INTERNATIONAL JOURNAL OF LOGISTICS: RESEARCH AND APPLICATIONS
2024, VOL. 27, NO. 7, 1071–1091
https://doi.org/10.1080/13675567.2024.2347925

The influence of supply chain leadership on innovation: the mediating role of team creativity climate and the moderating role of supply chain complexity

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ABSTRACT

Amid dispersed global value chains and increased external opportunities to innovate, supply chain leaders have remarkably understood and mobilised resources, and firms that use supply chain resources have actively innovated and interacted with one another. This study uses social cognitive theory to examine the influence of supply chain leaders on innovation performance, the mediating role of team creativity climate in this relationship, and the moderating role of supply chain complexity in the relationships among leadership, performance, and team creativity climate. A questionnaire was administered to 211 Chinese firms, and their responses were assessed using hierarchical regression and bootstrap analyses. The results showed that supply chain leadership significantly and positively affected innovation performance, a relationship mediated by team creativity climate. This mediation was positively moderated by supply chain complexity. Finally, a moderating mediating effect was observed.

ARTICLE HISTORY
Received 3 February 2023
Accepted 23 April 2024

KEYWORDS
Supply chain leadership; team creativity climate; innovation; supply chain static complexity; supply chain dynamic complexity

1. Introduction

Given the evolving meaning of innovation, shortening of product life cycles, and increased division of labour, new insights depend greatly on combining knowledge from diverse actors and various professional fields (Xu, Yang, and Xue 2019). New knowledge is more crucial than cost reduction for the competitiveness of an organisation's products (Crevoisier 2016). In the supply chain context, acquiring knowledge enables leveraging resources, yielding optimised results (Yan and Azadegan 2017). For example, working with suppliers uncovers insights that reduce costs and improve the quality of inputs and production processes (Slowinski et al. 2009). Obtaining customer feedback also enables organisations to understand consumers' sensitivity to market trends, evaluation of new product concepts, and first-hand user experiences (Chang and Taylor 2016). This highlight a cross-organisational governance style called supply chain leadership (Mokhtar et al. 2019). Hydro Polymers exercises this style of leadership. The company is a primary polyvinyl chloride producer that has secured a leading position in a valuable supply chain by disseminating sustainable designs and production best practices through online training and other mechanisms, such as supplier meetings (Gosling et al. 2016). Therefore, it has created a new industry standard for supply chain leadership.

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Supplemental data for this article can be accessed online at https://doi.org/10.1080/13675567.2024.2347925.

Research on supply chain leadership can be summarised into studies on organisational innovation facilitated by transformational leadership (Al Harbi, Alarifi, and Mosbah 2019; Jung, Chow, and Wu 2003) and investigations focusing on supply chain innovation stimulated by supply chain leadership (Aslam et al. 2020; Ojha, Acharya, and Cooper 2018). However, few studies have considered the entire supply chain as a collaborative whole (Chen, Li, and Zhang 2021), with the majority disregarding how individual performance and improvement are managed cooperatively (Jia, Gong, and Brown 2019). This insufficiency in research extends to supply chain leaders' innovation performance in cross-organisational endeavours, particularly the effects of supply chain leadership on internal innovation. Finally, there is a lack of attention paid to how supply chain leadership addresses firms' self-interested behaviours.

Considering the gaps and differences in existing literature, we could not adopt the term 'supply chain leadership' without carefully considering its origin. We explored the broader concept of leadership and included those in senior management roles based on whether these reflect an application of supply chain leadership (Sandberg and Abrahamsson 2010; Villena et al. 2018). We also considered various dimensions of leadership, such as cross-organisational leadership (Tan and Cross 2012; Lubi et al. 2021), leadership (Day et al. 2014; Ojha, Acharya, and Cooper 2018), creative leadership (Al Harbi, Alarifi, and Mosbah 2019; Bednall et al. 2018), and supply chain strategy (Tan and Cross 2012), to enrich the logical framework of the current research.

Further, we comprehensively synthesised the prevailing theoretical foundations associated with supply chain leadership. The feasibility of applying individual leadership to supply chain organisations was first proposed by Clifford Defee, Esper, and Mollenkopf (2009), who also demonstrated the interaction between organisations as supply chain leaders and members (Clifford Defee, Esper, and Mollenkopf 2009). Mokhtar et al. (2019) were the first to attempt a comprehensive and systematic literature review on supply chain leadership. However, they focused only on the role of such leadership in promoting the sustainability of an entire supply chain (Mokhtar et al. 2019). The most commonly used framework in this research in this discipline is leadership theory (Chen, Li, and Zhang 2021), whereas leadership – member exchange theory and social cognitive theory (SCT) are relatively new perspectives. Table 1 compares the theoretical bases of the existing leadership research and the degree of agreement between these studies and the current study. We used SCT as a theoretical framework because it can effectively illustrate how supply chain leaders change the environment and mobilise an organisation's members to engage in innovative behaviour.

Regarding cross-organisational mechanisms, a creative climate in the workplace is considered essential for employees to improve their innovative performance (Xie et al. 2018; Andersson, Moen, and Brett 2020; Ebrahimi, Moosavi, and Chirani 2016; Ye, Liu, and Tan 2022). For example, Hippo, a large grocer and fresh food chain store, obtains high-quality products from overseas by mobilising its staff to actively provide comprehensive e-commerce operation guidance and support services to its suppliers, regularly organising webpage design, training, and consultation programmes, and entering into cooperation agreements with 33 retailers worldwide (Ying 2023). An organisation cannot effectively manage external resources without fostering a climate characterised by team creativity (Kiratli et al. 2016). Therefore, numerous scholars have investigated how such creativity (Zhang and Bartol 2010; Henker, Sonnentag, and Unger 2015; Eisenbeiß and Boerner 2013) or individual innovation (Jaussi and Dionne 2003; Hwangbo, Shin, and Kim 2022; Jung, Chow, and Wu 2003; Shin and Park 2021) can be stimulated by leadership. Previous studies have focused primarily on internal organisational environments, which are important in innovative work behaviours and motivating employees to promote innovative performance (Widmann and Mulder 2018; Ye, Liu, and Tan 2022). According to SCT, a workplace managed via supply chain leadership is an external environment that affects team behaviour. Attention to the upstream and downstream segments of a supply chain can motivate team members to spontaneously offer support (Salanova, Rodríguez-Sánchez, and Nielsen 2022; Griffin, Parker, and Mason 2010) to create a climate of creativity, thereby advancing continuous innovation in an organisation (Lorentz

Table 1. Supply chain leadership theoretical basis and degree of agreement with this study.

Definition	Theoretical basis	Core view	Degree of agreement
Supply chain leadership is a relational concept involving a supply chain leader and one or more followers interacting in a dynamic, mutually influencing process (Clifford Defee, Stank, and Esper 2010).	Leadership theory (LT)	LT is characterised by attention to the traits, qualities, personalities, and behaviours of leaders. LT can achieve the expected goals and objectives from the influence process initiated by leaders to change the actions and behaviours of followers (Day et al. 2014; Uhl-Bien et al. 2014). Leadership is a social influence process where a leader should guide and motivate followers to act in an orderly manner to achieve a goal (Yammarino 2013). Therefore, much of the literature on this theory focuses on the influence of different leadership styles or behaviours (Mokhtar et al. 2019; Xie et al. 2018; Gosling et al. 2016).	Low (Focus on leadership style or behaviour)
	Leader – member exchange theory (LMET)	LMET emphasises a cross-organisational approach, focusing on two-way interactions between leaders and their subordinates. It shows that the exchange between leaders and their subordinates should include three dimensions: liking, freedom, and mutual support (Terpstra-Tong et al. 2020). LMET is characterised by the relationship between leaders and different members (Gu, Tang, and Jiang 2015), which is used to measure and assess partnership quality by supply chain leaders (Shin and Park 2021; Arrasyid and Pandin 2019).	Low (Focus on internal – internal or external – external relationships)
	Social cognitive theory (SCT)	SCT has been widely applied to study organisational behaviour. SCT holds that individuals are not only affected by the external environment (Wang, Zou, and Cui 2018) but can and will actively improve the external environment based on their own needs (Bandura 2012). When team members spontaneously support common goals and drive others to do the same through shared leadership, individuals share benefits and information with others to increase their organisational commitment, generate positive expectations of returns, and create a highly innovative performance to feed back to the organisation (Ye, Liu, and Tan 2022; Su et al. 2018).	High (Focus on external – internal relationship)

et al. 2012). A creative climate effectively captures phenomena of interest and their relationships with particular outcomes (Hunter, Bedell, and Mumford 2007; Cirella, Radaelli, and Shani 2014; Abi Saad and Agogué 2023). Despite these insights, there is no evidence on whether supply chain leaders transform external innovation into internal innovation in an innovative climate.

A supply chain system is a complex network encompassing various organisations, relationships, processes, and interactions. Multiple scholars have elucidated such complexity differently; some believe that predicting the results of these interactions becomes increasingly complicated when a complex system expands to accommodate more interaction partners. As the complexity of a supply chain increases, its performance may deteriorate (Bozarth et al. 2009; Tarei et al. 2021). Other scholars argue that complexity favourably adjusts the relationship between supply chains and organisations (Chowdhury et al. 2023) and that the types of supply chain complexity should be separately considered (Macchion et al. 2020). For example, BYD (a leader in renewable energy equipment and electric vehicles) focuses on innovation in its supply chain by investing in hard skills and technologies, such as batteries, artificial intelligence, and semiconductors. Their battery supplier, Fudi Technology, concentrates on the research and development of blade batteries, enabling BYD to occupy a leading position in the market and providing a platform for other organisations in the US and Japan to use the technology (Hua 2023). This case study demonstrates that supply chain complexity does not always result in poor outcomes. Therefore, it is crucial to refrain from underestimating the influence of complexity on an organisation. However, supply chain complexity can complicate its management. For instance, dynamic processes and interactions across the numerous levels of a system require leaders to effectively regulate the system, adapt to the ever-changing supply chain environment, and flexibly adjust strategic plans (Gosling et al. 2016). Consequently, highlighting the role of supply chain complexity with supply chain leadership and innovation performance is imperative.

Thus, this study seeks to answer two questions: (1) Does supply chain leadership promote innovation performance through a team creativity climate? (2) Does the relationship between supply chain leadership and innovation performance strengthen, depending on the type of supply chain complexity (dynamic or static)? We conducted a questionnaire survey of 211 firms in China and conducted descriptive, correlation, and regression analyses on the collected data. We assume that organisations can better use the innovation results derived by supply chain members through a team creativity climate, which positively affects innovation performance. Our study contributes to the literature on managing supply chains and innovation performance. It presents a practical path for the flow of innovation within and beyond organisations, and provides theoretical and practical guidance for managers on optimising their access to external innovation.

The remainder of this paper is structured as follows: Section 2 presents the literature review, including the proposed concepts related to supply chain leadership, team creativity climate, and supply chain complexity. It also describes hypothesis development based on the literature. Section 3 introduces the data sources and methods, and Section 4 details the empirical tests and results. Section 5 discusses the theoretical contributions and management implications of the study, and Section 6 concludes the paper and presents the limitations and future directions for related research.

2. Theoretical background and hypothesis development

2.1. Supply chain leadership, team creativity climate, and innovation performance

Supply chain leadership is a relational concept involving a supply chain leader and one or more supply chain followers (organisations) interacting in a dynamic, mutually influencing process (Clifford Defee, Stank, and Esper 2010). Supply chain leadership requires organisations to model leadership among supply chain partners to serve as supervisors in their supply chains (Chen, Li, and Zhang 2021). Empirical research on this leadership style has revealed that supply chain leaders across different industrial structures and product industries exhibit characteristics of traditional leaders but exercise more effective leadership than other member organisations (Sharif and Irani 2012; Mokhtar et al. 2019; Prabhu and Srivastava 2023). Companies with a considerable impact are effectively recognised as visionaries and can establish strong partnerships with other entities in a supply chain (Khalifa Alhitmi et al. 2023). Leading companies often encounter recurrent challenges when implementing initiatives, overseeing supplier relationships, and acquiring and effectively leveraging external resources (Wilhelm et al. 2016).

This study used SCT to explain the relationship between a leading company and its supply chain partners, and how supply chain leadership enhances companies' competitiveness in innovation by cultivating a climate conducive to team creativity. Prior studies have indicated that organisations remain attentive to the interplay between social and environmental factors (Salanova, Rodríguez-Sánchez, and Nielsen 2022; Griffin, Parker, and Mason 2010). SCT maintains that social factors and environmental structures can influence the cognitive capabilities and beliefs of individuals and groups (Malibari and Bajaba 2022). Frequent interactions within and outside an organisation generate beliefs that often lack links between management-related factors and desired outcomes (Anderson, Potočnik, and Zhou 2014). The given climate results from a unique pattern that underlies the team members' collective beliefs. According to SCT, supply chain leadership changes an organisation's vision of a supply chain, guides a team's purpose of action, and encourages the team to consider problems from different perspectives (Shen et al. 2021; Bagheri, Akbari, and Artang 2022). Changes in and their influence on the environment enable team members to spontaneously support shared goals and motivate others to act similarly (Bagheri, Newman, and Eva 2022). By sharing interests and information with others, individuals increase their organisational commitment, generate positive expectations for returns, and create high innovation performance for an organisation (Khaola 2019).

Specifically, the logic that supply chain leadership realises innovation through a team creativity climate is embodied in two aspects. First, supply chain leadership paves the way for consistently articulating a team's vision, generating opportunities, encouraging transformative thinking, and cultivating an innovation-oriented climate grounded in the shared beliefs of team members. This comprehensive approach effectively fosters a team's willingness to embrace and engage in innovative practices (Malibari and Bajaba 2022). Supply chain leadership creates an organisational climate that is psychologically non-threatening, supports risk-taking, and motivates employees to take initiative (Parzefall, Seeck, and Leppänen 2008; Prabhu and Srivastava 2023). A climate supportive of team creativity enhances employees' innovative work behaviours by fostering their ability to accept new ideas and increasing their enthusiasm for exploring new opportunities (Yeoh and Mahmood 2013; Yu, Yu, and Yu 2013). Simultaneously, supply chain leadership conveys a positive organisational vision to its members, who are intrinsically motivated to go beyond realising organisational interests after accomplishing their individual goals (Al Harbi, Alarifi, and Mosbah 2019). Through this stimulation, supply chain members can generate external ideas and opportunities. By leveraging each other's creativity, they can promote the creation, promotion, and implementation of novel and beneficial ideas. Creative employees are better at identifying, acquiring, and using external knowledge (Bagheri, Newman, and Eva 2022) and more effectively promote organisational success by generating, encouraging, and implementing fresh, advantageous concepts to improve work processes, products, and services (Savic, Lawton Smith, and Bournakis 2020).

Second, the team creativity climate supports innovative behaviour and performance. It emphasises the effects of team members' perceptions or experiences of a work environment on their creative efforts, and has a dynamic diffusion effect that extends horizontally and vertically (Hunter, Bedell, and Mumford 2007; Cirella, Radaelli, and Shani 2014; Abi Saad and Agogué 2023). This climate underscores the willingness to exercise innovation and the efforts made, which are complemented by opportunities and supported by supply chain leadership (Rosing, Frese, and Bausch 2011; Tse, To, and Chiu 2018). This process ultimately advances innovative work behaviours. However, fully mobilising and utilising the innovative abilities of team members can ensure the long-term effectiveness of the sustainable development of an organisation and tremendously improve innovation performance (Jia, Gong, and Brown 2019; Chowdhury et al. 2023). Accordingly, we formulated the following hypothesis:

> H1. Team creativity climate mediates the relationship between supply chain leadership and innovation performance.

2.2. Supply chain complexity as a moderating variable

Previous studies on innovation have often regarded dynamics and complexity as moderating variables representing the effects of uncertain external environments on innovative organisational behaviours (Lee and Wong 2011; Vega-Jurado et al. 2008; Fernández Campos, Huaccho Huatuco, and Trucco 2024). Supply chain complexity can be divided into dynamic and static forms (de Leeuw, Grotenhuis, and van Goor 2013; Sokolov et al. 2016; Isik 2010; Fernández Campos, Trucco, and Huaccho Huatuco 2019). Dynamic complexity represents supply chain uncertainty concerning industry characteristics, time, and randomness. Static complexity represents the structure of a supply chain, the diversity of its components, and the intensity of the interactions between these components (Serdarasan 2013).

This division of supply chain complexity is based on the following considerations. First, different complexities may have varying effects on innovative behaviours in supply chains (Fernández Campos, Huaccho Huatuco, and Trucco 2024). *Dynamic complexity* typically encompasses industrial, technological, and market changes (Fernández Campos, Trucco, and Huaccho Huatuco 2019). These factors are often unpredictable, resulting in increased uncertainty in the supply chain environment, making it difficult for organisations to promptly respond to changes (Jaiswal and Dhar 2015). *Static complexity* primarily reflects the complexity of a supply chain structure, including characteristics such as the number of suppliers, product types, and critical components (Serdarasan 2013). These factors are relatively stable. Static and dynamic complexity separately aid in exhaustively understanding the complexity of a supply chain and distinguishing the different innovation-related challenges organisations face.

Additionally, both forms of complexity reflect differences in the management methods and coping strategies of organisations operating in dissimilar environments. *Dynamic complexity* centres on uncertainty and variability, affecting supply chain decision-making and operations (Park and Kremer 2015). For example, fluctuations in market demand, technological advances, and the entry of new competitors may lead to changes in products in the chain, adjustments in supplier relationships, and the redesign of processes. Dynamic complexity necessitates agility and adaptability among supply chain managers and the ability to expediently adjust and respond to changes to ensure the stable and seamless operation of the supply chain (Bednall et al. 2018). *Static complexity* revolves around structural and organisational components, including supplier networks, diversity of product lines, and the establishment of internal processes and coordination mechanisms (Park and Kremer 2015). Static complexity can complicate the supply chain management and coordination. Supply chain managers must focus on the efficiency of coordination between different links in a supply chain and the accuracy of information transmission to ensure the overall effectiveness and seamless operation of the chain (Bode and Wagner 2015).

In summary, supply chain complexity highlights potential differences in supply chain leadership and innovation performance. When an organisation's supply chain is typified by considerable dynamic complexity, the demand for innovation becomes more urgent, necessitating flexible and agile innovation strategies (Chowdhury et al. 2023). Conversely, when a supply chain is characterised by static complexity, organisations should emphasise optimisation and coordination to enhance resource utilisation and overall supply chain efficiency (Aitken, Bozarth, and Garn 2016). Categorising supply chain complexity into dynamic and static complexities enables organisations to navigate supply chain uncertainties better and formulate effective innovation strategies.

2.2.1. Supply chain dynamic complexity

Dynamic complexity is the uncertainty caused by the extent of the change in a system. This results from the time-dependent activities that complicate a system by introducing unexpected events (Park and Kremer 2015). Emerging industries and high-tech organisations are knowledge-intensive and interdisciplinary entities confronted with rapid technological and market changes. They also depend considerably on external knowledge (Savic, Lawton Smith, and Bournakis 2020). As the level of dynamic complexity in a supply chain increases, the mutual influence between supply chain leadership and team creativity climate becomes more pronounced. Organisational managers, notably supply chain leaders, use supply chains to increase innovation (Bednall et al. 2018; Chen, Li, and Zhang 2021). They foster a creative work climate by motivating and supporting employees.

When a supply chain's dynamic complexity is high, employees are innovative and encouraged (Jaiswal and Dhar 2015; Fernández Campos, Trucco, and Huaccho Huatuco 2019). Meanwhile, industry and market dynamism increase the likelihood of an organisation benefitting from a particular innovation, and dynamic complexity in a supply chain can accelerate knowledge transfer (Fang and Zou 2010; Fernández Campos, Trucco, and Huaccho Huatuco 2019), facilitating decision-making by supply chain leaders (Salanova, Rodríguez-Sánchez, and Nielsen 2022).

The higher the dynamic complexity, the stronger the impact of the team creativity climate on innovation performance. According to SCT, environmental change can enhance employee creativity and behaviour (Khalifa Alhitmi et al. 2023). The stronger the nature and vitality of the industry and market in which an organisation operates, the greater the curiosity and willingness of employees, thus enhancing their enthusiasm for work (Malibari and Bajaba 2022). Climate significantly promotes the creation of new products (Ye, Liu, and Tan 2022). The dynamic complexity of a supply chain requires the team to reinforce its ability to explore and innovate, promoting innovation performance (Ojha, Acharya, and Cooper 2018). Thus, Hypothesis 2 was proposed.

> H2. Dynamic complexity moderates the relationship between supply chain leadership and innovation performance. Specifically, supply chain dynamic complexity positively moderates the relationship between (a) supply chain leadership and team creativity climate and (b) team creativity climate and innovation performance.

2.2.2. Supply chain static complexity

Static complexity refers to the physical configuration of a system, the structural characteristics of which reflect its level of uncertainty (Park and Kremer 2015). As complexity increases, individual knowledge, skills, and abilities are unlikely to meet task requirements. In complex tasks, cooperation and information exchange are necessary despite background demands and the realisation of team goals. Static complexity describes a supply chain's structure, the diversity of its components, and the intensity of their interactions (Serdarasan 2013). The more complex the technology and market, the more dependent a supply chain is on external knowledge to promote cooperation and information exchange (Nguyen et al. 2022). Therefore, in an environment with high static supply chain complexity, supply chain leaders tend towards cooperation and information, reinforcing the attention of an organisation and strongly affecting the team creativity climate. Complex environments require tolerant and supportive leaders, such as those demonstrating leadership qualities in a supply chain (Mahmood, Uddin, and Fan 2019; Omri 2015). A highly complex external environment can accelerate leaders' influence on employees' desire to participate in innovation efforts (Dóci and Hofmans 2015; Poutanen, Soliman, and Ståhle 2016; Willis, Clarke, and O'Connor 2017). When managers perceive a supply chain's complexity, they promote collaborative innovation and innovation performance by expressing their vision and placing high expectations on the team.

The higher the static supply chain complexity, the stronger the impact of the team creativity climate on innovation performance. Supply chain complexity reinforces the breadth and depth of an organisation's supply network. Static supply chain complexity requires organisations to frequently contact existing and potential supply chain members to identify high-quality suppliers and customers who meet the organisation's needs (Macchion et al. 2020; Bode and Wagner 2015). This requires teams to focus on innovation opportunities and acquire innovation partners. For example, suppliers' participation in developing new products can explain how an organisation innovates through supplier capabilities (Nguyen et al. 2022). When a team feels that supply is complex, they are more inclined to optimise the buyer – supplier relationship and dynamically adjust the supply base to match an organisation's current demand and achieve innovation. Thus, we propose the following hypothesis.

H3. Static supply chain complexity moderates the relationship between supply chain leadership and innovation performance. Specifically, supply chain static complexity positively moderates the relationship between (a) supply chain leadership and team creativity climate and (b) team creativity climate and innovation performance. Our overall research model is presented in Figure 1.

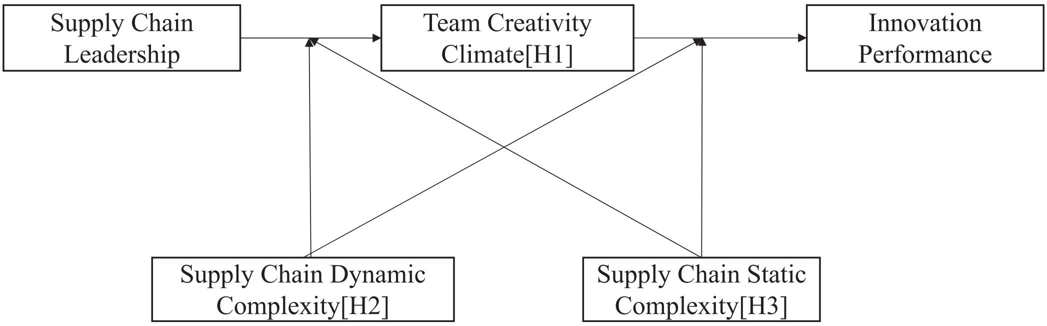

Figure 1. Conceptual framework.

3. Methodology

3.1. Data sources and collection

Data were collected using a questionnaire that mainly targeted secondary and tertiary industries in China, such as manufacturing (electronic equipment, medical care, automobile, food, etc.) and service industries (communication, transportation, finance, etc.). A strong dependence on supply chains and high requirements for innovation characterise these sectors. From October 2021 to June 2022, 500 firms were randomly selected from the member list published by the industry association as target test firms, according to the classification standards of large, medium, and small industrial organisations. The primary contact information of relevant organisations and personnel was obtained through headhunting organisations within industries, and the managers responsible for product research and development, supply chain, and marketing were selected as the research objects. Such employees understand the requirements of external innovation and promote innovation transformations. The survey used multiple contact methods, such as email, QQ, WeChat, telephone, and door-to-door visits, and was distributed and collected twice. A total of 500 questionnaires were distributed, and 211 were returned. The questionnaire comprised three parts. Section 1 briefly described the purpose and significance of the study. It guaranteed respondent anonymity to encourage them to answer questions honestly, ensuring no right or wrong answers and that responses would only be used for academic research. Section 2 included questions on the respondents' demographics and business information. Section 3 asked the respondents to rate the measurement items according to their level of agreement, with 1 indicating 'strongly disagree' and 5 indicating 'strongly agree.' The demographic characteristics of the participants are presented in Table 2.

3.2. Variable measurement

Variables were measured using a five-point Likert scale. Table 3 presents the measurement scales for all variables in this study. The value of χ^2/df was 1.157, less than 3, and RMSEA was 0.025, less than 0.05. The NFI RFI, IFI, TLI, and CFI were 0.922, 0.906, 0.989, 0.986, and 0.989, respectively, all greater than 0.9. Thus, all variables indicated a good fit. Supply chain leadership models, team creativity climate, innovation performance, dynamic complexity, and static complexity fit well.

Table 2. Respondent demographics.

Characteristics	Sample type	Number of samples
Employees education background	High school and below	40
	College	135
	Graduate student and above	36
Length of service (years)	Less than 2	33
	2–5	22
	5–10	52
	10–20	48
	Over 20	56
Firm size (number of employees)	Less than 100	126
	100–500	49
	Over 500	36
Age of employees (years)	18–30	105
	31–40	39
	41–50	30
	51–60	29
	Over 60	8

3.3. Common method deviation test

In empirical studies based on questionnaires, if the same participants answer all the observed variables in the questionnaire, a common method bias occurs, affecting the research results. Therefore, this study used an anonymous questionnaire to control for homologous variance, and Harman's

Table 3. Variable measurement, factor analysis, and reliability coefficient.

Construct and indicators	Factor loading
Supply chain leadership (AVE: 0.703, CR: 0.943, Cronbach's α: 0.922), *Source: Clifford Defee, Stank, and Esper (2010)*	
SCL1. Articulates a compelling vision for the future of the supply chain.	0.82
SCL2. Defines the core purpose of the actions of all supply chain members.	0.862
SCL3. Asks the company for a different point of view when solving a problem.	0.859
SCL4. Allows the company to see things from a different perspective.	0.871
SCL5. Asks the company for advice on improving supply chain issues.	0.843
SCL6. Helps the company develop supply chain execution.	0.8
SCL7. Encourages the company to continuously improve its supply chain skills.	0.813
Team creativity climate (AVE: 0.741, CR: 0.963, Cronbach's α: 0.956), *Source: Kiratli et al. (2016)*	
TCC1. My company is open to everyone's views and ideas.	0.89
TCC2. My company is committed to thinking across departments.	0.892
TCC3. My company actively seeks constructive discussions with the other party.	0.837
TCC4. My company encourages trying new ways of doing things.	0.847
TCC5. My company likes to explore unfamiliar or unknown ideas and perspectives.	0.837
TCC6. My company allows me to openly share ideas without the fear of rejection.	0.83
TCC7. My company will work according to each other's ideas.	0.899
TCC8. My company values the contribution of every team member.	0.882
TCC9. My company promotes behaviours that are conducive to building a trusting environment.	0.829
Innovation performance (AVE: 0.762, CR: 0.906, Cronbach's α: 0.848), *Source:* Nguyen et al.(2022)	
IP1. My company launches a large number of new products every year.	0.874
IP2. My company has a very short lead time to implement a new process or change an existing process.	0.889
IP3. My company has a very short lead time for new product launches.	0.856
Supply chain dynamic complexity (AVE: 0.777, CR: 0.946, Cronbach's α: 0.929), *Source:* Fang and Zou (2010)	
SCDC1. Customer preferences change rapidly over time.	0.89
SCDC2. Market needs and consumer tastes are always unpredictable.	0.886
SCDC3. The behaviour of our domestic and foreign competitors has been highly unpredictable.	0.883
SCDC4. Competition in my company changes quickly.	0.881
SCDC5. It is difficult for my company to predict the direction of technology in this field for the next five years.	0.867
Supply chain static complexity (AVE: 0.767, CR: 0.908, Cronbach's α: 0.865), *Source: Serdarasan (2013)*	
SCSC1. My company is highly interactive in the supply chain.	0.885
SCSC2. My company connects to a large number of orders/customers.	0.89
SCSC3. My company connects to a large number of suppliers.	0.852

Note: N = 211; Model fit indices: $\chi^2/df = 1.157$; NFI = 0.922; RFI = 0.906; IFI = 0.989; TLI = 0.986; CFI = 0.989; RMSEA = 0.025; AVE = average variance extracted, CR = composite reliability.

single-factor test was used to assess homologous variance. The results showed that the contribution rate of the first principal component factor was 26.335%, less than 40%, indicating no significant common method bias in the questionnaire. Therefore, we conducted further data analyses to test the relationships between the variables.

3.4. Reliability and validity

Combined reliability (CR) and factor loadings were used to test the reliability of the questionnaire, confirmatory factor analysis was used to test the scale's construct validity, and average variance extracted (AVE) was used to evaluate the convergent validity of the scale. Table 3 shows that the CRs of supply chain leadership, team creativity climate, innovation performance, supply chain dynamic complexity, and supply chain static complexity were 0.943, 0.963, 0.906, 0.946, and 0.908, respectively, all greater than 0.7. The AVEs of the five variables were 0.703, 0741, 0.762, 0.777, and 0.767, respectively, all greater than 0.5. The Cronbach's α of the five variables were 0.922, 0.956, 0.848, 0.929, and 0.865, respectively, all greater than 0.7.

Additionally, whether the square root of the latent variable AVE was greater than the correlation value between the latent variables was used to test discriminant validity. Table 4 shows that the square root of the AVE of the five variables was greater than the correlation coefficient among the latent variables and that there was a significant correlation between supply chain leadership, team creativity climate, and innovation performance ($p < 0.01$). Additionally, the absolute value of the correlation coefficient was less than 0.5, which was less than the square root of the corresponding AVE, indicating a correlation among the latent variables. Additionally, certain degree of discrimination among the latent variables was observed, indicating that the discriminant validity of the scale data was ideal. All the above indicators suggest that the measurement scale has good reliability and validity.

4. Empirical results

4.1. Descriptive statistics

Table 4 presents the mean, standard deviation, and correlation coefficients of supply chain leadership, team creativity climate, innovation performance, supply chain dynamics, and static complexity. Supply chain leadership significantly positively correlated with team creativity climate ($r = 0.111$, $p < 0.01$), innovation performance ($r = 0.484$, $p < 0.001$), supply chain dynamic complexity ($r = 0.351$, $p < 0.01$), and static complexity ($r = 0.220$, $p < 0.01$). Team creativity climate significantly positively correlated with innovation performance ($r = 0.264$, $p < 0.01$), supply chain dynamic complexity ($r = 0.420$, $p < 0.01$), and static complexity ($r = 0.313$, $p < 0.01$). Innovation performance significantly positively correlated with the supply chain dynamic complexity ($r = 0.472$, $p < 0.01$) and static complexity ($r = 0.281$, $p < 0.01$), verifying Hypotheses 1–3.

4.2. Mediating effect test

In supply chain leadership and performance research, structural equation modelling is widely recognised as the primary data evaluation method (Chen, Li, and Zhang 2021). Hierarchical

Table 4. Means, standard deviations, and correlation coefficient.

		Mean	Standard deviation	1	2	3	4	5
1	Supply chain leadership	4.0371	0.923	0.710	-	-	-	-
2	Team creativity climate	3.9205	1.01849	0.111**	0.741	-	-	-
3	Innovation performance	3.9573	0.95716	0.484***	0.246**	0.762	-	-
4	Supply chain dynamic complexity	3.9447	0.99661	0.351**	0.420**	0.472**	0.777	-
5	Supply chain static complexity	3.8597	1.05381	0.220**	0.313**	0.281**	0.151	0.767
	Square root of AVE	-	-	0.843	0.861	0.873	0.881	0.876

Note: ** $p < 0.01$, *** $p < 0.001$

regression analysis has been extensively employed to address similar research questions (Xie et al. 2018; Açıkgöz and Günsel 2016). A hierarchical regression model, the most well-known and widely used method in model testing, was used to test the research hypotheses (Desboulets 2018). By gradually adding predictor variables to the model, multicollinearity was eliminated. The final model only contained variables that significantly impacted the outcome variables and had higher explanatory power, thus improving the accuracy and predictive power of the model. Furthermore, this method can effectively handle large amounts of data and reduce errors (Thompson 1989). Table 5 presents the results of the regression analyses. Model 1 tested the direct effect, Models 2, 3, and 4 tested the mediating effect, and Models 5, 6, 7, and 8 test the moderating effect. Models 5–8 are also important for testing the moderated mediating effect.

To verify whether team creativity climate mediates between supply chain leadership and innovation performance, we first verified the direct effect of supply chain leadership and innovation performance. A regression analysis was conducted, with innovation performance as the dependent variable and the control variable as the independent variable. The results show that the regression coefficients of the control variables were insignificant, and the R^2 value of the goodness of fit was small, indicating that the control variables were insufficient to explain innovation performance. Supply chain leadership was added as an independent variable in Model 1, and the regression results show that supply chain leadership positively impacted innovation performance ($\beta = 0.189$, $p < 0.001$). Therefore, direct effects were verified.

Another regression analysis was conducted with team creativity climate as the dependent variable and supply chain leadership as the independent variable to test the mediating effect of team creativity climate, and the effects of the control variables were compared. The results show that the control variables could not effectively explain the model, and supply chain leadership significantly positively impacted team creativity climate ($\beta = 0.413$, $p < 0.01$) (Model 2). A subsequent regression analysis used innovation performance and team creativity climate as the dependent

Table 5. Regression analysis results.

	Dependent variable: Team creativity climate			Dependent variable: Innovation performance				
	Model 2	Model 5	Model 6	Model 1	Model 3	Model 4	Model 7	Model 8
Control variables								
Gender	0.028	0.084	0.016	0.064	0.048	0.067	0.019	0.008
Age of employees	0.088	0.084	0.065	0.048	0.031	0.039	0.058	0.049
Length of service	0.101	0.022	0.016	0.051	0.032	0.065	0.087	0.064
Educational background	0.012	0.026	0.025	0.041	0.115	0.095	0.054	0.024
Firm size	0.068	0.054	0.015	0.019	0.053	0.072	0.121	0.088
Industry type	0.025	0.054	0.008	0.075	0.061	0.054	0.061	0.048
Independent variables								
Supply chain leadership	0.413**	0.217**	0.246**	0.189**		0.621***		
Mediating variable								
Team creativity climate					0.284**	0.271**	0.514**	0.198**
Moderating variables								
Supply chain dynamic complexity		0.317**					0.188**	
Supply chain static complexity			0.368**					0.294**
Interaction terms								
Supply chain leadership × supply chain dynamic complexity		0.422**						
Team creativity climate × supply chain dynamic complexity							0.279**	
Supply chain leadership × Supply chain static complexity			0.365**					
Team creativity climate × supply chain static complexity								0.149**
R^2	0.087	0.084	0.171	0.224	0.313	0.341	0.185	0.058
ΔR^2	0.046	0.060	0.084	0.019	0.089	0.159	0.099	0.019

and independent variables, respectively (Model 3). The results show that supply chain leadership positively impacted innovation performance (β = 0.284, $p < 0.01$). Finally, innovation performance was used as the dependent variable (Model 4). The results show that supply chain leadership and team creativity climate significantly positively impacted innovation performance (β = 0.621, $p < 0.001$). Comparing the regression results of Models 3 and 4, the significance level of the regression coefficient of supply chain leadership and the coefficient value decreased (0.271 < 0.284). Therefore, team creativity climate mediated the relationship between supply chain leadership and innovation performance, verifying H1.

4.3. Moderating effect test

The moderating variables of supply chain dynamics and static complexity regulate the supply chain leader – team creativity climate and team creativity climate – innovation performance stages, which must be verified.

In the first stage of testing the moderating effect of supply chain dynamic complexity, team creativity climate was used as the dependent variable. The control variables of supply chain leadership and dynamic complexity and the interaction term of supply chain leadership and dynamic complexity were used as independent variables for the regression analysis (Model 5). The results show that dynamic supply chain complexity significantly positively moderated the relationship between supply chain leadership and team creativity climate.

In the second stage, innovation performance was considered the dependent variable. The control variables were team creativity climate and dynamic supply chain complexity, and the interaction term between team creativity climate and dynamic supply chain complexity was the independent variable for the regression analysis (Model 7). The regression results show that the interaction term between team creativity climate and supply chain dynamic complexity significantly positively impacted innovation performance (β = 0.279, $p < 0.01$), indicating that supply chain dynamic complexity significantly positively moderated the relationship between team creativity climate and innovation performance; thus, Hypothesis H2 is verified. Figures 2 and 3 show the moderating effect analysis diagram to observe the moderating effect of dynamic supply chain complexity. A simple slope analysis of the two-stage adjustment effect of the supply chain dynamic complexity is also presented. The results demonstrate that the relationship between supply chain leadership and team creativity climate was significant under a high (β = 0.119, $p < 0.01$) and low (β = 0.025, $p < 0.01$) level of supply chain dynamic complexity. However, the reinforcement effect of the high group was better than that of the low group. The relationship between team creativity climate and innovation performance was significant at the high (β = 0.524, $p < 0.01$) and low (β = 0.211, $p < 0.01$) level of supply chain dynamic complexity, but the reinforcement effect of the high group was better than that of the low group. Therefore, the moderating effect of dynamic supply chain complexity was further verified.

In the first stage of the moderating effect test on supply chain static complexity, team creativity climate was used as the dependent variable. The regression analysis used control variables, supply chain leadership, supply chain static complexity, and the interaction term between supply chain leadership and supply chain static complexity as independent variables (Model 6). The results show that the interaction term of supply chain leadership and supply chain static complexity significantly positively impacted team creativity climate (β = 0.112, $p < 0.010$), indicating that supply chain static complexity significantly moderated the relationship between supply chain leadership and team creativity climate.

In the second stage, innovation performance was the dependent variable. The control variable, team creativity climate, supply chain static complexity, and the interaction term between team creativity climate and supply chain static complexity were taken as independent variables for regression analysis (Model 8). The results show that the interaction term of team creativity climate and supply chain static complexity significantly impacted innovation performance (β = 0.149, $p < 0.010$),

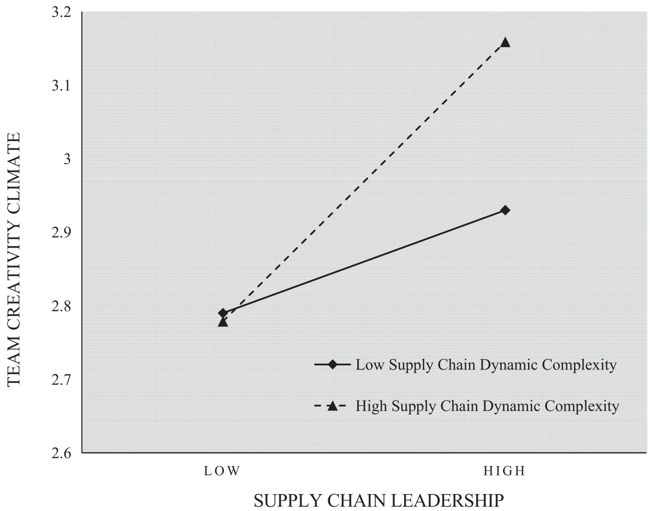

Figure 2. First-stage moderating effect of dynamic supply chain complexity.

indicating that supply chain static complexity significantly positively moderated the relationship between team creativity climate and innovation performance. To more clearly reveal the moderating impact of static supply chain complexity, this study drew a moderating effect analysis diagram (Figures 4 and 5) and performed a simple slope analysis of the two-stage moderating effect of static supply chain complexity. The results show that, at a high level of supply chain static complexity, the relationship between supply chain leadership and team creativity climate was significant ($\beta = 0.760$, $p < 0.01$). This relationship was also significant at a lower level of supply chain static complexity ($\beta = 0.242$, $p < 0.01$). However, the strength of the high group was better than that of the low group. The relationship between team creativity climate and innovation performance was significant at a high ($\beta = 0.483$, $p < 0.01$) and low level ($\beta = 0.186$, $p < 0.01$) level of supply chain static complexity, but the strengthening effect of the high group was better than that of the low group. Therefore, the moderating effect of the static complexity of the supply chain was further verified.

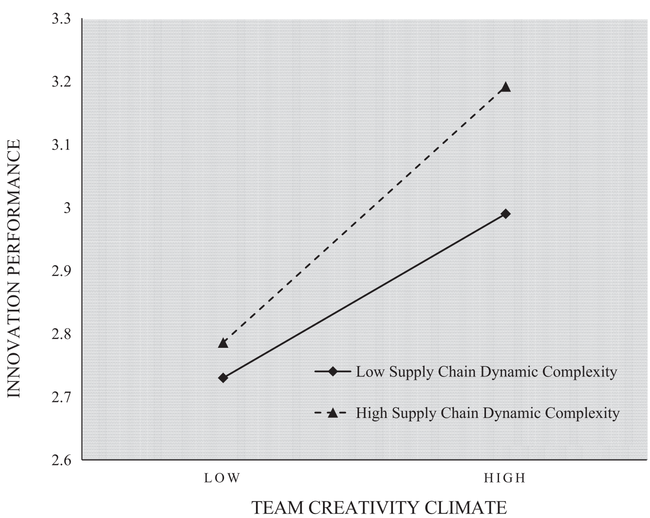

Figure 3. Second-stage moderating effect of dynamic supply chain complexity.

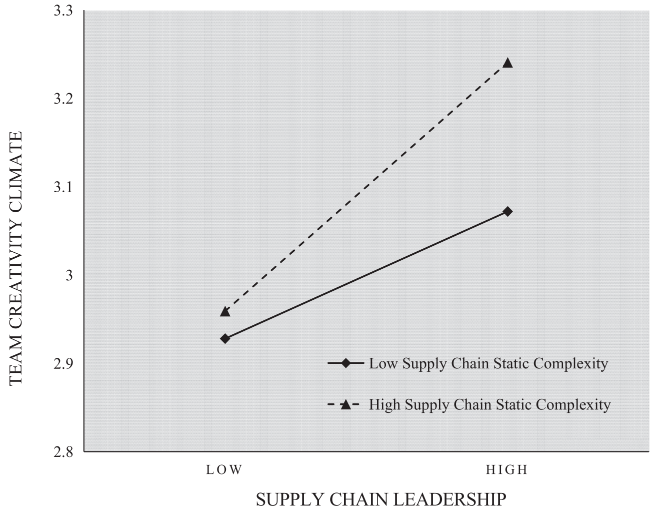

Figure 4. First-stage moderating effect of static supply chain complexity.

4.4. Moderated mediating effect test

In the adjusted mediating effect test, the adjusted path analysis method was used in the present study to test H2 and H3. In other words, the bootstrap test method was used to calculate the mediating effect under different supply chain dynamic complexity levels, and the PROCESS plug-in of SPSS was used to complete the calculation process. The bootstrap test does not depend on the specific form of data distribution and can deal with complex nonlinear models and multi-level structures (Song and Morgan 2019). Tables 6 and 7 present the inspection results. The results show that, at a high level of supply chain dynamic complexity (mean +1 SD), supply chain leadership significantly impacted innovation performance through the team creativity climate ($\beta = 0.119$, $p < 0.01$), and the 95% confidence interval (CI) of the indirect effect was [0.268, 0.338], excluding 0. At the lower level of supply chain dynamic complexity (mean − 1 SD), the impact of supply chain leadership on innovation performance through team creativity climate was not significant

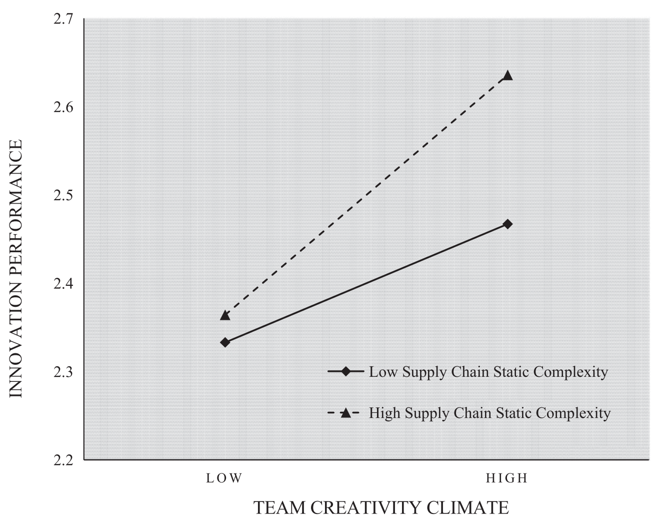

Figure 5. Second-stage moderating effect of static supply chain complexity.

($\beta = 0.025$, $p < 0.01$). The 95% CI of the indirect effect was [0.036, 0.101], including 0, confirming H2.

The results further show that, at a high level of supply chain static complexity (mean +1 SD), supply chain leadership significantly impacted innovation performance through team creativity climate ($\beta = 0.120$, $p < 0.01$), and the 95% CI of the indirect effect was [0.124, 0.364], excluding 0. At a low level of supply chain static complexity (mean − 1 S D), supply chain leadership significantly impacted innovation performance through team creativity climate ($\beta = 0.023$, $p < 0.01$), and the 95% CI of the indirect effect was [0.044, 0.284], including 0. Therefore, H3 was verified.

5. Discussion

5.1. Theoretical contributions

This study empirically investigated the role of supply chain leadership in enabling innovation performance, with team creativity climate as the mediating variable and dynamic and static supply chain complexities as the moderating variables. The theoretical significance of this study is as follows.

First, it elucidates the relationship between supply chain leadership and innovation performance and uncovers how the former affects the latter. These findings verify the views reported by Chen, Li, and Zhang (2021) and provide an expanded perspective on the role of supply chain leadership in improving innovation performance. This study also addresses the limited number of empirical studies on supply chain leadership by extending the exploration of such leadership and contributing to the implementation of supply chain management and open innovation strategies in organisations. It provides a new theoretical perspective for the in-depth analysis of supply chain innovation management.

Second, consistent with SCT, this study verifies the mediating role of team creativity climate between supply chain leadership and innovation performance. Extant research shows that supply chain leadership can improve innovation performance by fostering and promoting team creativity climate. Studies have also introduced different climate structures through various analytical backgrounds and levels (Schneider, Ehrhart, and Macey 2013; Andersson, Moen, and Brett 2020). This study enriches the innovation structure of team creativity climate and confirms that it can better capture the phenomenon of interest and its relationship with innovation results (Kiratli et al. 2016; Ye, Liu, and Tan 2022). Instead of focusing on improvements in self-innovation generated by team creativity, we focus on the effects of the team creativity climate on external innovation. This complements the explanation of two dynamic forces by which the internal and external flows of an organisation ultimately obtain innovative results: the top-down force, wherein supply chain leadership is mobilised, and the bottom-up force, wherein team members willingly innovate and contribute. These forces enrich the cross-border performance of a creative team climate.

Third, this study adds to the research on the classification of supply chain complexity and explores the reinforcing effect of supply chain complexity on supply chain leadership, thereby promoting innovation performance. Although numerous scholars have classified supply chain complexity into dynamic and static forms (Fernández Campos, Huaccho Huatuco, and Trucco 2024; Sokolov et al. 2016; de Leeuw, Grotenhuis, and van Goor 2013), no consensus has been reached on whether increased supply chain complexity in organisations has positive or negative effects on innovation (Tarei et al. 2021; Chowdhury et al. 2023). This may be because most studies have

Table 6. Moderated mediating effect under different supply chain dynamic complexity.

	Variables	Effect	BootSE	BootLLCI	BootULCI
Moderated mediating effect	Eff1(M-1Sd)	0.025	0.098	0.036	0.101
	Eff2(M)	0.106	0.077	0.080	0.305
	Eff3(M + 1Sd)	0.119	0.111	0.268	0.338

Table 7. Moderated mediating effect under different supply chain static complexity.

	Variables	Effect	BootSE	BootLLCI	BootULCI
Moderated mediating effect	Eff1(M-1SD)	0.023	0.089	0.044	0.284
	Eff2(M)	0.085	0.083	0.055	0.296
	Eff3(M + 1SD)	0.120	0.124	0.124	0.364

focused on complexity issues without considering the supply chain perspective (Aitken, Bozarth, and Garn 2016). The present study confirms the positive role of supply chain complexity in this context. It highlights the underlying mechanisms of dynamic and static complexities and their relationships with supply chain management.

5.2. Management implications

The findings also have implications for improving innovation performance in a team creativity climate. First, modern societies require organisations to cultivate a broad vision of leadership and supply chain leadership. Supply chain leaders play a key role in this context. They must establish cooperative relationships with external supply chain members to secure external innovation opportunities. Such opportunities can promote an organisation's development by sharing knowledge, technology, and resources. By exploring the innovative resources of supply chain members, organisations can discover innovative ideas and technologies from the upstream and downstream segments of the supply chain. These discoveries enable enhanced implementation of open innovation strategies, promotion of the application of external innovation, and transformation of internal innovation.

Second, supply chain leaders can advocate the establishment of a team creativity climate, thereby incorporating this aspect into innovation performance. A climate characterised by team creativity aids in fostering group dynamics. A highly creative team has a culture and climate that affects and changes individual behaviour and thoughts accordingly. These changes stimulate team members' creativity and innovation ability, promote the planning and design of new technologies, products, and services, and improve enthusiasm and innovation among members. Therefore, managers can implement a supply chain leadership position to nurture cooperation and knowledge sharing during supply chain activities and innovation exchange among supply chain members. They can achieve this by creating an innovation climate that reinforces innovation performance.

Third, supply chain leaders should be aware of the dual nature of supply chain complexity, complicating its management and providing excellent opportunities and resources for the diversified development of organisations. These concerns may change an organisation's development trajectory. High – and low-dynamic supply chain complexities should be evaluated to adjust management strategies. Under high complexity, more attention should be paid to cultivating a team creativity climate by encouraging innovative thinking and providing corresponding training courses. Other factors are more appropriate because of the low supply chain complexity.

6. Conclusion

6.1. Research conclusions

This study aimed to reveal the mechanism through which supply chain leadership influences innovation performance. The results are summarised as follows:

First, We found that the behaviours of supply chain leaders in influencing and coordinating the actions and behaviours of their supply chain partners clarify the way to establish practical innovation flow activities inside and outside company boundaries. This expansion encourages companies to develop supply chain leadership, view the supply chain as a collaborative whole, and effectively manage and acquire external innovations.

Second, based on SCT, supply chain leadership significantly positively impacts innovation performance, and team creativity climate is an intermediary in this relationship. The findings enhance the innovation structure of the team creativity climate and confirm that innovation climate can better capture the phenomenon of interest and its relationship with innovation results and cross-border performance, enriching a team's creative climate.

Third, supply chain complexity positively moderates the mediating effect of the team creativity climate, that is, a moderating mediating effect. A highly complex supply chain will likely stimulate a relationship between supply chain leadership, team creativity climate, and innovation performance. Specifically, the faster the random changes in industrial technologies and markets, the more evident the effects of supply chain leadership on innovation performance in a team creativity climate. The more complex a supply chain, the greater the volume of product types generated and supplied, and the more significant the role of supply chain leaders in improving innovation performance through a team creativity climate, and vice versa.

6.2. Limitations and future research directions

This study has several limitations. First, although the study verified the importance of dynamic and static complexities whereby supply chain leadership promotes innovation performance, this verification was conducted separately for the two complexity variants. Researchers can explore performance differences across supply chain complexity categories in various industries and their interactions. Second, this study regarded innovation at this stage as a non-unilateral aspect of an organisation. In cross-organisational innovation research, supply chain leadership can be exercised from other perspectives, such as those centred on supply chain relationships and capabilities and governance.

Data availability statement

Data supporting the findings of this study are available from the corresponding author upon request.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by the National Social Science Fund Project [grant no 23BGL073]; General special project of Education Department of Shaanxi Province [grant no 22JK0101].

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