What configurations of structures facilitate supply chain learning? A supply chain network and complexity perspective

Junbin_Wang *(School of Business, Changshu Institute of Technology, Changshu, China) (School of Management, Fudan University, Shanghai, China)*
Xiaowei_Dong *(School of Business, Changshu Institute of Technology, Changshu, China)*
Yu_Xiong *(Business School, University of Surrey, Guildford, UK)*
Umair_Tanveer *(University of Exeter)*
Changping_Zhao *(School of Business, Changshu Institute of Technology, Changshu, China)*

Abstract
Purpose – This study explores how factors arising from supply chain (SC) network and complexity work together in supply chain learning (SCL) behavior.
Design/methodology/approach – Fuzzy set qualitative comparative analysis (fsQCA), which is an emerging configurational analysis method, was adopted to examine the complex combination of five influencing factors. The data was collected using a two-stage survey. First, we selected seven typical firms with an awareness of SCL. Second, questionnaires were sent to the partners of the seven selected firms, and 156 valid questionnaires were obtained from 76 firms.
Findings – Drawing on emergent insights from the initiative, we find that multiple configurations of SC network and complexity lead to high SCL. Specifically, weak ties are necessary conditions of such learning, while strong ties are also conducive to this. Moreover, a moderate SC complexity is conducive to SCL.
Practical implications – This study enriches our understanding of SCL and provides new insights for SC management practitioners to take measures to improve it.
Originality/value – This study addresses the lack of in-depth understanding of the antecedent conditions of SCL in the literature. It establishes an integrated and comprehensive theoretical framework of such learning based on contingency theory. Additionally, this study incorporates ambidextrous SCL (i.e. creation capability and dispersion capacity). An overall prototype of SCL capability is proposed on SC network and complexity theory.
Keywords Supply chain learning, Configurational analysis, Fuzzy-set qualitative comparative analysis, Supply chain network, Supply chain complexity.
Paper type Research paper

1. Introduction

The current turbulent business climate means that supply chains (SCs) need to have strong learning capabilities to cope with crises, such as trade wars and pandemics. This learning ability is critical to the efficiency and effectiveness of the SC, such as improving agility, solving complex problems, and adopting new technologies and business models (Ojha *et al.*, 2018a). However, for selecting the configuration of the SC structure to improve the supply chain learning (SCL) ability, the focal firms in different industries take different actions. For example, Coca-Cola adopted a local sourcing strategy to simplify its SC during the pandemic, while firms such as Apple, Nike, and Walmart have diversified theirs to make them more complex (Xu *et al.*, 2022).

Although a growing number of studies analyze the formation mechanism of SCL (e.g. Bessant *et al.*, 2003; Berghman *et al.*, 2012; Manuj *et al.*, 2014; Ojha *et al.*, 2016; Ojha *et al.*, 2018a; Ojha *et al*., 2018b) and influencing factors (e.g. Gosling *et al.*, 2017; Selviaridis and Spring, 2018; Gong *et al*., 2018; Cormack *et al.*, 2021; Huo *et al*., 2021), only a tiny proportion have linked SCL to structure (see the review by Yang *et al.* 2019 for details). Owing to this gap in the literature, different choices of structures that facilitate SCL capabilities are still not well covered, but there are clues in at least two directions. On the one hand, the internal structure of the SC (or complexity) may affect SCL. For example, research suggests that structural integration could lead to SCL (Bessant *et al*., 2003; Flint *et al.*, 2008). In addition, Bozarth *et al.* (2009) establish that the complexity of upstream, internal, or downstream in an SC has a negative impact on a firm's performance. Similarly, according to Bode and Wagner (2015), SC disruptions are more likely to occur in areas with spatial, vertical, or horizontal complexity. On the other hand, the external connection of the SC (or network) may also affect SCL. For example, some researchers have explored the link between focal firms' SC networks and their learning abilities (Bellamy *et al.*, 2014; Sharma *et al.*, 2020). From the social network perspective, a firm's actions and results are determined by its social relationships with others and its position within a social network (Moran, 2005). Considering that the focal firm is embedded in an interwoven SC with its partners, the strength of its links with such partners may promote or hinder the ability of SCL (Galaskiewicz, 2011). Consequently, the impact of SC structure on SCL needs to be explored in more detail.

In SCL literature, resource-based views (RBVs), knowledge-based views (KBVs), relational views (RVs), information-based views (IBVs), and organizational views (OGs) are commonly used theories (Yang *et al.*, 2019). However, these cannot construct an integrated perspective on the SC structure, which combines the internal structure of the SC with the external connection. Furthermore, contingency theory treats SCs as open systems exchanging information through input-process-output (Schoonhoven, 1981). Specifically, internal and external contextual issues comprise the input (Grötsch *et al.,* 2013). Therefore, we adopt the perspective of contingency theory to integrate the view of SC structure. Based on this theory, we explore how the two contingency factors are configured to create a higher or lower SCL ability: SC network and SC complexity. We address the following research question (RQ): *How do factors arising from the SC network and SC complexity work together on supply chain learning behavior?*

To address this RQ, we propose an integrated framework and employ the fuzzy-set qualitative comparative analysis (fsQCA) method for configuration analysis. As an exploratory method based on case studies, configuration analysis allows researchers to discover "different success recipes" through configuration logic (Forkmann *et al.*, 2017). Furthermore, it is based on the hypothesis of causal complexity to analyze how conditional configurations related to a research topic interact to explain the results of interest (Furnari *et al.*, 2021). Specifically, we classify SCL as creation and dispersion capacities following Bessant *et al.*'s (2003) and Ojha *et al.*'s (2018a) seminal studies. Moreover, we split the antecedents into SC network and complexity. The former contains two types of ties (weak and strong), while the latter comprises three types of complexity (downstream, internal, and upstream).

The study yields some findings and contributes to the literature as follows: First, in response to the call for additional research to expand the SCL literature (Willis *et al.*, 2016; Flint *et al.*, 2008), we explore the SC structure in favor of SCL from a contingency theory perspective. Specifically, we construct an SCL framework that includes the two core conditions of the SC network and complexity. Second, studying SCL in depth is difficult because of the dynamic and highly complex characteristics of SC relationships (Toni *et al.*, 2011; Biotto *et al.*, 2012). With the help of configuration analysis, we identify multiple paths that facilitate or hinder SCL in complex environments, which opens up new directions for subsequent empirical studies. Finally, previous studies on the link between SC structure and SCL tend to focus on local features (e.g. Hernández - Espallardo *et al.*, 2010; Lambrechts *et al.*, 2012; Selviaridis and Spring, 2018; Gong *et al.*, 2018). In contrast, we consider the SC's external link (SC network) and internal structure (complexity) from a holistic perspective. Moreover, by examining the learning performance of SCs under different structures, the findings explain the contradictions observed in practice; that is, focal firms in different sectors of the SC take different actions.

The rest of the paper is organized as follows. Section 2 reviews the literature and provides a theoretical background, and section 3 discusses the research method and details of data sampling. The results and analysis are presented in section 4. Section 5 describes the theoretical and practical implications and highlights the limitation and recommendations for future research. Finally, section 6 concludes the study.

2. Literature review and theoretical background

This section first presents the study's theoretical background and then identifies key antecedents from the literature. We then discuss the linkages between the conditions, and finally, a structural model (the overarching framework) developed for the study.

2.1 Supply chain learning

Before Bessant *et al.* (2003) formally proposed the concept of "supply chain learning", the closest concept was inter-organizational learning (Coghlan and Coughlan, 2015). According to Mohr and Sengupta (2002) and Theodorakopoulos *et al.* (2005), inter-organizational learning occurs when information from outside an organization is acquired, disseminated, interpreted, used, and stored within an organization. As a result, scholars had different views on the boundaries of such learning. In the context of the SC, according to Hult and Ferrell (1997), SC organizational learning has four dimensions: team, system, learning, and memory. SC organizational learning further blurs the boundaries between organizations and emphasizes their integration (Zhu *et al.*, 2018). As Spekman *et al.* (2002) highlighted, an influential research direction of inter-organizational learning was the learning in the SC. Bessant *et al.* (2003) proposed a relatively comprehensive concept of SCL, which defined the stages as establishment, operation, and maintenance. They specified different tasks and governance mechanisms required for effective learning in the SC. Based on Hult and Ferrell (1997) and Bessant *et al.* (2003), we divided SCL into two dimensions: creation and dispersion capacities. Among them, a SCL's creation and dispersion capacities can enhance its short-term and long-term practices (Ojha *et al.*, 2018a). Specifically, creation capacity includes team-orientation and learning-orientation, representing the use of individuals and teams and their knowledge as production tools to explore and produce new knowledge for new products or processes (March, 1991; Ojha e*t al.*, 2018a; Easterby-Smith *et al.,* 2000). Dispersion capacity includes system-orientation and memory-orientation. The SC's ability disseminates knowledge and skills throughout the organization and to acquire, extend, and refine stored knowledge is represented by this concept.

Due to SCL's significant impact on the types of interactions among members, it is crucial to analyze its antecedents (Thakkar *et al.,* 2011). Following the previous literature on SCL, we divide the antecedents into drivers and barriers. In terms of drivers, Flint *et al.* (2008) explored that cross-functional organizational insights into customer value could improve SCL. SCL can be promoted by knowledge management and total quality management (Loke *et al.*, 2012). In sustainable supply chain management (SCM), Gosling *et al.* (2017) found that different kinds of SC leadership positively affected SCL. Ojha *et al.* (2016) and Ireland and Webb (2007) demonstrated the positive impact of trust on SCL and its mechanism. Huo *et al.* (2021) divided SCL into the supplier, internal, and customer learning, and found that information sharing improved SCL in all three dimensions. Moreover, the three dimensions of SCL can facilitate each other. In terms of barriers, there are few studies on SCL to explore this topic (Yang *et al.,* 2019). Some key barriers to SCL, including lack of learning skills or structure, have been summarized by Morris *et al.* (2006) and Bessant and Tsekouras (2001). Yang *et al.* (2019) further divided these barriers into inter-organizational, people, and objective barriers. In addition, Williams (2007) also indicated that structure was one of the major barriers to learning. Following this logic, we argue that SC structure has important implications for SCL.

2.2 Supply chain network

Firms and their embedded SC members can generally be seen as partners of social networks from the perspective of SC relationships (Galaskiewicz, 2011). Social networks are formed from the interactions between actors (Meqdadi *et al.*, 2019). Ties in social networks are strong and weak, and different ties play a role in the access of nodes to resources and information. Network ties are the structure of the relationship between firms and can be expressed as the degree of interconnection between firms (Granovetter, 1992). Granovetter (1973) divided the strength of ties into two forms: strong and weak ties. A strong tie is a repeated, continuous, and fixed link between nodes. Therefore, frequent interactions can facilitate understanding and trust among individuals. In the SC, the trust generated by a business can promote close cooperation between organizations and form strategic relationships (Golicic and Mentzer, 2006). Weak ties refer to the non-repeated, non-continuous, and non-fixed linkages between nodes, with significant differences between nodes (Granovetter, 1973). Such weak ties enable the flow of information and resources between different individuals, and enhance communication between individuals.

Based on social network theory, the relationships between focal and other firms in an SC network affect the performance of SCL. Learning also means working in embedded structures that may have highly various characteristics and relationships. In a business, these relationships are viewed as interpretation schemes or shared cognitive belief systems owned by firms, teams, and individuals. And they filter managers' attention and guide the behaviors of firms (Strandvik *et al.*, 2014). For instance, Peng *et al.* (2020) proposed that exploiting the structure-hole theory to achieve higher cooperation performance for certain network structures. Existing literature provides evidence that the dissemination and development of SC practices and new ideas, conduits of information, and access to knowledge rely on SC network services (Bellamy *et al.*, 2014). Therefore, in terms of SCL, in a SC network consisting of firms as nodes, the different ties among firms in the network will inevitably affect its learning effect.

2.3 Supply chain complexity

SC networks are complex adaptive systems (Pathak *et al.*, 2007). While it is crucial to explore how network linkage types impact on SC learning, it is also vital to capture the influence of SC complexity on overall SCL. The flow of materials and information is limited, and both the opportunistic behavior of the SC partner and the cost of managing it is increased by the SC complexity (Sharma *et al.,* 2020). Thus, we posit that SCL may be hindered by SC complexity.

Scholars differ in their understanding of the definition of SC complexity. According to Lu and Shang (2017), SC complexity is reflected in the relational redundancy, spatial dispersion of suppliers, vertical integration, and suppliers' sharing among firms. Bode and Wagner (2015) defined complexity structurally as a system that includes numerous elements. On this basis, Giannoccaro *et al.* (2018) summarized complexity into three main dimensions: vertical, horizontal, and spatial complexities. Actually, horizontal complexity originates from direct suppliers, spatial complexity arises from the geographical distance between suppliers and focal firms, and vertical complexity comes from the number of secondary suppliers per tier (Bode and Wagner, 2015; Lu and Shang, 2017; Bozarth *et al.,* 2009). Choi and Krause (2006) conceptually reduced complexity to the number of suppliers, level of differentiation, and degree of interrelationships between suppliers.

SC complexity is argued to decrease the achievement effect of manufacturing plants (Bozarth *et al.*, 2009), increase the complexity of decision-making (Manuj and Sahin, 2011), increase the risk of disruptions (Narasimhan and Talluri, 2009), and facilitate innovation performance (Sharma *et al.,* 2020). Few studies have explored the influence of SC complexity on learning. Bessant *et al.* (2012) suggested that formally configuring groups of organizations, such as SCs and networks, has become an increasingly important channel for learning. Therefore, exploring whether SCL benefits from or is adversely affected by SC complexity is necessary.

2.4 Structural model based on contingency theory

2.4.1 Contingency theory

According to contingency theory by Fiedler (1964), Lawrence and Lorsch (1967), and Luthans (1976), different scenarios create different antecedents means that organizational, decision-making, and leadership processes cannot be managed in the single best way. The central proposition of this theory is that an organization's structure and process need to be adapted to its environment, culture, technology, and so on (Drazin and van de Ven, 1985). Therefore, these contingency factors significantly alter the prospect of operations management (OM) (Gunasekaran and Ngai, 2012). Sousa and Voss (2008) acknowledged that contingency theory could be a useful theoretical lens through which to view OM problems, especially in areas where OM theory is less fully developed.

Contingency theory is particularly useful in the current study. According to Yang *et al.* (2019), there are some commonly used theories in the field of SCL, including RBV, KBV, RV, IBV, and OG. Although these can explain the source or formation mechanism of SCL in various situations, they also have some limitations (Yang *et al.*, 2019). For example, they mainly focus on the organization itself and ignore the interaction between the members upstream and downstream of the SC (Manuj *et al.*, 2013). Therefore, Javed *et al.* (2016) gave a systematic overview of contingency factors at the firm, industry, and country levels and called for using new contingency factors for research.

Furthermore, previous researchers have underlined the contingency nature of SCL (Peters *et al.*, 2016), where the term "contingency" reflects how SC members engage in and benefit from learning. This is then combined with the research objective of our study, which is to build a comprehensive framework for predicting which SC structures facilitate or hinder SCL. Contingency theory provides a helpful approach to frame the broader social context where decisions and learning occur in organizations or individuals.

2.4.2 Structural model

According to contingency theory, firms must match contingency factors' changing nature (Nair *et al.*, 2021). Classic examples include mechanical, efficiency-oriented structures and organic, flexibly oriented structures in predictable and unpredictable environments (Lawrence and Lorsch, 1967). The OM literature recommends improving process connectivity and simplicity through internal and external process integration with suppliers and customers to facilitate this matching (Swink *et al.*, 2007). Previous studies suggested that a more significant integrated effort was needed to successfully manage an increasingly fragmented environment. However, OM scholars have provided many insights into SC integration (see Danese *et al.* (2020) and Marty (2022) for recent reviews). Danese *et al.* (2020) also highlighted that the less used fit form and the combination of multiple fit forms could help solve some unresolved problems in SC integration. From the perspective of contingency theory, more appropriate forms or more complex combinations can be defined or explored.

As previously mentioned, the existing research has revealed the impact of SC network and complexity on SCL. This study explores the influence of two contingency factors (Xie *et al.*, 2022), the external SC network and internal SC complexity, on SC's learning process and orientation under the contingency theory framework. More specifically, based on the literature mentioned above review and the theoretical framework, we infer that SC network and complexity play a significant role in facilitating or hindering SCL. They can be causally interrelated. Although existing studies examined the impact of SC network or complexity on SCL separately, from the perspective of contingency theory, these explorations still cannot cover the complete SC structure (i.e. internal complexity and external connection). In addition, the concept of SCL has received a new interpretation; that is, it can be evaluated and studied from a creation-dispersion perspective (Ojha *et al.*, 2018a). Therefore, it is necessary to examine how the interplay of SC network and complexity affects SCL's creation or dispersion capacity. This study builds a structural model based on the theoretical framework contingency theory (see **Figure 1**), which adopts a fsQCA method to explore the configurational causes underlying SCL (including creation and dispersion capacities) from a holistic perspective. We split the antecedents into the SC network and SC complexity. An SC network contains two types of ties: weak and strong ties. SC complexity consists of downstream, internal, and upstream complexity.

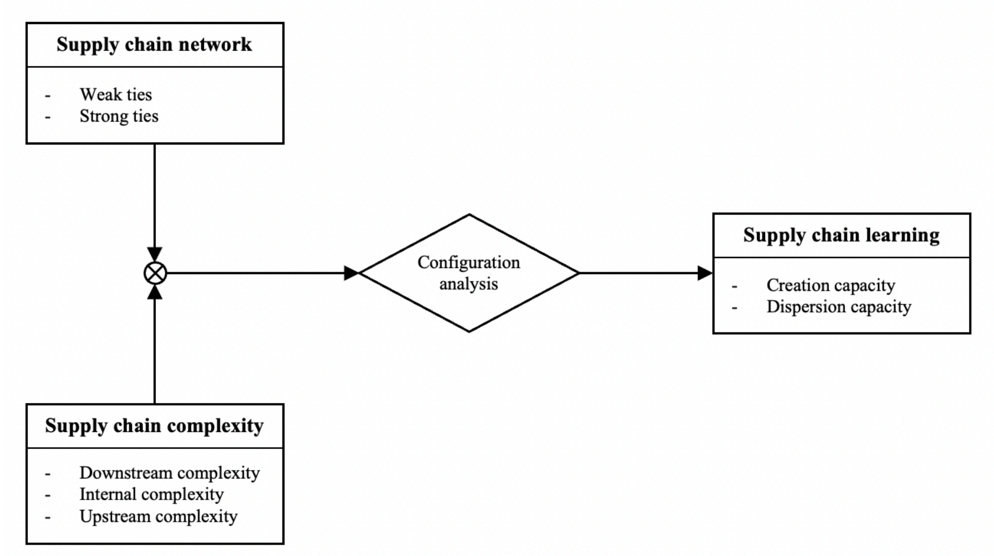

Figure 1. Supply chain structure of configurations producing supply chain learning
(Source: Created by authors)

3. Research methodology

3.1 Fuzzy-set qualitative comparative analysis

We use fsQCA to explore how contingency factors arising from the SC network and complexity work together in SCL. With the help of fuzzy-set theory and Boolean algebra, fsQCA breaks the divide between quantitative and qualitative studies and shifts the focus from regression-based approaches to set-based approaches (Rihoux and Ragin, 2009). As such, compared with the traditional regression-based approach, it has the useful characteristic of being more capable of analyzing complex causal links among different factors (Urueña *et al.*, 2018) and determining the best linkage between condition and outcome variables from various combinations of causal conditions (Ragin, 2008). With fsQCA, we can accurately identify how the SC network and complexity combine to facilitate SCL in our studied scenario.

3.2 Data collection

We focus on the landscape of the Chinese SC. According to Huo *et al.* (2021), China has successfully learned much knowledge and experience of SCM, and plays an increasingly vital role in global SCs.

Our data collection involves two key steps. First, the questionnaire was designed and revised. With some adjustments after pilot testing, several well-established scales were applied to ensure the quality of the questionnaire items. Specifically, pilot tests were conducted at five companies. We subsequently revised and refined the questionnaire to ensure that it could be understood and adapted to Chinese practice. In the second step, a two-stage survey was carried out. First, we conducted visits and surveys in areas of China where industrial clusters are evident, such as Suzhou, Nanjing, and Shanghai. A total of seven typical firms with an awareness of SCL were selected after visits and surveys. Aligned with our aims, these firms were selected on two criteria: 1) having SCL activities and 2) having an entire SC structure with at least one supplier and one buyer (Gurbuz *et al.*, 2023). Second, with the help of these selected firms, a questionnaire was sent to their partners. Respondents were department heads responsible for the company's SC, or middle and senior management.

In the end, 228 questionnaires were sent out, and 187 questionnaires were returned from 76 firms. After eliminating invalid responses (i.e. missing critical information), a total of 156 valid questionnaires were employed for the following analyses, achieving a response rate of 68.42%.

3.3 Measures

According to the structural model in Figure 1, the SC network and complexity are condition variables, while SC is the outcome variable in the framework of QCA research. With reference to pertinent previously published study (see Table 1), the five-point Likert scale, which ranges from "(1) strongly disagree" to "(5) strongly agree" are applied to measure all variables in this research.

[Insert Table 1 here]

Supply chain complexity. Bozarth *et al.* (2009) categorized SC complexity as downstream, internal, and upstream complexities. Three items were used to measure downstream complexity, focusing on the customers and products of a firm. We measured internal complexity using three items covering the diversity of products, number of materials, and daily production schedule. We assessed upstream complexity using a three-item scale that included the number of suppliers, delivery time, and difficulty of on-time delivery.

Supply chain network. We captured the characteristics of the SC network by involving strong and weak ties based on Granovetter's (1973, 1992) theory. We adopted a four-item scale from Tiwana (2008) to measure weak ties and a five-item scale from Golicic and Mentzer (2006) and Morgan and Hunt (1994) to assess strong ties. Weak ties focus on whether a firm can obtain real or tangible benefits from its partners, specifically, the complement of experiences, resources, skills and abilities, and business fields. Strong ties value the good quality of partners and continuous cooperation and are measured by partners' trust, honesty, and fairness.

Supply chain leaning. Following Ojha *et al.* (2018a) and Hult (1998), SCL was further categorized into creation and dispersion capacities. Creation capacity reflects the interaction outcomes of team and learning orientations, and thus was operationalized by taking the product of the mean of their scales. We adopted two four-item scales to measure these orientations (Hult, 1998; Ojha *et al.*, 2018a). Similarly, dispersion capacity reflects the interaction effects of system and memory orientations, and thus was operationalized by taking the product of the mean of their scales. We applied two four-item scales to these orientations (see Table 1). In the same way, the SCL was operationalized by taking the product of the mean of creation capacity and dispersion capacity.

3.4 Validity and reliability

Table 1 reports the validity and reliability of all constructs. Regarding the sub-dimensionality of each construct, all the loading of items is between 0.634 and 0.918, which meets the cutoff level (0.600) established by Samagaio *et al.* (2018). Cronbach's α values for downstream complexity, upstream complexity, and weak ties were 0.544, 0.588, and 0.685, respectively, while other variables of this value exceeded 0.7, indicating that the questionnaire had acceptable reliability. We also report both composite reliability (CR) and average variance extracted (AVE) to measure convergent validity in Table 1. Except for downstream complexity, all other constructs had AVE values above 0.5, but we can accept 0.4. Fornell and Larcker (1981) stated that if AVE is less than 0.5, but CR is higher than 0.6, the convergent validity of the construct is still adequate (Lam, 2012). Thus, our questionnaire had good reliability and convergent validity.

We report the correlation coefficient matrix for all variables in Table 2. The five antecedents are related to each other and to the two types of SCL, which can match the application logic of the QCA approach. Specifically, the antecedents are somehow linked to each other rather than isolated (Rihoux and Ragin, 2009).

[Insert Table 2 here]

3.5 Variable calibration

Variable calibration is an indispensable step when using QCA because all variables must be calibrated to a fuzzy-set scale with values between 0 (full-set non-membership) and 1 (full-set membership) (Ragin, 2008). Following Xie and Wang (2020), we take the multi-items' average scores as the associated construct's measure. With reference to Fiss (2011), we employ a direct calibration method to calibrate all variables, including five antecedents and two outcome variables. Specifically, the following three breakpoints are applied during calibration: (i) 10% percentile as the breakpoint of full-set non-membership, (ii) 50% percentile as the crossover point, and (iii) 90% percentile as the breakpoint of full-set membership (Delmas and Pekovic, 2018; Greckhamer, 2016). The descriptive statistics and calibration values are presented in Table 3.

[Insert Table 3 here]

4. Empirical analysis

4.1 Analysis of necessary conditions

The necessity of each condition must be checked before applying the fsQCA approach to analyze sufficient combinations of conditions (Schneider and Wagemann, 2010). To identify whether causal conditions are necessary for SCL, we analyze whether the condition is present (absent) in all cases in which the outcome is present (absent). According to Ragin (2008), we consider an antecedent to be a necessary condition when its consistency score exceeds 0.9. As shown in Table 4, weak ties are always necessary, regardless of the target outcomes. Such ties are necessary conditions for the creation and dispersion capacities. Considering that creation and dispersion capacities constitute SCL, we propose the following:

Proposition 1. Weak ties are a necessary condition for high-level supply chain learning.

In fact, this finding extends the strength of the weak ties theory constructed by Granovetter (1973). Compared with strong ties, weak ties bring SC partners with new and different characteristics to a firm or an organization. These new and different characteristics are what a firm is able to acquire through SCL.

[Insert Table 4 here]

Accordingly, excluding weak ties, we incorporated the rest of the causal conditions (i.e. downstream, internal, and upstream complexities, and strong ties) into the truth table analysis of fsQCA to explore the configurations of various antecedents that could result in high SCL.

4.2 Analysis of sufficient conditions

Sufficient conditions reflect causal conditions, or a combination of causal conditions can lead to the outcome (Ragin, 2008). The first step is to obtain the number of all possible combinations using the truth table to determine whether the causal condition is sufficient. The next step is to define two cutoffs, namely consistency and frequency cutoffs. According to our research scenario, we set them to 0.9 and 2, respectively, allowing us to capture over 85% of the cases. The third step is to select the criteria for determining whether sufficient conditions have been established. Following Ragin (2008) and Misangyi and Acharya (2014), the consistency threshold is 0.75. In other words, sufficient configurations can be identified if solution consistency exceeds 0.75.

Having conducted truth table analysis, we obtained three solutions: complexity, intermediate, and parsimonious solutions. We choose the intermediate solution to interpret the final configuration, which is superior to the other two types of solutions with the characteristics of simplicity and rationality (Rihoux and Ragin, 2009). In addition, parsimonious and intermediate solutions are regularly used to identify peripheral and core conditions in fsQCA. A condition is considered as a core condition when it appears in both the parsimonious and intermediate solutions, while a peripheral condition appears only in the intermediate solution (Ragin, 2008). Moreover, a core condition plays a decisive role, and a peripheral condition plays a supporting role in the recipe or configuration. The configurations that lead to high SCL from creation and dispersion capacities are presented in Tables 5 and 6, respectively. Those that lead to low-degree SCL, that is, low creation and dispersion capacities, are provided in Tables 7 and 8, respectively.

[Insert Tables 5 and 6 about here]
[Insert Tables 7 and 8 about here]

4.2.1 Analysis of sufficient conditions for high supply chain learning

Following Ojha *et al.* (2018a) and Hult and Ferrell (1997), SCL can be excavated from creation and dispersion capacities; that is, a high creation and dispersion capacities correspond to high levels of SCL, and vice versa. The results of the four pathways leading to high creation capacity and high dispersion capacity are reported in Tables 5 and 6, respectively.

(1) Recipes of high creation capacity

Considering the fundamental effect of the core conditions in all-sufficient configurations by comparing intermediate solutions with parsimonies solutions (see Table 5), the four pathways that drive high creation capacity can be categorized into three types.

The first type consists of pathways 1A1 and 1A2, driven by the core condition of strong ties. Furthermore, combined with the peripheral conditions of downstream complexity (1A1) or internal complexity (1A2), strong ties can achieve high creation capacity in the SC. The second type is pathway 1 B, which is dominated by the absence of internal complexity as a core condition, with the assistance of peripheral conditions of downstream complexity and the absence of upstream complexity. The absence of downstream and upstream complexities constitutes the core condition of another alternative configuration, pathway 1C, while internal complexity is its peripheral condition. Regarding pathways 1B and 1C, the SC should have a moderate level of complexity to reach a high creation capacity in SCL, regardless of whether it is a downstream or internal stream. However, all three types of complexity cannot appear simultaneously or as core conditions in one configuration. In terms of high creation capacity in

SCL, they are overcomplicated. We, therefore, consider configurations with the following characteristics as moderate complexity: 1) the configuration contains one or two kinds of complexity, 2) complexity is not a core condition in configurations. These scenarios are reasonable. Specifically, downstream complexity is customer-oriented, internal complexity is production-oriented, and customers and products are the most critical creation drivers. In fact, only moderate SC complexity (e.g. pathway 1A1, 1A2, 1B, and 1C) will require high-level creation capacity to solve. Moreover, following Bozarth *et al.* (2009), Bode and Wagner (2015), and Sharma *et al.* (2020), complexity is one attribute of an SC that can be managed. For instance, the complexity of an SC can be changed by a temporary de-embedding (Sting *et al.*, 2019). Our finding also motivates the study of management regarding SC complexity. According to the principle of "progress on use and retarding on waste," moderate SC complexity helps to increase the creation capacity of the SC, and then achieve a high level of SCL. Taking all the above configurations of high creation capacity, the solution consisting of overall pathways barely reaches the threshold of 0.75 (0.746). We therefore propose Proposition 2a.

Proposition 2a. Both strong ties and moderate complexity positively influence on creation capacity of supply chain learning.

(2) Recipes of high dispersion capacity

As reported in Table 6, four paths can lead to a high dispersion capacity of the SC, and its overall solution consistency is 0.818, while the solution coverage is 0.848. Pathways 2A1 and 2A2 emphasized that the core condition of downstream complexity could not appear in related recipes. Meanwhile, upstream complexity (pathway 2A1) or strong ties (pathway 2A2) are required to act as a peripheral condition. Pathway 2B revealed that core conditions of upstream complexity and strong ties could lead to a high level of dispersion capacity. Pathway 2C includes (a) internal complexity, (b) absence of upstream complexity, and (c) absence of strong ties; these three components are core conditions. From a high dispersion capacity perspective, our findings provide different choices according to the actual scenarios of different firms. In other words, in pursuit of high SC dispersion capacity, firms can maintain their contingent or obtain a certain degree of independent choice by referring to Proposition 2b according to their real situations.

Proposition 2b1. To achieve a high dispersion capacity of the supply chain, firms may establish a certain level of upstream complexity or strong ties with the absence of downstream complexity as a core condition.

Proposition 2b2. A firm can achieve a high dispersion capacity of the supply chain by constructing upstream complexity and strong ties. A firm can also achieve high supply chain dispersion capacity by nurturing internal complexity while obtaining upstream complexity and strong ties is difficult.

4.2.2 Sufficient conditions for low supply chain learning

From the perspective of management practice, firms care about how to obtain high SCL manifested as high creation and dispersion capacities and how to avoid low SCL with low creation and dispersion capacities. According to Table 1, the five causal conditions are not the necessary conditions of low creation or dispersion capacity. All five causal conditions are involved in this analysis of sufficient configurations. The results of the QCA analysis are reported in Tables 7 and 8.

(1) Configuration of low creation capacity

According to Table 7, the overall solution consistency is 0.817 and the solution coverage is 0.723, which means that our findings warrant further analysis. The six pathways with low creation capacity can be categorized into four types. The first is pathway 3A, consisting of (a) the absence of strong ties serves as a core condition, (b) weak ties, (c) internal complexity, and (d) absence of upstream complexity. The latter three conditions act as peripheral conditions in this configuration.

The second type, pathway 3B, comprises downstream, internal, and upstream complexity, and weak ties. Among these "ingredients," downstream and upstream complexities are core conditions, whereas internal complexity and weak ties are peripheral conditions. It can be argued that this configuration is dominated by SC complexity to some extent, which means that a firm with extreme complexity in its SC aspect moves toward low creation capacity, even if it has weak ties.

We noticed that the absence of weak ties is a core condition in pathways 3C1, 3C2, and 3C3. Strong ties were also absent as core conditions in pathways 3C1 and 3C2. Therefore, we regard these three pathways as an SC network-oriented configuration, a third type of configuration. It can be inferred that a firm without a high-quality SC network also moves toward low creation capacity with a high probability, especially in the absence of core conditions of weak ties. Pathway 3A can also be considered as an SC network-oriented configuration. Therefore, firms should avoid low-quality SC network with the absence of weak (or strong) ties from the creation capacity perspective.

Moreover, we compared and analyzed the 3D and 3C1 pathways. Although the core condition of internal complexity is missing, a firm's SC will most likely face low creation capacity. Internal complexity stemming from production is essential to creation capacity (Zimmermann *et al.*, 2016). In summary, we propose the following propositions from the perspective of low creative capacity:

Proposition 3a1. Extreme complexity leads to low creation capacity; however, the absence of internal complexity is not conducive to creation capacity.

Proposition 3a2. An imperfect supply chain network also leads to low creation capacity, whether in the absence of weak or strong ties.

(2) Configuration of low dispersion capacity

The results in Table 8 indicate that the overall solution consistency was high at 0.821, and the solution coverage was 0.742. A total of six pathways with low dispersion capacities were constructed. From the distribution of core conditions, we tend to consider that low dispersion capacity originates from an incomplete SC network: the absence of weak or strong ties. Specifically, pathways 4A1, 4A2, 4A3, 4B, and 4D can be viewed as such scenarios. The dispersion capacity of the SC depends on the SC network (Lorentz *et al.*, 2012). Even in pathway 4C, a low dispersion capacity still appears, whereas both strong and weak ties are involved in peripheral conditions. This configuration is due to the absence of internal and downstream complexities, as they both play the role of core conditions. A relatively reasonable inference is that internal complexity originating from production positively contributes to the SC's dispersion capacity. In contrast, downstream complexity arising from customers negatively influences dispersion capacity (Gnizy, 2019). Therefore, we present the following propositions.

Proposition 3b1. Low dispersion capacity is mainly caused by the absence of a relatively complete supply chain network, that is, the absence of weak ties or strong ties.

Proposition 3b2. The absence of internal complexity and downstream presence also plays an important role in low dispersion capacity.

4.3 Robustness test

Combining all the propositions (i.e. Propositions 1, 2, and 3), we can draw the following inferences from the high SCL, represented by the interaction between creation and dispersion capacity.

Inference 1. Weak ties are always the necessary condition of high supply chain learning.

Inference 2. The moderate complexity of the supply chain is conducive to high supply chain learning.

Inference 3. Strong ties (or supply chain network) are conducive to high supply chain learning.

If our findings are robust, then the three core inferences will always hold, even if we measure the outcome variables (i.e. SCL) differently. To ensure the robustness of our findings, we measure SCL by taking the square root of the product of creation and dispersion capacity. The causal condition variables are downstream complexity, internal complexity, upstream complexity, weak ties, and strong ties. Weak ties are necessary conditions of SCL because the consistency score exceeds 0.9 (Ragin, 2008). Therefore, Inference 1 still holds.

[Insert Table 9 here]

According to Table 9, we identified four pathways leading to high SCL. The overall solution consistency was high at 0.832, and the solution coverage was 0.748. Comparing all four configurations, Inferences 2 and 3 also hold.

[Insert Table 10 here]

Following Judge *et al*. (2020), we raised the case frequency threshold from 2 to 3, and tested the above configurations, leading to high SCL. The results are presented in Table 10. Although the number of configurations is reduced to three, Inferences 2 and 3 still hold. Overall, our main findings are robust.

5. Discussion

We primarily investigate how factors arising from the SC network and complexity work together in SCL through the lenses of contingency theory. Our findings make several significant theoretical and practical contributions.

5.1 Theoretical Contributions

This study contributes to the literature in the following three aspects. First, our results contribute to the SCL literature by offering some new insights for facilitating SCL by configuring the SC structure. There are a few pioneering studies on SCL, which mainly focus on concept elaborating (e.g. Bessant *et al.*, 2003; Gong *et al*., 2018), or some specific learning behaviors, such as innovation capability (Bessant *et al.*, 2012) and knowledge transfer (Blome *et al*., 2014). Along with highly turbulent and uncertain economic environments that have become the main challenges facing the SC (Silvestre, 2015), the importance of SCL is widely recognized, but how to promote the formation of this learning ability is still not fully understood (Gong *et al*., 2018; Yang *et al.*, 2019; Silvestre *et al.*, 2020). In particular, existing studies do not answer the RQ of which SC structure configurations contribute to SCL. As Bessant *et al.* (2012) highlight, formally configured groups of organizations, such as SCs and networks, have become increasingly important for improving SCL and innovation. Overall, our findings extend the pioneering studies on SCL (e.g. Bessant *et al.*, 2003; Bessant *et al.*, 2012) by providing in-depth insights into the formation mechanism of high or low capacity of SCL, and also answer the RQ regarding what kind of configurations of structures may facilitate SCL, which previous studies have not fully addressed.

Second, based on contingency theory, this study proposes a different approach to configure SCs to facilitate SCL. Specifically, this study proposes for the first time to configure the SC from the internal structure (i.e. complexity) and external link (i.e. SC network). It reveals the causal complexity between different configuration paths and SCL, thus extending the SCL theory by outlining its structural characteristics. Furthermore, our integrative framework goes beyond the traditional approach of examining the net impact of individual antecedents on SCL. Since existing literature lacks theoretical integration and focuses on the net effect of a single antecedent, the immediate consequence is inconsistent research results on SCL (Haq *et al.*, 2021; Huo *et al.*, 2020; Willis *et al.*, 2016; Zhu *et al.*, 2018). In this study's context of SC structure, we focus on the SC network (Bessant *et al.*, 2012; Smart *et al.*, 2007) and complexity (Huang *et al*., 2020; Silvestre, 2015). Previous studies related to SC network highlight the critical role of the embedded nature of ties in supply networks in SCL (e.g. Bellamy *et al.*, 2014), and weak ties enhance communication and, in turn, intuitively promote SCL. However, according to contingency theory, the SC network (i.e. the linkage between SC members) cannot fully represent the SC structure. Our analysis confirms the value of theoretical integration in addressing the differences observed in previous studies. Under the theoretical framework of contingency theory, our results also provide a new explanation to what configurations of structures can lead to high or low level of SCL ability. Overall, our new inferences provide valuable insights into the theoretical frameworks that more empirical studies can apply in the future.

Finally, instead of analyzing the antecedent conditions of SCL as a single variable, we examined how factors from two perspectives combine into multiple configurations to influence SCL. Previous conceptual or empirical studies on such antecedents have mainly used case studies or regression models. However, our results indicate that the linear net effect of antecedents on results is inaccurate. In contrast, in the configuration of SCL, individual antecedents may or may not exist, depending on how they are combined with other antecedents. Compared with general regression analysis methods, the method we employed (fsQCA) can identify different configuration sets composed of “attribute patterns” (Fiss, 2007) and explore complex combinations of causal conditions in the relationship between SC structural configuration and SCL. This is because it can identify different sets of configurations made up of “attribute patterns” (Fiss, 2007). For instance, Inference 1 suggests that weak ties are still necessary for high SCL. This finding responds to the propositions in the literature that weak ties can establish links between groups (Ryberg and Larsen, 2008), provide information transmission channels (Granovetter, 2005), make information spread faster and wider (Centola and Macy, 2007), and play a leading role in information diffusion (Bakshy *et al.*, 2012).

However, Inference 2 shows that a high SCL capacity requires a moderate SC complexity; that is, all three types of complexity cannot exist simultaneously or act as core conditions in one configuration. This finding goes against the conventional wisdom that complexity is bad for a firm's operational performance (e.g. Bozarth *et al.*, 2009; Sharma *et al.*, 2020). More importantly, from the perspective of contingency theory, we further explain the role of the overall configuration of SC structure in SCL. Overall, using both the fsQCA method and contingency theory can better reveal how these structural components are combined to facilitate SCL.

5.2 Practical Contributions

The findings of this study provide valuable insights for SC focus companies, such as automotive manufacturers, to develop more effective responses to SCL (e.g. jointly addressing the impact of SC disruptions caused by COVID-19 and providing SC resilience).

First, when managing SC complexity, managers should not only consider its impact on the firm's operational, financial, or innovation performance (Akın Ateş *et al.*, 2022), but also avoid the ineffective trap of low SCL ability or accelerate the formation of high SCL ability. This study highlights that extreme complexity leads to low SCL ability, while the lack of internal complexity also hinders SCL. Therefore, managers need to balance the structure of each SC link, especially in the context of multi-tier SCM (Gong *et al.*, 2018; Najjar and Yasin, 2021). For example, managing some forms of SC complexity may become a strategy for focal firms to expand markets and increase profitability (Bozarth *et al.*, 2009; Aitken *et al.*, 2016), such as expanding product lines and introducing higher levels of customization. It can also contribute to higher SCL ability. However, managers in focal firms need to own the tools or approaches to adjust the SC complexity dynamically. A recent industry survey of SC professionals revealed that knowing little about complexity is one of the main causes of "sleepless nights" for SC leaders (Sharma *et al.*, 2020). Thus, managers should first understand and update each link's complexity in their SC and adapt it to meet the state requirements of high SCL capacity. For example, Sting *et al.* (2019) investigated a temporary de-embedding approach, in which the focal firm could strategically loosen the SC and then selectively recover it. Japanese carmaker Nissan has achieved a better SCM effect through this approach.

Further, the causal recipes yielded by this study can guide firms to improve SCL capacity directly or indirectly through the rational configuration of SC structures. In addition to taking appropriate measures to reduce the SC structure to a moderate level of complexity, we suggest that weak ties are always necessary for good SCL, while strong ties are beneficial. An interesting management issue is that, despite the growing importance of the SC network, up to 50% of inter-firm collaborations fail (Michelfelder and Kratzer, 2013). Therefore, managers need to guide the construction of strong and weak ties among SC members. Prior study has also pointed out that both weak and strong ties have advantages and disadvantages, and only the combination of such ties can be most effective in applications (Huszti *et al.*, 2013). Moreover, Chen *et al.* (2017) suggested that managers could use them following the mode of strong-weak collaborative management. Michelfelder and Kratzer (2013) further demonstrated that this combination of strong and weak ties also produced a "positive interaction effect." Owing to this, companies such as Toyota and Schneider Electric have been building and reassessing their supply networks (Bellamy *et al.*, 2014).

6. Conclusion

Based on the contingency theory perspective, we developed a holistic and comprehensive framework to identify the antecedents of SCL, considering the configuration of the SC structure. Using SC focal firm survey data and the fsQCA method, we performed a configuration analysis to examine SCL measures and their antecedents, including SC network strong and weak ties and upstream, internal, and downstream complexity. We present several major findings, including theoretical propositions. These emphasize the importance of using SC network, SC complexity perspectives, and configuration analysis methods to examine SCL ability. Overall, this can serve as a basis for future research to compensate for the current focus on SCL in conceptual studies.

This study has some limitations. First, it identifies the antecedents of SCL from the contingency theory perspective. However, the antecedents examined herein were not exhaustive. Other factors, such as cultural adaptation (Jia and Lamming, 2013), may also interfere with learning outcomes among SC members. Future studies should further explore the impact of these factors, particularly in conjunction with those examined in this study. Second, this study relied on self-reported data to measure SCL. Future studies could explore the possibility of using other methods to measure SCL, such as combining self-reported data with experimental behavioral data. Third, this study focused only on two dimensions of SCL. Although this study primarily elaborates on the connotation and antecedent conditions of SCL, which is of practical significance, future research can explore more dimensions to enrich the theory of SCL.

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Table 1. Construct measurement

Construct (Source)	Code	Item description	Loading	Cronbach's α	CR	AVE
Downstream complexity (Bozarth *et al.*, 2009)	DC	All of our customers desire essentially the same products. (Reverse scored)	0.726	0.544	0.740	0.488
		What is the average life cycle of your products(years)? (Reverse scored)	0.634			
		Our total demand, across all products is relatively stable. (Reverse scored)	0.732			
Internal complexity (Bozarth *et al.*, 2009)	IC	This plant's output requires many individual active part numbers of material items.	0.814	0.761	0.851	0.662
		The company's products are diverse.	0.842			
		The company's daily production schedule is different.	0.784			
Upstream complexity (Bozarth *et al.*, 2009)	UC	The company has many suppliers.	0.768	0.588	0.757	0.510
		The company strives to shorten the delivery time of its suppliers.	0.676			
		The company believes that the supplier will deliver on time.	0.693			
Weak ties (Tiwana, 2008)	WT	My partners vary widely in their areas of expertise.	0.705	0.685	0.812	0.521
		My partners have a variety of different backgrounds and experiences.	0.765			
		My partners have resources that complement each other's.	0.750			
		My partners have skills and abilities that complement each other's.	0.650			
Strong ties (Golicic and Mentzer, 2006; Morgan and Hunt, 1994)	ST	My partners treat my firm fairly and justly.	0.793	0.885	0.917	0.688
		My partners are sincere in their promises.	0.867			
		My partners have high integrity.	0.885			
		My partners can be counted on to do what is right.	0.831			
		My partners are firms my firm trust completely.	0.760			
Team orientation (Hult, 1998; Ojha *et al.*, 2018)	TO	A team spirit pervades our ranks in the supply chain processes.	0.892	0.922	0.945	0.810
		There is a commonality of purpose in the supply chain processes.	0.918			
		There is total agreement on our organizational vision in the supply chain processes.	0.917			
		We are committed to sharing our vision of the supply chain processes across all levels, functions, and divisions.	0.874			

Learning orientation (Hult, 1998; Ojha *et al.*, 2018)	LO	The sense around here is that employee learning is an investment, not an expense.	0.585	0.818	0.883	0.659
		The basic values of the supply chain processes include learning as a key to improvement.	0.880			
		The collective wisdom involved in the supply chain processes is that once we quit learning, we endanger our future.	0.856			
		We basically agree that our ability to learn is the key to improvement in the supply chain processes.	0.884			
Memory orientation (Hult, 1998; Ojha *et al.*, 2018)	MO	There is a good deal of supply chain conversation that keeps alive the lessons learned from history.	0.881	0.898	0.931	0.771
		We always keep records of unsuccessful supply chain endeavors and communicate the lessons learned widely.	0.879			
		We have specific mechanisms for sharing lessons learned in the supply chain processes from project to project.	0.905			
		We have formal routines that we use to uncover faulty assumption that we have made about the supply chain processes.	0.836			
System orientation (Hult, 1998; Ojha *et al.*, 2018)	SO	All activities that take place in the supply chain processes are clearly defined.	0.727	0.862	0.909	0.714
		We understand the contribution of the various supply chain processes towards the basic value chain and how our work fits into that chain.	0.871			
		We have a good sense of the interconnectedness of all parts of the supply chain processes.	0.888			
		We understand where all activities fit in the supply chain processes.	0.875			

(Source: Created by authors.)

Table 2. Correlation matrix

variables	1	2	3	4	5	6	7
1 Downstream complexity	1						
2 Internal complexities	-0.028	1					
3 Upstream complexities	-0.100	0.127	1				
4 Weak ties	-0.121	0.420**	-0.027	1			
5 Strong ties	-0.404**	0.203*	-0.266**	0.395**	1		
6 Creation capacity	-0.337**	0.233**	-0.164*	0.374**	0.455**	1	
7 Dispersion capacity	-0.364**	0.379**	-0.049	0.396**	0.425**	0.785**	1

Note: * indicates 5% significance level, and ** indicates 1% significance level. (Source: Created by authors)

Table 3. Descriptive statistics and calibration value of variables.

variables	Descriptive statistics				Calibration values		
	Mean	SD	Min	Max	Percentile 10	Median	Percentile 90
1 Downstream complexity	2.693	0.698	1.00	4.33	1.33	2.67	4.00
2 Internal complexities	3.613	0.916	1.00	5.00	1.40	3.00	4.60
3 Upstream complexities	2.769	0.393	1.67	4.00	1.83	2.84	3.77
4 Weak ties	3.563	0.604	1.25	5.00	1.63	3.13	4.63
5 Strong ties	3.700	0.560	1.80	5.00	3.12	3.4	4.68
6 Creation capacity	14.606	4.307	3.50	25.00	5.65	14.25	22.85
7 Dispersion capacity	14.017	4.140	1.50	25.00	3.85	13.25	22.65

(Source: Created by authors)

Table 4. Necessity of conditions relative to the occurrence and no occurrence of the creation capacity and the dispersion capacity

Variables	CR (consis, cover)		~CR (consis, cover)		DE (consis, cover)		~DE (consis, cover)	
DC	0.66	0.66	0.78	0.72	0.65	0.69	0.80	0.70
~DC	0.73	0.78	0.64	0.64	0.72	0.81	0.65	0.61
IC	0.87	0.65	0.83	0.57	0.89	0.70	0.82	0.53
~IC	0.42	0.72	0.49	0.78	0.40	0.73	0.54	0.81
UC	0.63	0.70	0.73	0.76	0.65	0.77	0.72	0.71
~UC	0.79	0.76	0.72	0.64	0.76	0.77	0.77	0.65
WT	0.91	0.70	0.82	0.59	0.92	0.74	0.84	0.57
~WT	0.47	0.74	0.58	0.85	0.47	0.78	0.62	0.86
ST	0.89	0.73	0.77	0.59	0.88	0.77	0.81	0.59
~ST	0.50	0.70	0.65	0.85	0.52	0.77	0.68	0.83

(Source: Created by authors)

Table 5. Configurations of complexities and strong ties (supply chain network) leading to high creation capacity

variables	high creation capacity			
	1A1	1A2	1B	1C
DC	•	○	•	⊗
IC	○	•	⊗	•
UC	○	○	⊗	⊗
ST	●	●	○	○
consistency	0.799	0.782	0.839	0.886
Raw coverage	0.601	0.798	0.336	0.571
Unique coverage	0.005	0.083	0.010	0.012
Solution consistency	0.746			
Solution coverage	0.862			

NOTES: ●indicates the presence of a core condition, • indicates the presence of a peripheral condition, ⊗ indicates the absence of a core condition, ⊗ indicates the absence of a peripheral condition, ○ indicates "don't care". (Source: Created by authors)

Table 6. Configurations of complexity and strong ties (supply chain network) leading to high dispersion capacity

variables	high dispersion capacity			
	2A1	2A2	2B	2C
DC	⊗	⊗	○	○
IC	○	○	○	●
UC	•	○	●	⊗
ST	○	•	●	⊗
consistency	0.897	0.871	0.886	0.902
Raw coverage	0.517	0.680	0.598	0.407
Unique coverage	0.018	0.169	0.064	0.046
Solution consistency	0.818			
Solution coverage	0.848			

NOTES: ●indicates the presence of a core condition, • indicates the presence of a peripheral condition, ⊗ indicates the absence of a core condition, ⊗ indicates the absence of a peripheral condition, ○ indicates "don't care". (Source: Created by authors)

Table 7. Configurations of complexities and supply chain network leading to low creation capacity

variables	low creation capacity					
	3A	3B	3C1	3C2	3C3	3D
DC	○	●	•	⊗	⊗	•
IC	•	•	⊗	•	•	⊗
UC	⊗	●	⊗	•	⊗	⊗
WT	•	•	⊗	⊗	⊗	•
ST	⊗	○	⊗	⊗	•	•
consistency	0.887	0.853	0.965	0.951	0.894	0.913
Raw coverage	0.436	0.542	0.298	0.337	0.356	0.341
Unique coverage	0.033	0.112	0.022	0.015	0.027	0.029
Solution consistency	0.817					
Solution coverage	0.723					

NOTES: ●indicates the presence of a core condition, • indicates the presence of a peripheral condition, ⊗ indicates the absence of a core condition, ⊗ indicates the absence of a peripheral condition, ○ indicates "don't care". (Source: Created by authors)

Table 8. Configurations of complexities and supply chain network leading to low dispersion capacity

variables	low dispersion capacity					
	4A1	4A2	4A3	4B	4C	4D
DC	•	○	•	⊗	●	⊗
IC	○	•	•	○	⊗	•
UC	⊗	⊗	○	⊗	○	•
WT	○	•	•	⊗	•	⊗
ST	⊗	⊗	⊗	•	•	⊗
consistency	0.915	0.905	0.883	0.899	0.919	0.948
Raw coverage	0.492	0.472	0.513	0.413	0.393	0.357
Unique coverage	0.032	0.013	0.051	0.052	0.054	0.009
Solution consistency	0.821					
Solution coverage	0.742					

NOTES: ●indicates the presence of a core condition, • indicates the presence of a peripheral condition, ⊗ indicates the absence of a core condition, ⊗ indicates the absence of a peripheral condition, ○ indicates "don't care". (Source: Created by authors)

Table 9. Configurations of complexities and strong ties leading to high supply chain learning (case frequency cutoff is 2)

variables	high supply chain learning 4A	4B1	4B2	4C
DC	⊗	⊗	○	⊗
IC	○	⊗	⊗	•
UC	○	●	●	⊗
ST	●	○	•	○
consistency	0.860	0.925	0.907	0.898
Raw coverage	0.697	0.304	0.335	0.569
Unique coverage	0.104	0.004	0.036	0.010
Solution consistency	0.832			
Solution coverage	0.748			

NOTES: ●indicates the presence of a core condition, • indicates the presence of a peripheral condition, ⊗ indicates the absence of a core condition, ⊗ indicates the absence of a peripheral condition, ○ indicates "don't care". (Source: Created by authors)

Table 10. Configurations of complexities and strong ties leading to high supply chain learning (case frequency cutoff is 3)

variables	high supply chain learning 5A	5B	5C
DC	⊗	•	⊗
IC	•	⊗	•
UC	○	●	⊗
ST	●	•	○
consistency	0.884	0.913	0.898
Raw coverage	0.644	0.297	0.569
Unique coverage	0.077	0.044	0.011
Solution consistency	0.861		
Solution coverage	0.700		

NOTES: ●indicates the presence of a core condition, • indicates the presence of a peripheral condition, ⊗ indicates the absence of a core condition, ⊗ indicates the absence of a peripheral condition, ○ indicates "don't care". (Source: Created by authors)