparel and textile sub-industries are located in Zhejiang Province, such as warp knitting firms in Haining, tie manufacturers in Shengzhou, women's clothing manufacturers in Hangzhou and Ningbo, and chemical fiber manufacturers in Shaoxing (Lin et al., 2011). We also chose Tianjin because it is a large city in northern China in the Bohai Sea Economic Development Zone; Chongqing because it is a traditional industrial city in northwestern inland China representing an early economic development stage; and Hong Kong because manufacturers in Hong Kong operate differently from those in other Chinese cities, with their factories in mainland China and their headquarters in Hong Kong (Huo et al., 2014). We thus considered these cities to be representative of the different areas of China in the apparel and textile industry (Huo et al., 2014).

Moreover, the population frame of our sample was defined as SC professionals in the apparel and textile industry in China. Skippari et al. (2017) pointed out that SC innovation typically occurs at the operational and top management levels. The survey data were therefore collected from top management teams (chief executive officers and chief financial officers) and middle or frontline managers working in different functional areas of their firms with corresponding knowledge of the apparel and textile industry. These included fabric managers, trim and accessory managers involved in material sourcing, product development managers, procurement managers, production managers, brand managers, information technology managers, logistics (or shipping) managers, and sales and marketing managers. All of the participants had worked for more than five years in the industry and in their firm, ensuring their role in the success, maintenance, and development of their firm. These experienced SC professionals were targeted as participants as they were well qualified to answer questions on the implementation of innovation in SC. As younger or smaller firms may have comparatively fewer resources available to exploit innovation opportunities (Stam and Elfring, 2008; Li et al., 2011), our study included firm size and firm age as control variables. Appendix M summarizes the profile of our participants and their firms, which matched the conditions of diversity in terms of SC innovation, ranging from the textile and fabric sector to the fashion apparel sector. After completing the survey, the participants were given a non-expiring gift card with which to purchase store merchandise.

5. RESULTS

Step Eight—Assessing scale validity

This step aimed to evaluate whether the items used to analyze the focal construct 1) had discriminant validity, i.e., were distinguishable from the indicators of other constructs; 2) included the multidimensional nature of the construct; 3) accurately represented the underlying construct; and 4) had nomological validity, i.e., were related to the measures of other constructs in the theoretical framework (MacKenzie et al., 2011). The SC innovation model was evaluated using the partial least squares (PLS) method, a component-based approach particularly suited to smaller datasets. SmartPLS version 3.2.8 was used to test the higher-order model by means of the hierarchical component model (Wold, 1982; Lohmoller, 2013). PLS was a suitable choice for our third-order factor model with formative measures (Wetzels et al. 2009; Gefen et al. 2011) for the second- and third-order factors and reflective measures for the first-order factors. PLS also allowed the estimation of the structural model (the direction and strength of the relationships among the variables) and testing of the measurement model (measuring a variable using the psychometric properties of the scales) (Kankanhalli et al., 2015).

5.1 Evaluation of measurement properties

Following the procedures of Agarwal and Karahanna (2000), we used confirmatory factor analysis to evaluate the item loadings, reliability, and discriminant validity of the reflective constructs. To represent the latent variable, the reflective items should be unidimensional and correlated with each other. Hair et al. (2014) highlighted that the item loadings should be at least 0.70, so that more than half of the variance is explained by the constructs. The loadings of all 31 items were above this threshold, as shown in Table 2. The reliability of the constructs, a further requirement for construct validity (Nunnally, 1967), was evaluated by calculating Cronbach's alpha for each construct as illustrated in Table 2. In exploratory research, an alpha statistic of 0.5 to 0.6 is sufficient (Nunnally, 1978). As the alpha values were greater than 0.7 for six of the constructs and greater than 0.6 for another three constructs, the instrument showed reasonably reliability. Discriminant validity was confirmed because all of the indicators loaded more strongly on their own constructs than on the other constructs in the model, as shown in Table 3. Finally, as required by Hair et al. (1998), the minimum composite reliability value was above 0.70 for all of our constructs, therefore, all of the constructs had adequate discriminant validity and reliability (Gefen et al., 2000).

<<Inert Table 2 about here>>

<<Inert Table 3 about here>>

The results of the measurement model confirmed the reliability and validity of both the 31-item instrument for SC innovation and the 14-item scale of SC performance. Therefore, this conceptualization of SC innovation can be used to assess the contribution of SC innovation to SC performance. In addition, non-response bias was insignificant, as all of the responses were collected within four consecutive days and no reminder was used (Hoehle and Venkatesh, 2015)

5.2. Common method variance

According to Chang et al. (2010), common method variance is a concern for many researchers. Therefore, we considered this concern when developing our research instrument. Podsakoff et al. (2003) stated that common method variance is the "variance that is attributable to the measurement method rather than to the constructs" (p. 879). We followed the remedial approaches recommended by these authors to reduce this problem. For example, for the SC performance construct we used scale items that were well established in the literature, divided the questions into groups based on their content, guaranteed anonymity in our survey process, and used different response formats for different research constructs.

A Harmon one-factor test (Podsakoff and Organ 1986) was conducted on the 10 conceptually crucial variables in our research model, namely, customer orientation, marketing knowledge acquisition, product innovation, information management, innovation orientation, IT infrastructure flexibility, logistics flexibility, logistics innovation, logistics social responsibility, and SC performance. This test revealed that the total variance for a single factor was 44.8%, indicating that common method variance was unlikely to have influenced our results.

5.3. Test of the structural model

Step Nine—Cross validation

According to the survey instrument development process of MacKenzie et al. (2011), the next step is to cross-validate the results to evaluate the stability of the scale. Following Chin (1998b), the standard errors and *t*-statistics were obtained using a bootstrapping procedure. The significance of the statistical tests was evaluated at the 0.05 level by a one-tailed *t*-test with unidirectional hypotheses. The structural model test was designed to evaluate (1) the SC innovation structure and (2) the influence of SC innovation on a firm's SC performance. The hypothesized SC innovation structure was a third-order construct (SC innovation) formed by three dimensions (MOIA, TDOIA, and LOIA), each comprising three factors. MOIA included customer orientation, market knowledge acquisition, and product innovation, TDOIA comprised information management, innovation orientation, and IT infrastructure flexibility, and LOIA consisted of logistics flexibility, logistics innovation, and logistics social responsibility. As mentioned in sub-section 3.3, a hierarchical component model (see Figure SF2) was used to estimate the higher-order constructs of the model, consisting of indicators of lower-order constructs. According to Chin (1998a), this approach with indicator duplication allows a model to be evaluated using the standard partial least squares algorithm, and also allows testing of the relative path weights of the factors constituting the higher-order constructs. The results of the SC innovation structure indicated that the three dimensions of SC innovation had significant paths (shown in Figure SF4). The three first-order constructs of MOIA also had significant paths. Their relative significance in descending order was (1) market knowledge acquisition, (2) product innovation, and (3) customer orientation. Similarly, the three first-order constructs of TDOIA had significant paths. Their relative significance in descending order was (1) information management, (2) innovation orientation, and (3) IT infrastructure flexibility. Finally, the three first-order constructs of LOIA had significant paths. Their relative significance in descending order was (1) logistics social responsibility, (2) logistics innovation, and (3) logistics flexibility.

To evaluate the validity of the second- and third-order constructs, we examined three areas. First, we evaluated all of the indicator weights to assess the absolute contribution of the formative indicators to the higher-order constructs (Ringle et al., 2012; Wright et al., 2012). Table ST1 shows that all indicator weights were significant, indicating that the higher-order constructs were interpreted by the lower-order constructs. Second, we tested the conceptual redundancy of the formative constructs. Owing to the formative nature of lower-order latent constructs compared with higher-order latent constructs, they should not be collinear if their influence on the respective construct can be distinguished (MacKenzie et al., 2011). The variance inflation factor (VIF) was used to evaluate multicollinearity (Ringle et al., 2012), and no first- or second-order construct in our model had a value greater than the threshold value (10.0). Therefore, multicollinearity did not significantly bias our results (Diamantopoulos, 2011; Hair et al., 2019).

Moreover, the path linking SC innovation with SC performance (see Figure SF4) confirmed the nomological validity of the SC innovation construct. Many performance measures have been used in the SC context. For example, Shepherd and Gunter (2010) summarized a number of SC performance indicators associated with innovativeness, flexibility, reliability (or quality), time, and cost. In fact, SC performance is a commonly used dependent variable by researchers to measure SC, and many measures are available for it.

In this study, we examined the effect of SC innovation on the SC as a whole and reviewed the literature as a basis for developing this scale (Cai et al., 2009; Kores and Ghosh, 2010; Rexhausen et al., 2012; Qrunfleh and Tarafdar, 2014). We used 14 scale items taken from Cai et al. (2009) and Kroes and Ghosh (2010). The actual measurement items of SC performance are shown in Table 1.

The value of 0.846 ($p < 0.05$) for this path indicated the influence of SC innovation on the dependent variable. The significant and positive R^2 values for firm SC performance ($R^2 = 0.715$)

and the path coefficients confirmed the link between SC innovation and SC performance.

An alternative model with three second-order constructs directly affecting SC performance was also evaluated (see Figure SF5). Although this model explained 71.5% of the variance in SC innovation, only the path linking MOIA with SC performance was significant. These results provided further evidence of the importance of including a third-order construct in our proposed model (see Figure SF4). In addition, the third-order model showed the direct effect of SC innovation, the core construct and focus of this study, highlighting the relative importance of MOIA, TDOIA, and LOIA in SC innovation.

In summary, we hypothesized that SC innovation in firms affects their SC performance. The results showed that SC innovation accounted for 71.5% of the variance in firms' SC performance. We also proposed that SC innovation in firms is a third-order, multidimensional latent construct formed from the definitional properties of MOIA, TDOIA, and LOIA. The results confirmed this structure, with significant paths linking all second-order constructs with the third-order construct (i.e., SC innovation) and all first-order constructs with all second-order constructs.

Step Ten—Norm development

The final step in the survey instrument development process was to develop norms for the new scale (MacKenzie et al., 2011). This step was crucial to help interpret the results and provide directions for future research. MacKenzie et al. (2011) noted the importance of considering that the scales could vary across time and research context. In this study, however, we only investigated our survey instrument and the conceptualization of the SC innovation concept in the context of the apparel and textile industry in China, using survey data. Our results indicated that the developed measurement scales were reasonably good and stable in this context. Future research should therefore examine the applicability of this instrument to industries other than the apparel and textile industry.

6. DISCUSSION, CONTRIBUTIONS, LIMITATIONS AND FUTURE RESEARCH

Since 1999, the literature has emphasized the significance of SC innovation in firms and its potential to improve SC performance (Desbarats, 1999). In this study, we developed an SC innovation model, defined and conceptualized its constructs, and developed a scale to measure the relationship between SC innovation and SC performance. The proposed SC innovation model, which positioned "SC innovation" as a third-order construct, was fully supported by the data and the component innovation activities.

6.1 Theoretical contributions

Although SC innovation has been a key emerging concept in operations management, psychology (Aitken and Harrison, 2013), marketing (Archer et al., 2008; Cai et al., 2009; Jajja et al., 2017), IS (Vickery et al., 2003; Jean et al., 2012; Storer et al., 2014), and other fields, few studies have focused on conceptualizing the SC innovation construct, and no study has attempted to develop a measurement scale to operationalize this construct (Wong and Ngai, 2019). Valid and reliable survey instruments are needed to evaluate SC innovation for firms that rely on innovation to help them compete efficiently and effectively (Govindarajan and Kopalle, 2006). We addressed this issue by proposing an in-depth conceptualization of SC innovation and developing a valid and reliable instrument. Therefore, this study advances current knowledge in numerous ways.

First, most previous studies have used the RBV as a theoretical lens to investigate innovation management issues in the SC context (Lavastre et al., 2014; Kwak et al., 2018). The validated SC innovation measurement provides empirical evidence of interconnected organizational activities, namely, MOIA, TDOIA, and LOIA. Theoretically conceptualized on the basis of the RBV, the empirically validated SC innovation scale provides evidence that these interconnected organizational activities are complementary in SC innovation practice, such that the SC innovation dimensions require the collective effort of functions and SC partners to improve operational efficiency, enhance service effectiveness, increase revenue, and maximize joint profits.

Second, our study adds to the body of knowledge on SC innovation, providing researchers with a valuable tool to examine an important aspect of innovative SCs. This study is the first to develop a complementary and multidimensional conceptualization of SC innovation based on the RBV and the dynamic capabilities view. Previous studies have primarily used scales developed for SC innovation in the logistics area (Kwak et al., 2018) and in SC technological/process innovation (Lee et al., 2011) and have not approached the SC innovation context in a comprehensive way. Following the call to develop the field of SC innovation (Arlbjorn et al., 2011), we designed and validated constructs specific to the SC innovation context. The MOIA construct includes several items focused on customers and marketing, while the LOIA construct comprises several items focused on logistics. Our findings extend the SC literature to provide a richer understanding of SC innovation in three different contexts: MOIA, TDOIA, and LOIA. The results presented here can help managers to select the most relevant measurement scales for measuring SC innovation.

Third, our conceptualization and measurement scale for SC innovation offers a more comprehensive and precise representation of SC innovation than previous studies have done. We therefore believe that our development results will be useful in future research. Previous researchers have applied a pick-and-choose strategy or combined several theoretical constructs to measure SC innovation (Lee et al., 2011; Kwak et al., 2018). We believe that such strategies should no longer be used because the instrument we have developed clarifies the underlying constructs of all key areas of SC innovation. In our study, we operationalized the construct of SC innovation and developed a measurement scale for it. We then used our newly developed scale to examine the impact of key variables on SC performance. The results showed that SC innovation has a positive influence on SC performance, and that it is influenced by firms' MOIA, TDOIA, and LOIA.

6.2 Managerial implications

Our study results have important managerial implications. According to Kotter (2001), managing dynamic and structural complexities has become a key responsibility of managers and executives. SC innovation is a set of complex processes that respond to customer needs and environmental uncertainty by applying new technologies to improve organizational processes in new ways (Lee et al., 2011). As mentioned in the previous section, SC innovation has become increasingly important for firms. Our study adds to the body of knowledge on SC innovation, providing a measurement tool that managers can use to communicate and describe SC innovation in various ways.

First, the empirically validated research model of SC innovation can be a useful tool for communicating and defining SC innovation. By applying this framework, managers can define the specific areas and elements of SC innovation that they need to manage and consider.

Second, the measurement scale developed in this study can be applied to manage and evaluate SC innovation in business processes. It is difficult for managers to evaluate the degree of SC innovation in their firm without such a tool. Managers require a better understanding of SC innovation because of its potential effects on organizational outcomes, including operational efficiency, economic prosperity, environmental protection, service effectiveness, and social responsibility (Wong and Ngai, 2019). Therefore, having a tool to accurately assess SC innovation enables firms to improve their SC performance, as empirically proven by our research model.

In addition, the third-order factor, three second-order factors, and nine first-order factors can help achieve various objectives in the practice of managing and estimating SC innovation. The full SC innovation scale we developed can be used in predicting SC performance. However, managers can also use the partial scale to assess the extent of SC innovation in their business units. This is useful for evaluating specific areas of innovation activity, allowing managers to strategically control and manage the most important areas of SC innovation in business processes.

6.3 Limitations and future research

The use of SC performance in the model investigated in this study allowed us to examine the nomological validity of the SC innovation construct. However, several areas for future research remain. The model investigated in this study requires expansion through further development of the dependent variables tested (Doty et al., 1993; Koste et al., 2004; Sharma et al., 2010; Hoehle and Venkatesh, 2015; Chan et al., 2016). The use of SC performance in the model served to examine the nomological validity of the SC innovation measure. Although SC performance has been shown to be a good predictor of SC success, knowing the relationship between SC innovation and SC performance with stakeholders, along with SC deployment in support of MOIA, TDOIA and LOIA, would be interesting. Further research is recommended to investigate other interesting and untested relationships between the constructs in our nomological network regarding SC innovation.

However, SC innovation can be a double-edged sword for firm success, as it offers opportunities but also creates uncertainties (Pettit et al., 2010). This study focused only on the contribution of SC innovation to SC performance in firms at the conceptual level, based on a set of organizational actions, including MOIA, TDOIA, and LOIA. Future studies should examine the risks or downside of SC innovation (Kwak et al., 2018), such as unexpected fluctuations in logistics operations resulting from newly introduced SC innovation that can lead to unpredictable demand (Fisher, 1997; Kwak et al., 2018). We strongly believe that SC innovation research will benefit empirically from a quantitative measure of this concept.

In addition, the instrument developed and validated in this study should help future studies to test a broader model at different levels of analysis. For instance, experts from other fields may be included to compare their functional and cross-functional expertise with SC performance. Finally, as the developed instrument focused on the apparel and textile industry, which is a demand driven industry, the generalizability of these results to other industries is limited. Future research should therefore examine the applicability of this instrument in other industries.

7. CONCLUSION

SC innovation involves a set of interactions or collaborations between different functional areas that improve SC performance in a way that benefits firm performance. To succeed in this endeavor, firms must develop SC innovation in various areas. Therefore, we can conclude that the innovation activities of firms in marketing, technology development, and logistics play an important role in SC performance. We developed a framework encompassing the different areas of cross-functional innovation activities and represented SC innovation as a higher-order construct formed by MOIA, TDOIA, and LOIA. Our work contributes to the body of research on SC innovation. This study also contributes to the literature on firm performance, as high levels of SC innovation increase SC performance.

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Table 1 - Measurement Items and supporting literatures

Item code	Measurement items	Supporting literatures
Marketing-oriented innovation activities (MOIA)		
MOIA-a	We produce products that satisfy and/or exceed our main customer expectations.	Chen and Paulraj (2004)
MOIA-c	Our firm is flexible in terms of accommodating customer's special requests.	Allred et al. (2011)
MOIA-e	Satisfying customer needs is the central purpose of our business.	Chen and Paulraj (2004)
MOIA-f	We frequently collect information about our main international customer's operations that is relevant to our business (e.g. purchasing, marketing, R&D).	Jean et al. (2012)
MOIA-g	We continually review the likely effects of changes in the business environment that might affect our main international customer management practices.	Jean et al. (2012)
MOIA-h	We use multiple methods to gather information about our main international customer's products, services, and strategies.	Jean et al. (2012)
MOIA-i	We regularly collect information about our main competitor's products, services, and strategies.	Jean et al. (2012)
MOIA-j	We are able to develop unique features for products.	Koufteros et al. (2012)
MOIA-k	We are able to develop a number of "new" features.	Koufteros et al. (2012)
MOIA-l	Our capability of developing a number of "new" products	Koufteros et al. (2012)
Technological-development-oriented innovation activities (TDOIA)		
TDOIA-a	We like to be in the forefront when it comes to trying new information technologies.	Ragu-Nathan et al. (2001)
TDOIA-b	We expect increased emphasis on integrated computer systems/ electronic data interchange between our firm and our main customers, suppliers, and other channel members.	Spillan and Mellat-Parast (2014)
TDOIA-c	We achieve much progress in our company regarding integrated computer systems/ electronic data interchange between our firm and our main customers, suppliers, and channel members.	Spillan and Mellat-Parast (2014)
TDOIA-d	We are constantly on the look-out for new systems applications.	Ragu-Nathan et al. (2001)
TDOIA-e	We use existing or new techniques to develop new services.	Chen et al. (2011)
TDOIA-f	We respond to external environment changes quickly.	Chen et al. (2011)
TDOIA-g	Our employees are willing to share new knowledge.	Chen et al. (2011)
TDOIA-h	We encourage our employees to adopt new techniques.	Chen et al. (2011)
TDOIA-j	Information systems between our firm and our key partner are designed to accommodate changes in business requirements quickly.	Cheng et al. (2014)
TDOIA-k	Our firm and our key partner have established rules and standards for hardware and operating systems to ensure platform compatibility.	Cheng et al. (2014)
TDOIA-l	Our firm and our key partner have identified and standardized data to be shared across systems and the business units.	Cheng et al. (2014)
Logistics-oriented innovation activities (LOIA)		
LOIA-a	We adjust delivery capacity to meet volume for delivering.	Yu et al. (2017)
LOIA-b	We adjust storage capacity if demand fluctuates.	Yu et al. (2017)
LOIA-c	We make flexible use of multiple transportation modes to meet the schedule for delivering.	Yu et al. (2017)
LOIA-d	We address reverse logistics issues mainly with technologies we have developed (customization).	Richey et al. (2005)
LOIA-g	Logistics planning is well coordinated with the overall strategic planning process in our firm.	Spillan and Mellat-Parast (2014)
LOIA-h	Our speed in new product development is fast enough/ competitive.	Lee et al. (2014)

LOIA-i	We include environmental consideration in our selection criteria for key suppliers.	Miao et al. (2012)
LOIA-j	We include business ethics consideration in our selection criteria for key suppliers.	Miao et al. (2012)
LOIA-k	We emphasize honesty business operations.	Miao et al. (2012)
LOIA-l	We encourage our employees in compliance with the code of professional ethics.	Miao et al. (2012)
Supply chain performance		
Please indicate the level of your business unit's performance along each of the following dimensions compared to that of your major industry competitor(s):		
SCP-a	Delivery cycle times	Kroes and Ghosh (2010)
SCP-b	Manufacturing cycle time	Kroes and Ghosh (2010)
SCP-c	Missed/wrong/damaged/defective products shipped	Kroes and Ghosh (2010)
SCP-d	On-time delivery performance	Kroes and Ghosh (2010)
SCP-e	Warranty/returns processing costs	Kroes and Ghosh (2010)
SCP-f	Business performance	Kroes and Ghosh (2010)
SCP-g	Profit margin (%)	Kroes and Ghosh (2010)
SCP-h	Returns on sales	Kroes and Ghosh (2010)
SCP-i	Returns on total assets (ROA)	Kroes and Ghosh (2010)
SCP-j	Sales over assets	Kroes and Ghosh (2010)
SCP-k	Process improvement	Cai et al. (2009)
SCP-l	Rates of sales in new products	Cai et al. (2009)
SCP-m	Number of new products launched	Cai et al. (2009)
SCP-n	Supply chain stability	Cai et al. (2009)

Table 2 - Loading of the indicator variables (Sample size = 298)

Construct	Measurement items	Loadings	Mean	Standard deviation	Cronbach's Alpha	Composite Reliability	Significant level
Customer orientation	MOIA-a	0.80	5.82	0.93	0.66	0.81	p<0.05
	MOIA-c	0.75	5.85	0.96			p<0.05
	MOIA-e	0.77	5.87	0.96			p<0.05
Market knowledge acquisition	MOIA-f	0.76	5.76	0.91	0.73	0.83	p<0.05
	MOIA-g	0.71	5.83	0.93			p<0.05
	MOIA-h	0.73	5.89	0.99			p<0.05
	MOIA-i	0.76	5.74	0.94			p<0.05
Product innovation	MOIA-j	0.82	5.87	0.96	0.74	0.85	p<0.05
	MOIA-k	0.80	5.79	1.00			p<0.05
	MOIA-l	0.82	5.84	0.97			p<0.05
Information management	TDOIA-a	0.80	5.72	1.01	0.75	0.84	p<0.05
	TDOIA-b	0.71	5.80	0.94			p<0.05
	TDOIA-c	0.77	5.82	0.98			p<0.05
	TDOIA-d	0.73	5.81	0.99			p<0.05
Innovation orientation	TDOIA-e	0.79	5.83	0.91	0.73	0.83	p<0.05
	TDOIA-f	0.71	5.80	0.99			p<0.05
	TDOIA-g	0.73	5.84	0.92			p<0.05
	TDOIA-h	0.75	5.90	0.99			p<0.05
IT infrastructure flexibility	TDOIA-j	0.83	5.72	0.99	0.66	0.82	p<0.05
	TDOIA-k	0.80	5.74	1.03			p<0.05
	TDOIA-l	0.71	5.78	0.93			p<0.05
Logistics flexibility	LOIA-a	0.79	5.86	0.89	0.67	0.82	p<0.05
	LOIA-b	0.76	5.88	0.97			p<0.05
	LOIA-c	0.78	5.85	0.97			p<0.05
Logistics innovation	LOIA-d	0.83	5.66	1.00	0.70	0.84	p<0.05
	LOIA-g	0.78	5.87	0.99			p<0.05
	LOIA-h	0.76	5.81	0.98			p<0.05
Logistics social responsibility	LOIA-i	0.81	5.81	0.97	0.78	0.86	p<0.05
	LOIA-j	0.78	5.85	1.01			p<0.05
	LOIA-k	0.76	6.06	1.02			p<0.05
	LOIA-l	0.76	5.88	1.04			p<0.05

Table 3 - Factor analysis (Sample size = 298)

	Customer orientation	Market knowledge acquisition	Product innovation	Information management	Innovation orientation	IT infrastructure flexibility	Logistics flexibility	Logistics innovation	Logistics social responsibility
MOIA-a	0.80	0.66	0.64	0.60	0.63	0.64	0.64	0.63	0.63
MOIA-c	0.75	0.52	0.44	0.48	0.52	0.54	0.50	0.48	0.48
MOIA-e	0.77	0.57	0.50	0.50	0.51	0.49	0.55	0.50	0.59
MOIA-f	0.57	0.76	0.64	0.66	0.58	0.58	0.56	0.59	0.58
MOIA-g	0.50	0.71	0.56	0.57	0.55	0.55	0.55	0.49	0.58
MOIA-h	0.58	0.73	0.56	0.57	0.62	0.54	0.62	0.56	0.52
MOIA-i	0.61	0.76	0.52	0.57	0.55	0.54	0.57	0.55	0.54
MOIA-j	0.58	0.63	0.82	0.69	0.67	0.68	0.61	0.65	0.64
MOIA-k	0.51	0.61	0.80	0.62	0.62	0.59	0.59	0.55	0.56
MOIA-l	0.60	0.64	0.82	0.63	0.64	0.60	0.60	0.61	0.63
TDOIA-a	0.54	0.68	0.69	0.80	0.68	0.66	0.61	0.64	0.62
TDOIA-b	0.43	0.55	0.49	0.71	0.55	0.51	0.48	0.53	0.52
TDOIA-c	0.57	0.58	0.62	0.77	0.65	0.57	0.63	0.61	0.57
TDOIA-d	0.54	0.60	0.59	0.73	0.58	0.56	0.54	0.51	0.64
TDOIA-e	0.61	0.67	0.70	0.68	0.79	0.66	0.64	0.67	0.65
TDOIA-f	0.44	0.52	0.51	0.58	0.71	0.54	0.63	0.56	0.51
TDOIA-g	0.55	0.53	0.57	0.57	0.73	0.57	0.54	0.53	0.52
TDOIA-h	0.54	0.57	0.57	0.60	0.75	0.55	0.58	0.52	0.58
TDOIA-j	0.61	0.61	0.66	0.65	0.63	0.83	0.67	0.67	0.63
TDOIA-k	0.55	0.59	0.60	0.60	0.63	0.80	0.66	0.59	0.62
TDOIA-l	0.54	0.53	0.51	0.52	0.55	0.71	0.55	0.53	0.49
LOIA-a	0.65	0.66	0.63	0.63	0.65	0.67	0.79	0.64	0.61
LOIA-b	0.46	0.59	0.58	0.60	0.62	0.59	0.76	0.52	0.59
LOIA-c	0.61	0.55	0.52	0.51	0.60	0.64	0.78	0.58	0.58
LOIA-d	0.59	0.64	0.64	0.67	0.64	0.68	0.64	0.83	0.57
LOIA-g	0.53	0.54	0.58	0.58	0.60	0.60	0.54	0.78	0.57
LOIA-h	0.54	0.57	0.54	0.55	0.58	0.55	0.59	0.76	0.59
LOIA-i	0.59	0.61	0.67	0.69	0.66	0.70	0.62	0.66	0.81
LOIA-j	0.51	0.53	0.59	0.57	0.56	0.53	0.59	0.51	0.78
LOIA-k	0.62	0.57	0.53	0.59	0.58	0.57	0.59	0.54	0.76
LOIA-l	0.59	0.60	0.55	0.56	0.57	0.55	0.56	0.54	0.76

Figure 1. Scale development and validation process of the measurement scales – Adopted from Chin et al. (1997) and MacKenzie et al. (2011)

Phase (Purpose)	Details
Phase 1 (**Developmental**)	**Step 1** – Construct definition * Comprehensive view of supply chain innovation from the literature review * Complementary literature review on the three dimensions: marketing-oriented innovation activities, technology-development-oriented innovation activities, and logistics-oriented innovation activities. * Complementary literature review (on the nine sub-dimensions of the three measurement scales): (1) Content-database of supply chain innovation studies, (2) Sub-construct wise presentation in previous literature, and (3) construction of taxonomy * Extension of supply chain literature review of Wong and Ngai (2019) by including related articles from 2017 to 2020.
Phase 2 (**Exploratory**)	**Step 2** – Measure development * Development of measures: Exploratory qualitative studies including: Focus group discussion, Sample size: 10 Card sorting exercises, sample size: 6 (Phase I) & 4 (Phase II) Sample: 64 analyzed items **Step 3** - Content validity assessment **Step 4** – Measurement model specification **Step 5** – Scale pre-test * Exploratory qualitative studies, Sample size: 10 **Step 6** – Scale purification * Exploratory quantitative studies, Sample size: 15
Phase 3 (**Confirmatory**)	**Step 7** – New sample data collection **Step 8** – Assessing scale validity * Scales validation: Confirmatory quantitative study, Sample size: 298 **Step 9** – Cross Validation **Step 10** – Norm development