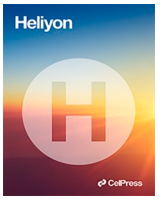
Heliyon 10 (2024) e25282

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon



Research article

The chain mediating effect of shared leadership on team innovation

Bo Tang [a], Yang Han [b,*], Gang He [b], Xianmiao Li [c]

[a] Department of Management, Birmingham Business School, University of Birmingham, Edgbaston, Birmingham, B152TT, United Kingdom
[b] Department of Finance and Accounting, School of Economics and Management, Anhui University of Science and Technology, Huainan, 232001, China
[c] Department of Business and Administration, School of Economics and Management, Anhui University of Science and Technology, Huainan, 232001, China

ARTICLE INFO

Keywords:
Shared leadership
Team member exchange
Team resilience
Team innovation

ABSTRACT

Background: Although recent literature has explored the effectiveness of shared leadership in teamwork, there is still a lack of more in-depth research on the process mechanism of shared leadership's effect on team innovation.
Objective: Based on self-determination theory, social cognitive theory and adaptive structure theory, this study investigates the influence of shared leadership on team innovation, as well as the mediating roles played by team member exchange (TMX) and team resilience. A total of 107 knowledge-based teams were invited to participate in the study.
Results: The findings indicate that: (1) shared leadership has a positive influence on team innovation, TMX and team resilience; (2) TMX and team resilience, respectively, mediate the influence of shared leadership on team innovation; (3) TMX and team resilience play a chain mediating role between shared leadership and team innovation.
Conclusion: In knowledge-based teams, shared leadership has a positive effect on team innovation by promoting team communication and enhancing team resilience. The results contribute to research on the relationship between shared leadership and team innovation and their practical applications.

1. Introduction

The external environment and processes of team innovation are increasingly characterised by complexity and uncertainty, while the level of knowledge, skills and the importance of team members are increasing, making shared leadership a growing concern for theoretical researchers and management practitioners [1]. In contrast to the traditional vertical and fixed-role leadership styles, shared leadership emphasises the use of collective wisdom and the flexibility to shift leadership roles among team members based on task characteristics. Shared leadership not only emphasises full empowerment, co-management and co-creation and continuous team interaction but also enables the flexible matching of leadership roles and authority with the contextual needs of task activities that has a positive impact on the relevant team outputs [2]. In addition, shared leadership emphasises the division of labour and knowledge

* Corresponding author. Department of Finance and Accounting, School of Economics and Management, Anhui University of Science and Technology, Huainan, 232001, China.
E-mail address: yhan@aust.edu.cn (Y. Han).

https://doi.org/10.1016/j.heliyon.2024.e25282
Received 16 June 2023; Received in revised form 12 January 2024; Accepted 24 January 2024
Available online 25 January 2024

sharing, which is more conducive to the team's ability to cope with an innovation-focused environment full of uncertainty and may also help to improve the team's level of innovation.

Several studies have explored the effectiveness of shared leadership. Hu, Dongqing and Gu, Qinxuan (2022) and Gu, Qinxuan et al. (2020) found positive associations between shared leadership and team creativity, team organisational citizenship behaviour and other outcome variables [3,4]. Siangchokyoo and Klinger (2021) found that core self-evaluation moderated the effect of shared leadership on team performance [5]. Shoukat et al. (2022) found that team learning mediated between shared leadership and team performance in healthcare teams, and that workplace bullying attenuated the effect of shared leadership on team learning [6]. However, some researchers argue that shared leadership lacks the impact of vertical leadership and the rigour of regulations and appraisal policies, which can lead to inconsistent decision making and a lack of synergy and requires more time and resources for team communication and development, which can reduce team effectiveness [7]. The gaps and inconsistencies in the existing literature provide a direction for subsequent research, which includes researching the circumstances in which shared leadership has a positive effect on team innovation, as well as the mechanisms involved in using shared leadership to promote team innovation.

Accordingly, based on self-determination theory, social cognitive theory and adaptive structure theory, this study explores the influencing effect of shared leadership on team innovation in knowledge teams. A knowledge team is a group of members with knowledge in different fields who are concerned with a specific problem and task and a focus on solving complex problems and achieving innovation goals by sharing knowledge and collaboration; such a team is typically characterised by multidisciplinary knowledge skills, innovative knowledge work, knowledge sharing, effective communication and self-management [8,9]. With the development of a knowledge economy, the status of knowledge-based groups is becoming increasingly more important. Knowledge-based groups must face challenges such as motivating and stimulating creativity, effective communication and collaborative work and lifelong learning and knowledge updating. Existing study found that knowledge sharing plays a mediating role between shared leadership and innovative behaviour, and team cohesion has a cross-level positive moderating effect between shared leadership and knowledge sharing [10]. Knowledge sharing and team cohesion can also be evaluated through team member exchange (TMX) and team resilience.

This study explored the impact of shared leadership on TMX, team resilience and team innovation to examine the mediating role of TMX and team resilience in the relationship between shared leadership and team innovation, and to explore how TMX and team resilience form a sequential chain of mediation to transmit the influence of shared leadership on team innovation. This study enriches knowledge about the mechanism of the relationship between shared leadership and team innovation.

2. Theoretical basis and research hypothesis

2.1. The relationship between shared leadership and team innovation

Shared leadership is a leadership style in which team members transcend status and hierarchical differences to select the member who knows the most about the current situation and, accordingly, has the best expertise as a leader; team members also share power and influence each other, respect one another and listen to and understand others, thereby overcoming the limitations of individual expertise to consciously improve their work and enhance their performance according to the complex and changing external context and task requirements [11]. Based on self-determination theory, social cognitive theory, and adaptive structure theory, this study argues the following. First, shared leadership can fit the dynamic complexity of the team innovation process. For knowledge innovation teams, the complexity of the innovation task can make it difficult for a single leader or member to master all the knowledge required for the task. Studies have found that shared leadership enables knowledge teams to adopt a decentred approach to innovation through the division of knowledge among members, while each individual in the team is only responsible for learning and remembering a specific part of knowledge in the task activity. Furthermore, the knowledge is shared and diffused among the team members, which takes into account specialisation in knowledge creation and promotes the flexible use of individual knowledge resources at the team level, which is conducive to the improvement of the team's innovation level [12–14]. In addition, the full empowerment of shared leaders can stimulate the proactivity of team members, which provides an intrinsic drive for team innovation [3,15]. Furthermore, due to the complexity of team innovation tasks, the process will require overcoming many difficulties and obstacles. Shared leadership requires the flexible switching of leadership roles among team members, assigning management roles to those who know the most about the field of expertise involved when the team encounters specialised problems, and relying on each other to lead the task, which can improve team members' sense of self-efficacy and collective efficacy. This approach provides positive psychological and professional support for overcoming obstacles in the innovation process and solving difficult problems, which is conducive to the improvement of team innovation [4]. Accordingly, this study proposes the following hypothesis:

H1. Shared leadership has a positive impact on team innovation.

2.2. The mediating role of TMX

Team member exchange is manifested as reciprocal interactions among team members to communicate and negotiate at a high frequency through the mutual exchange of knowledge, information and resources and to generate team cohesion to jointly achieve team goals [16]. This study argues that TMX is one of the mediating mechanisms of shared leadership on team innovation and can transmit the influence of shared leadership on team innovation from three aspects: process, relationship and function. First, the process aspect of shared leadership is characterised by the continuous emergence of temporary leaders in the team according to the

characteristics of the task, which necessitates that the leadership role cannot be fixed on a specific individual. Rather, the member with the best knowledge of the domain must be selected as the leader according to the task requirements. Therefore, team members must deconstruct and adapt to the complexity and dynamics of innovation tasks by exchanging leadership roles as well as sharing knowledge among themselves, which helps to form a high level of TMX to achieve common goals and improve team innovation performance by leading each other [17]. Second, in terms of relationships, shared leadership requires the construction of good collaborative relationships among team members, which manifests as mutual synergy among team members. In addition, shared leadership requires team members to demonstrate a sense of responsibility, work spontaneously for the team and demonstrate positive behaviours, which fits with the cohesiveness and communication negotiation exhibited by high-level TMX and supports knowledge and team integration within the team innovation process [18]. Finally, from a functional perspective, the complexity of innovation tasks and the heterogeneity of knowledge among members distribute problem-solving among team members rather than concentrating this task on one member or leader. As an exchange behaviour, TMX manifests itself as the transfer of knowledge required for leadership functions and the diffusion of tasks among different team members, which helps the team overcome difficulties and obstacles encountered in the innovation process and promotes the achievement of team innovation [19]. Accordingly, this study proposes the following hypotheses:

H2. Shared leadership has a positive impact on TMX.

H3. TMX mediates the impact of shared leadership on team innovation.

2.3. The mediating role of team resilience

Team resilience is the ability of teams to develop and use their capabilities and resources to continuously adjust to their environment in the face of adversity [20]. This study argues that team resilience is also one of the process mechanisms by which shared leadership acts on team innovation. First, the impact of market demand and rapid scientific and technological development changes on teams engaged in knowledge innovation is manifested in the contradiction between the relative stability within the team and the rapid dynamic nature of the external environment, as well as between the limited knowledge of team members and the complexity and challenge of the innovation task [21]. Thus, difficulties and uncertainties are always present throughout the process of team innovation. When faced with difficulties and problems, the team's decision to either rise to the challenge or avoid difficulty and give up is crucial to the success or failure of team innovation. Based on self-determination theory, shared leadership can increase team members' enthusiasm for work, making them more willing to complete challenging tasks through subjective efforts and reflecting a sense of efficacy to overcome difficulties at work, demonstrating a higher level of resilience. Additionally, innovation at work is generated to some extent from creative breakthroughs related to bottlenecks and pain points, which facilitates the improvement of team innovation levels [22].

Second, shared leadership can attract team members with diverse knowledge to participate in the leadership decision-making process. The diverse expertise of knowledgeable workers and its application can improve the overall knowledge base and cognitive flexibility of the team, which, in turn, can help the team to better anticipate and respond to changes, quickly find matching solutions to problems and facilitate the improvement of the team's innovation level [23]. Finally, according to social cognitive theory, shared leadership can fully motivate team members to present a state of mutual learning, derived from the role of full empowerment and role modelling, to achieve flexibility and synergy in the process of coping with difficulties and solving problems; as a result, the effectiveness and efficiency of problem-solving can be improved and the team will be enabled to better cope with the dynamic complexity of innovation tasks [24]. Therefore, team resilience, as a mediating variable, plays a bridging role between shared leadership and team innovation, which is conducive to enhancing the team's ability to cope with adversity and changes in innovation, as well as improving the level and efficiency of team innovation. Accordingly, the following hypotheses were formulated:

H4. Shared leadership has a positive impact on team resilience.

H5. Team resilience mediates the impact of shared leadership on team innovation.

2.4. The chain mediating role of TMX and team resilience

Based on the above hypotheses, this study argues that TMX among team members can also contribute to the improvement of team resilience levels and that both successively play a mediating role in the impact of shared leadership on team innovation. First, by improving the quality of relationships among team members, TMX can increase employee and colleague satisfaction, improve work attitudes and create an optimistic work climate within the team. This increases the collective efficacy and cohesiveness of the team and enhances the team's level of resilience [24]. Second, TMX is more conducive to the exchange of knowledge, the collision of ideas and communication than thinking in isolation. This helps to stimulate the generation of heterogeneous new ideas, enables the team to understand problems in a more comprehensive and refined way to avoid the bias of single-minded thinking, improves the team's creativity level and helps the team find solutions to obstacles quickly. Finally, TMX can enhance team members' sense of teamwork and improve solution efficiency when solving problems through the innovation process [25]. Concerning the impact of shared leadership on team innovation, this study concludes that TMX and team resilience not only have parallel roles in the context of one another but also fulfil a sequential chain mediating role, i.e. shared leadership can increase the level of TMX in teams through empowerment, leadership role sharing and flexible switching according to task situation needs. In turn, the increased level of TMX can further increase the team's level of cognitive, psychological and resource resilience, thus helping it to cope with dilemmas and problems in the innovation process. Accordingly, the following hypothesis was formulated:

H6. TMX and team resilience play a chain mediating role between shared leadership and team innovation (Fig. 1).

3. Study design

3.1. Research participants

The research sample was drawn from knowledge teams in 15 organisations in the Shanghai, Jiangsu and Anhui provinces of China, in the fields of information technology (IT), software, and mechanical engineering that are committed to developing and improving new technologies, products and services. The researcher contacted these teams through and confirmed their willingness to participate in the study. The questionnaires were distributed and returned between September 2022 and February 2023. Before starting the formal questionnaire survey, the researcher conducted a pre-study to identify and correct possible biases. During the questionnaire research, the researcher provided a brief explanation of the meaning of the relevant concepts and how the questionnaire should be completed. After the explanation, the questionnaire was completed online. This study was approved by the School of Economics and Management, Anhui University of Science and Technology, China. Written informed consent was obtained from all participants.

According to the no-response bias test proposed by Armstrong et al. [26], this study compared the variables in the pre-survey and the formal survey, namely, shared leadership, TMX, team resilience, team innovation, task interdependence and team size. The results of variance analysis showed that none of the variables showed significant differences at the 0.050 level. This indicated that no serious response bias was present in the study sample.

To reduce the effects of common method bias, this study adopted a multi-source, time-lagged research design. At time point T1, the team members were asked to complete demographic information and rate task interdependence, shared leadership, TMX and team resilience. At time point T2 (one month later), team leaders were asked to rate team innovation. To facilitate questionnaire collection and matching, the researcher labelled the different questionnaires. During the data collation process, the researcher screened the collected data to eliminate questionnaires with incorrect and incomplete responses. A final sample of 107 knowledge-based teams with 488 team members was obtained. The valid return rate of the team leader questionnaire was 85.60 %, and the valid return rate of the team member questionnaire was 90.71 %. On average, each team had 5 members. In terms of industry distribution, teams in the IT and electronic components industry accounted for 47.66 %, teams in the software industry accounted for 23.37 %, teams in the machinery industry accounted for 17.76 % and other industries such as design and medicine accounted for 11.21 %. Regarding the composition of team members, there were 279 men and 209 women, accounting for 57.17 % and 42.83 % of the total number, respectively. In terms of age distribution, 11.89 % were below 25 years of age, 35.45 % were between 26 and 30 years old, 25.82 % were between 31 and 35 years old, 18.03 % were between 36 and 40 years old and 8.81 % were above 41 years old. In terms of education level, 6.15 % were specialists, 50.02 % were bachelors, 39.14 % were masters and 4.51 % were PhDs. The results of descriptive statistical analysis are shown in Table 1.

3.2. Measurement

The measurement scale of this study was revised based on the mature foreign scales using several measures, such as translation–back translation and expert discussion to ensure the consistency of the Chinese questionnaire with the English version, as well as the accuracy and ease of comprehension of the presentation statements so that the respondents could understand and complete the answers.

(1) Shared leadership. This variable was measured with reference to Muethel et al. [27] and Hiller et al. [28], with 25 items (e.g. 'All members initiate work improvement processes for the team') rated by team members on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree).
(2) Team member exchange. Referring to Seers' [29] study, 10 items (e.g. 'I am flexible in handing over work to other members of our team') were rated by team members on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree).
(3) Team resilience. This variable was measured using a scale developed by Talat and Riaz [30], with 4 questions (e.g. 'When in a difficult situation, the team looks for creative ways to change the situation') rated by team members on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree).

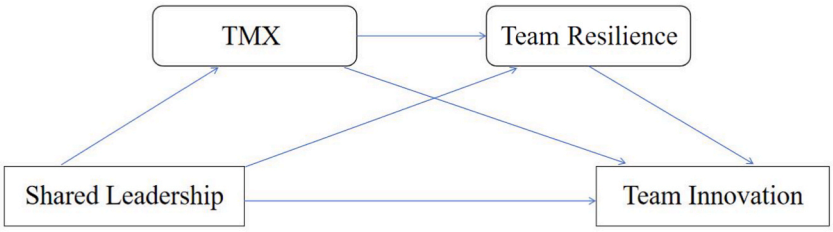


Fig. 1. Study model.

Table 1
Descriptive statistical analysis.

Team Level	N = 107	Percentage
Industry Type		
IT and Electronic Components	51	47.66 %
Software	25	23.37 %
Machinery	19	17.76 %
Others such as chemicals and pharmaceuticals	12	11.21 %
Team Member Level	N=488	Percentage
Gender		
Male	279	57.17 %
Women	209	42.83 %
Age		
≤25	58	11.89 %
26-30	173	35.45 %
31-35	126	25.82 %
36-40	88	18.03 %
41≤	43	8.81 %
Education level		
Specialty	30	6.15 %
Undergraduate	245	50.20 %
Master	191	39.14 %
PhD	22	4.51 %

(4) Team innovation. This variable was measured on a scale developed and used in studies by Welbourne et al. [31] and Zacher and Rosing [32], with 4 questions (e.g. 'Teams come up with new ideas' and 'Teams look for ways to improve what they do') rated by team leaders on a 5-point Likert scale from 1 (needs much improvement) to 5 (excellent).
(5) Task interdependence. In this study, this variable was set as a control variable, drawing on the scale developed and used by Richard et al. [33], with 3 questions (e.g. 'The nature of our work requires us to consult frequently with other team members') rated by team members on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree).
(6) Team size. This variable was set as a control variable in this study because a larger team size increases the difficulty of communication and coordination, dilutes the strength of relationships within the team and has the probability of having an impact on team innovation. The present study employed team size as a measure.

4. Statistics of test results

4.1. Aggregation analysis

This study involves four team-level variables: task interdependence, shared leadership, TMX and team resilience. Before calculating the mean value, the aggregation is measured by three indicators, that is, *ICC(1)*, *ICC(2)* and r^*_{wg}.

Task interdependence, shared leadership, TMX and team resilience must be aggregated to the team level in this study. As shown in Table 2, the r^*_{wg} for each variable was greater than the critical value of 0.700 [34]. Additionally, *ICC(1)* was greater than the critical value of 0.050, shared leadership *ICC(2)* was close to the critical value of 0.500 and the remaining variables were greater than 0.500. These results provided the basis for the subsequent inter-team analysis.

The minimum *r*wg* value for task interdependence was 0.631, the maximum value was 1, the mean value was 0.735 and the *ICC(1)* and *ICC(2)* were 0.356 and 0.735, respectively. The minimum value of the *r*wg* for shared leadership was 0.682, the maximum value was 1, the mean value was 0.742, and the *ICC(1)* and *ICC(2)* were 0.140 and 0.449, respectively. The minimum value of the *r*wg* for TMX was 0.608, the maximum value was 1, the mean value was 0.727 and the *ICC(1)* and *ICC(2)* were 0.241 and 0.614, respectively. The minimum value of the *r*wg* for team resilience was 0.518, the maximum value was 1, and the mean value was 0.781. The *ICC(1)* and *ICC(2)* were 0.173 and 0.511, respectively. In summary, the mean value of the *r*wg* of the four variables was greater than 0.700, the *ICC(1)* was greater than 0.100, and the *ICC(2)* was greater than 0.500. Chen et al. [35] proposed a relatively high *r*wg*, and that the variance between groups was significant and could be aggregated, which met the statistical requirements of aggregating variables from the individual to the team level.

Table 2
Aggregation analysis.

Variables	r^*_{wg}	*ICC(1)*	*ICC(2)*	*MSW*	*MSB*
Task interdependence	0.735	0.356	0.735	0.529	1.994
Shared Leadership	0.742	0.140	0.449	0.516	0.937
TMX	0.727	0.241	0.614	0.546	1.413
Team Resilience	0.781	0.173	0.511	0.439	0.897

Note: the critical value of r^*_{wg} was 0.700, the critical value of *ICC(1)* was 0.050, the critical value of *ICC(2)* was 0.500.

4.2. Common method bias test, collinearity, reliability, validity and correlation analysis of the main variables

Mplus 7.0 and SPSS 21.0 software were used for statistical analysis to test the common method bias of the sample data. Factor analysis was conducted on the four continuous variables of task interdependence, shared leadership, TMX and team resilience. The results showed that the first principal component could only explain 25.508 % of the total variation and could not explain most of the variation; therefore, the scale of the common method bias was not sufficient to have a substantial impact on the results. The operation of the latent variable control method using Mplus takes the common method bias as a latent variable, compares it with the factor analysis model without the common method bias. After adding the latent variable of the common method bias, compared with the fitting index of the four-factor model, the index of goodness of fit did not improve: the chi-square (X^2) value and the Root Mean Square Error of Approximation (*RMSEA)* were increasing, and the values of comparative fit index (CFI) and Tucker-Lewis index (TLI) were reduced, indicating that after adding the latent variable of the common method bias, the fitting index of the model did not improve, signifying a lack of any significant common method deviation. The results of the collinearity analysis showed that the *VIF* values were significantly lower than 2. Accordingly, there were no collinearity issues.

In this study, confirmatory factor analysis was used to test the discriminant validity. The results of discriminant validity for task interdependence, shared leadership, TMX and team resilience are shown in Table 3. The fitting results of the four-factor model were $X^2/df = 1.994$, CFI = 0.967, TLI = 0.953 and *RMSEA* = 0.068, RMR = 0.045. The model reflected a good fit, indicating that the four variables in this study had sufficient discriminant validity in terms of connotation and measurement. The index fitting of the four-factor model was better compared with other models, which further indicates that there were no common method bias in this study.

As shown in Table 4, Cronbach's α coefficient for each variable was greater than the critical value of 0.700, indicating good reliability for each variable. The CR values of each variable were greater than the critical value of 0.700 and the AVE values were greater than 0.500, indicating good convergent validity.

Descriptive statistical analysis (as shown in Table 5) indicated that task interdependence, shared leadership, TMX, team resilience and team innovation are significantly positively correlated.

4.3. Hypothesis testing

In this study, a *bootstrapping* repeated sampling method was used. *Bootstrap* was set to 5000 times, and non-standardised path coefficients, standard deviations and confidence intervals were output for direct and mediating effects tests.

The results of the direct effects tests are shown in Table 6. In regression 1, the direct effects test yielded an effect value of 0.484 for shared leadership on team innovation with a confidence interval of (0.174, 0.793), excluding 0, after controlling for team size and task interdependence, which indicates that shared leadership has a positive effect on team innovation, thus supports H1. In regression 2, the direct effects test yielded an effect value of 0.508 for shared leadership on TMX with a confidence interval of (0.240, 0.775), excluding 0, which indicates that shared leadership has a positive effect on TMX, thus supports H2. In regression 3, a direct effects test yielded an effect value of 0.467 for shared leadership on team resilience with a confidence interval of (0.278, 0.655), excluding 0, which indicates that shared leadership has a positive effect on team resilience and, accordingly, supports H4.

The results of the mediating effect test are shown in Table 7. After controlling for team size and task interdependence, the mediation analysis of TMX and team resilience in the relationship between shared leadership and team innovation was conducted, and the indirect effect value of TMX was found to be 0.140 with a 95 % confidence interval of (0.015, 0.284), excluding 0, which indicates that TMX played a mediating role between shared leadership and team innovation, thereby supports H3. The indirect effect value for team resilience was 0.189 with a 95 % confidence interval (0.031, 0.384), excluding 0, indicating that team resilience played a mediating role between shared leadership and team innovation, thus supports H5. The indirect effect value for TMX and team resilience was 0.085 with a 95 % confidence interval (0.023, 0.167), excluding 0, suggesting a chain mediating effect of the two variables on the relationship between shared leadership and team innovation, supports H6.

5. Discussion

5.1. Research findings

Based on self-determination theory, social cognitive theory, and adaptive structure theory, this study aimed to investigate the effect

Table 3
Results of confirmatory factor analysis.

Models	Factor	χ^2/df	*CFI*	*TLI*	*RMSEA*	*RMR*
Four-factor model	TI,SL,TMX,TR	1.994	0.967	0.953	0.068	0.045
Three-factor model	TI + SL,TMX,TR	7.474	0.858	0.837	0.125	0.098
Three-factor model	SL,TI + TMX,TR	7.516	0.853	0.835	0.125	0.102
Two-factor model	TI + SL,TMX + TR	19.555	0.515	0.438	0.241	0.202
One-factor model	TI + SL + TMX + TR	23.975	0.431	0.335	0.279	0.226

Note: TI indicates task interdependence, SL indicates shared leadership, TMX indicates team leader member exchange, and TR indicates team resilience.

Table 4
Reliability, CR and AVE values of the variables.

Variables	*Cronbach's α*	*CR*	*AVE*
Task interdependence	0.913	0.916	0.879
Shared Leadership	0.870	0.875	0.846
TMX	0.879	0.881	0.841
Team Resilience	0.821	0.829	0.549
Team Innovation	0.791	0.804	0.616

Note: the critical value of *Cronbach's α* was 0.700, the critical value of *CR* was 0.700, the critical value of *AVE* was 0.500.

Table 5
Variable means, standard deviations and correlation coefficients.

Variables	Mean	SD	1	2	3	4	5	6
1. Team size	5.03	0.552	–					
2. Task interdependence	3.55	0.799	0.079	**0.937**				
3. Shared leadership	3.73	0.495	−0.170	0.242*	**0.919**			
4.TMX	3.48	0.659	0.173	0.280**	0.384**	**0.917**		
5. Team resilience	3.84	0.467	−0.122	−0.085	0.449**	0.436**	**0.740**	
6. Team innovation	4.00	0.724	−0.007	0.223*	0.358**	0.481**	0.496**	**0.785**

Note: ** indicates $p < 0.01$, * indicates $p < 0.05$, and the diagonal black deepened data are *AVE* square root.

Table 6
Results of Bootstrap direct effect analysis.

Variables	Effect Value	*Boot SE*	T-value	95 % confidence interval	
				Lower bound	Upper bound
Regression 1: dependent variable = team innovation					
Team Size	0.050	0.136	0.366	−0.221	0.320
Task interdependence	0.127	0.095	1.331	−0.063	0.317
Shared Leadership	0.484	0.156	3.106	0.174	0.793
Regression 2: dependent variable = TMX					
Team Size	0.268	0.117	2.283	0.035	0.501
Task interdependence	0.141	0.082	1.704	−0.024	0.304
Shared Leadership	0.508	0.135	3.773	0.240	0.775
Regression 3: dependent variable = team resilience					
Team Size	−0.019	0.083	−0.229	−0.184	0.146
Task interdependence	−0.118	0.058	−2.038	−0.234	−0.003
Shared Leadership	0.467	0.095	4.921	0.278	0.655

Table 7
Results of Bootstrap mediating effects analysis.

Paths	Effect Value	*Boot SE*	95 % confidence interval	
			Lower bound	Upper bound
Shared Leadership → TMX → Team Innovation	0.140	0.069	0.015	0.284
Shared Leadership → Team Resilience → Team Innovation	0.189	0.089	0.031	0.384
Shared Leadership → TMX → Team Resilience → Team Innovation	0.085	0.038	0.023	0.167

of shared leadership on team innovation and the corresponding process mechanisms. Specifically, the study attempted to parse the effect of shared leadership on team innovation by introducing mediating variables, that is, TMX and team resilience. The results of the theoretical analysis and empirical tests show the following: (1) shared leadership had a positive effect on TMX, team resilience and team innovation; (2) shared leadership influenced team innovation through TMX; (3) shared leadership influenced team innovation through team resilience; and (4) TMX and team resilience played a chain mediating role between shared leadership and team innovation. These findings provide information on the pathways of theories on how shared leadership facilitates team innovation and have theoretical and practical implications for improving team innovation.

5.2. Theoretical insights

First, the effect of shared leadership on TMX, team resilience and team innovation was explored. In terms of the role that shared leadership plays in the team innovation process, this study found that shared leadership had a positive effect on TMX, team resilience

and team innovation at the team level, starting from shared leadership, a management approach that is distributed among team members. This suggests that shared leadership not only enhances team innovation but also promotes the quality of relationships among team members and the development of a positive state of resilience when the team encounters adversity in the innovation process that helps them to overcome the difficulties and obstacles encountered. These findings are to some degree different from previous research that indicated that shared leadership may lead to difficulty in reaching a consensus and a lack of synergy within teams. This study found shared leadership to be significantly and positively associated with TMX and team resilience, which is explained by the fact that shared leadership allows each member's ideas and values to be considered, and team leaders do not become excessively disconnected from their members, facilitating mutual understanding and support among team members and creating team synergy [36,37]. This finding enriches shared leadership theory in terms of impact effects.

Second, the role of TMX in the relationship between shared leadership and team resilience was explored. Team resilience is expressed as the team's ability to absorb the shock of sudden changes and adapt accordingly to return to a state of normality when encountering unexpected external problems and difficulties. In the current post-epidemic era, technological breakthroughs and their applications have exacerbated the vulnerability of teams, requiring them to adjust to cope with the complexity and dynamism of the environment and the innovation process. Team resilience, on the other hand, enables teams to be adaptive. While research has focused on the impact of specific leadership styles (e.g. transformational leadership) on team resilience, there is a need for a more comprehensive and detailed analysis of the relationship between the two; this study found that TMX transmitted the impact of shared leadership on team resilience [38]. In contrast to existing research, this study found that social exchange within teams is one of the process mechanisms through which shared leadership shapes team resilience [39]. Thus, this study enriches the theory of the relationship between the two.

Finally, the parallel and chain mediating effects of TMX and team resilience on shared leadership and team innovation were explored. This study found that TMX and team resilience were not only able to conduct separately between the relationship of shared leadership and team innovation but also reflected sequential and chain-mediating effects. This suggests that explaining the effect of shared leadership on team innovation only in terms of one aspect (e.g., either team members' exchange quality or the team's ability to cope with shocks) is inadequate and that both should be analysed together. This study found that the quality of exchange among team members improved the team's ability to cope with unexpected changes and shocks, allowing it to improve team innovation in the process of solving problems. Although prior research on shared leadership has explored the process mechanisms of its effects on relevant team outcome variables, there is a dearth of research on chain mediating effects, particularly the continuous mediating role of social exchange and team resilience states [7]. Therefore, this study enriches the theory of the relationship between shared leadership and team innovation.

5.3. Practical insights

The findings of this study have practical implications for how managers of knowledge-based teams can improve team innovation. In terms of management, promoting the use of shared leadership with distributed characteristics and strengthening a team's specialised division of labour and the flexible use of knowledge and information resources are important ways to stimulate and promote the team and its members to work effectively. Specifically, measures can be taken in the following three areas.

First, knowledge-based teams should be fully aware of the importance of all team members and the role of shared leadership. The speed of technological advancement and iteration has accelerated, and the innovation tasks teams face have become more complex, systematic and integrated, requiring each team member not only to be a manager but also to take on part of the leadership responsibility and play a proactive role in the process of problem discovery and solution. Currently, shared leadership, which stimulates and accommodates the innovative thinking of team members, is more practically applicable than the command leadership approach. Team leaders can use shared leadership to make the entire team aware of the leadership responsibilities of team members and the importance of collective wisdom to improve the overall level of innovation of the team.

Second, knowledge-based teams should adopt mutual exchange to solve problems in the innovation process. With the increasing complexity of the work tasks of knowledge teams, all of the knowledge required for completing tasks is increasingly not limited to what a single individual can master. Accordingly, sharing leadership and thereby strengthening TMX can help team members communicate promptly and gain a deeper understanding of each other's ideas and expertise. This has a positive effect on the formation of good interpersonal relationships, synergy, responsibility and risk-taking awareness among team members, thus enhancing team cohesion and promoting team knowledge integration. Managers should adopt a series of diversified communication, collaboration and sharing programmes to facilitate the exchange of information among team members, thereby developing and tapping into the potential of specialised talents in various fields.

Knowledge-based teams can take full advantage of each other's expertise through exchanges between team members to solve the specialised challenges that exist in the innovation process. The distribution of knowledge within a team is an inherent characteristic of the composition of a knowledge-based team and is also a strength of the team. Organisations and teams should focus on the role of playing and mobilising the implicit cognition distributed among team members and recognise the construction of meaning in the innovation process at the team level through the explicit transformation of individual knowledge. Managers can engage a diverse range of professionals and plan and implement training and learning programmes that meet the characteristics of knowledge-based teams to promote deep specialisation among knowledge-based team members and develop the scope of a team's professional knowledge.

Finally, attention should be paid to increasing the level of resilience of knowledge-based teams in the innovation process. Knowledge-based teams and their members should recognise that innovation work is challenging and that there are difficulties in its process. Teams with high levels of resilience in the innovation process will be better capable of achieving high levels of team

innovation compared to teams with low levels of resilience. When recruiting and selecting team members, the leaders of knowledge innovation teams should actively focus on and understand the resilience characteristics of candidates and include team members with high resilience characteristics. Once a team is formed, its members' psychological resilience and adaptability should be cultivated through a combination of systematic training and guidance using multiple dimensions, thereby improving the team's adaptability and innovation abilities under dynamic and complex environmental conditions. In general, promoting the use of shared leadership with distributed characteristics and strengthening the division of labour and knowledge integration in teams are important ways of motivating and promoting teams and team members to work together effectively.

5.4. Research limitations and prospects

This study explored the mechanism of shared leadership in knowledge-based teams on team innovation from the perspective of internal team interaction.The study suggests that shared leadership indirectly affects team performance through the dual mediating role of knowledge sharing and psychological security [40]. Knowledge sharing requires TMX, and psychological security can enhance team resilience. Based on social network theory and group dynamics theory, this study also propose the multiple chain mediating effects of team psychological safety climate, cognitive motivation and social motivation between shared leadership and team creativity in innovative teams [41]. It is believed that shared leadership has a significant positive impact on team creativity in innovative teams.

In the future, we can further explore the mediating mechanisms of other variables such as team trust and compare them with the behavioural integration mediating mechanism of this study. Concurrently, moderating variables such as team size can be introduced to analyse their moderating effect and obtain more accurate and comprehensive results. This study did not consider the moderating effects of situational variables such as environmental uncertainty and the industry characteristics faced by groups. In the future, the moderating effects of these variables can be further explored to clarify the boundary conditions of shared leadership on group innovation. There are differences in the ways that entrepreneurial teams in different industries share leadership. Future research can further refine the impact of shared leadership on innovation performance among entrepreneurial teams in different industries. Accordingly, future research can adopt a 'double-edged sword' theoretical perspective to explore the possible negative or non-linear impact effects of shared leadership on the relevant outcome variables [42].

Ethics and consent to participate

This study was conducted in accordance with the Declaration of Helsinki and all methods were carried out in accordance with relevant guildelines and regulations. Written informed consent was obtained from all participants.

Consent for publication

Not applicable.

Availability of data and materials

Data associated with this study has not been deposited into a publicly available repository. All data included in article.

Funding

This work is supported by Youth Fund of the National Natural Science Foundation of China (71701004).

CRediT authorship contribution statement

Bo Tang: Conceptualization, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. **Yang Han:** Data curation, Formal analysis, Writing – review & editing. **Gang He:** Data curation, Formal analysis, Writing – review & editing. **Xianmiao Li:** Formal analysis, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

Not applicable.

References

[1] C.J. Xiang, G. Yang, Research on the mechanism of social media on knowledge integration of knowledge workers under the framework of ASA, J. Intell. 41 (7) (2022) 151–159.
[2] Q. Wu, K. Cormican, Shared leadership and team effectiveness: an investigation of whether and when in engineering design teams, Front. Psychol. 11 (2021 Jan 18) 569198, https://doi.org/10.3389/fpsyg.2020.569198.
[3] D.Q. Hu, Q.X. Gu, Effect of team power distance and collectivism on team creativity:from the perspective of shared leadership, Manag. Rev. 34 (5) (2022) 167–175.
[4] Q.X. Gu, M.L. Liu, M.X. Xu, A study on the effectiveness of shared leadership competency pairs from the perspective of shared leadership and participatory safety climate, Chinese Journal of Management 17 (12) (2020) 1786–1794, https://doi.org/10.3969/j.issn.1672-884x.2020.12.006.
[5] N. Siangchokyoo, R.L. Klinger, Shared leadership and team performance: the joint effect of team dispositional composition and collective identification, Group Organ. Manag. 47 (1) (2021) 109–140, https://doi.org/10.1177/10596011211019928.
[6] M.H. Shoukat, I. Elgammal, S.A. Shah, et al., Nexus between shared leadership, workplace bullying, team learning, job insecurity and team performance in health care, Team Perform. Manag. 23 (3/4) (2022) 125–144, https://doi.org/10.1108/TPM-04-2021-0034.
[7] C.L. Pearce, H.P. Sims, Vertical versus shared leadership as predictors of the effectiveness of change management teams: an examination of aversive, directive, transactional, transformational, and empowering leader behaviors, Group Dynam.: Theory, Research, and Practice 6 (2) (2002) 172–197, https://doi.org/10.1037/1089-2699.6.2.172.
[8] A. Hargadon, R.I. Sutton, Technology brokering and innovation in a product development firm, Adm. Sci. Q. 42 (4) (1997) 716–749, https://doi.org/10.5465/ambpp.1996.4980474.
[9] I. Nonaka, A dynamic theory of organizational knowledge creation, Organ. Sci. 5 (1) (1994) 14–37, https://doi.org/10.1287/orsc.5.1.14.
[10] Pengwei Yuan, Xiaoqing Dong, Huaiyuan Zhai, et al., Research on the influence of shared leadership on the innovative behavior of knowledge workers-the role of knowledge sharing and team cohesion, Soft Sci. 32 (1) (2018) 87–91, https://doi.org/10.13956/j.ss.1001-8409.2018.01.18.
[11] J.B. Carson, P.E. Tesluk, J.A. Marrone, Shared leadership in teams: an investigation of antecedent conditions and performance, IEEE Eng. Manag. Rev. 44 (3) (2016) 86–103, https://doi.org/10.1109/EMR.2016.7559064.
[12] K. Rosing, M. Frese, A. Bausch, Explaining the heterogeneity of the leadership-innovation relationship ambidextrous leadership, Leader. Q. 22 (5) (2011) 956–974, https://doi.org/10.1016/j.leaqua.2011.07.014.
[13] X.M. Liu, Z. Liu, Research on the influence of shared leadership on team creativity, Soft Sci. 33 (4) (2019) 114–118, https://doi.org/10.13956/j.ss.1001-8409.2019.04.24, 140.
[14] G. Qu, X.Y. Wang, H. Zhao, The impact of transactive memory system on team performance——the moderating effect of social network and social identity, Manag. Rev. 32 (12) (2020) 168–179, https://doi.org/10.14120/j.cnki.cn11-5057/f.2020.12.013.
[15] C. Chen, X.M. Liu, R.B. Ge, A study on the effect of leadership-leadership exchange on team innovation on chain mediation, Manag. Rev. 33 (6) (2021) 192–200.
[16] K. Yin, J.M. Sun, K. Zhang, et al., The effect of workplace friendship on constructive behavior: a moderated mediation model, Manag. Rev. 30 (4) (2018) 132–141. CNKI:SUN:ZWGD.0.2018-04-012.
[17] L.Y. Zhang, J.Y. Seong, D.S. Hong, Interactive effects of person-group fit and team-member exchange in predicting continuous improvement, Sustainability 14 (24) (2022) 1–9.
[18] C.P. Tan, J.Y. Zhang, Y.Q. Zhang, The mechanism of team-member exchange on knowledge hiding under the background of “Guanxi”, J. Bus. Res. 148 (2022) 304–314, https://doi.org/10.1016/j.jbusres.2022.04.063.
[19] H. Fan, Y. Liu, B. Han, A study on the effect of role pressure and shared leadership on creativity of cross-border employees, Soft Sci. 29 (12) (2015) 77–81, https://doi.org/10.13956/j.ss.1001-8409.2015.12.17.
[20] M.X. Sun, F.W. Zhu, J.N. Guo, et al., The impact of transformational leadership on team resilience: a meaning-making perspective, Manag. Sci. 34 (3) (2021) 27–41, https://doi.org/10.3969/j.issn.1672-0334.2021.03.003.
[21] Y.H. Zhu, Y.L. Zhao, Y.Y. Zhou, et al., Resilience in organizations: constructs of protective resources based on psychological and systemic pathways, Adv. Psychol. Sci. 27 (2) (2019) 357–369, https://doi.org/10.3724/SP.J.1042.2019.00357.
[22] X.Q. Lin, Y.X. Luan, K. Zhao, et al., An equivariate analysis of the relationship between leadership style and employee innovation performance: based on a self-determination perspective, Adv. Psychol. Sci. 30 (4) (2022) 781–801.
[23] A.C. Stoverink, B.L. Kirkman, S. Mistry, et al., Bouncing back together: toward a theoretical model of work team resilience, Acad. Manag. Rev. 45 (2) (2020) 395–422.
[24] A. Hartwig, S. Clarke, S. Johnson, et al., Workplace team resilience: a systematic review and conceptual development, Organizational Psychology Review 10 (3/4) (2020) 169–200, https://doi.org/10.1177/2041386620919476.
[25] K.H. Yoo, B.C. Lee, S.Y. Kim, The effect of team diversity on team performance: the role of transformational leadership and team member exchange relations, Korean Journal of Resources Development 22 (2) (2019) 59–86, https://doi.org/10.24991/KJHRD.2019.06.22.2.59.
[26] J.S. Armstrong, T.S. Overton, Estimating nonresponse bias in mail surveys, J. Market. Res. 14 (3) (1977) 396–402.
[27] M. Muethel, S. Gehrlein, M. Hoegl, Socio-demographic factors and shared leadership behaviors in dispersed teams: implications for human resource management, Hum. Resour. Manag. 51 (4) (2012) 525–548, https://doi.org/10.1002/hrm.21488.
[28] N.J. Hiller, D.V. Day, R.J. Vance, Collective enactment of leadership roles and team effectiveness: a field study, Leader. Q. 17 (4) (2006) 387–397, https://doi.org/10.1016/j.leaqua.2006.04.004.
[29] A. Seers, Team-member exchange quality: a new construct for role-making research, Organ. Behav. Hum. Decis. Process. 43 (1) (2007) 118–135, https://doi.org/10.1016/0749-5978(89)90060-5.
[30] A. Talat, Z. Riaz, An integrated model of team resilience: exploring the roles of team sensemaking, team bricolage and task interdependence, Person. Rev. 49 (9) (2020) 2007–2033, https://doi.org/10.1108/PR-01-2018-0029.
[31] T.M. Welbourne, D.E. Johnson, A. Erez, The role-based performance scale: validity analysis of a theory-based measure, Acad. Manag. J. 41 (5) (1998) 540–555, https://doi.org/10.2307/256941.
[32] H. Zacher, K. Rosing, Ambidextrous leadership and team innovation, Leader. Organ. Dev. J. 36 (1) (2015) 54–68, https://doi.org/10.1108/LODJ-11-2012-0141.
[33] R. Saavedra, P.C. Earley, L. Van Dyne, Complex inter-dependence in task-performing groups, J. Appl. Psychol. 78 (1) (1993) 61–72, https://doi.org/10.1037/0021-9010.78.1.61.
[34] M.K. Lindell, C.J. Brandt, Assessing interrater agreement on the job relevance of a test: a comparison of the CVI, T, rWG(J), and r*WG(J) indexes, J. Appl. Psychol. 84 (4) (1999) 640–647, https://doi.org/10.1037/0021-9010.84.4.640.
[35] G. Chen, P.D. Bliese, The role of different levels of leadership in predicting self- and collective efficacy: evidence for discontinuity, J. Appl. Psychol. 87 (3) (2002 Jun) 549–556, https://doi.org/10.1037/0021-9010.87.3.549. PMID: 12090612.
[36] H. He, Y. Hu, The dynamic impacts of shared leadership and the transactive memory system on team performance: a longitudinal study, J. Bus. Res. 130 (1) (2021) 14–26.
[37] O.R. Mihalache, J.J.P. Jansen, F.A.J. Van Den Bosch, H.W. Volberda, Top management team shared leadership and organizational ambidexterity: a moderated mediation framework, Strateg. Entrep. J. 8 (2) (2014) 128–148, https://doi.org/10.1002/sej.1168.
[38] R.V.D. Kleij, D. Molenaar, J.M. Schraagen, Making teams more resilient: effects of shared transformational leadership training on resilience, Proc. Hum. Factors Ergon. Soc. Annu. Meet. 55 (1) (2011) 2158–2162, https://doi.org/10.1177/1071181311551450.
[39] J.B. Carson, P.E. Tesluk, J.A. Marrone, Shared leadership in teams: an investigation of antecedent conditions and performance, Acad. Manag. J. 50 (5) (2007) 1217–1234, https://doi.org/10.5465/amj.2007.20159921.

[40] J. Yoon, Y. Jeong, M. Kim, Shared leadership, dynamic capability, and effectiveness in teams: the case of Korean Firms, J. Leader. Stud. 16 (4) (2023) 4–21, https://doi.org/10.1002/jls.21830.
[41] M.H. Shoukat, S.A. Shah, D. Muneeb, Shared leadership and team performance in health care: how intellectual capital and team learning intervene in this relationship, Learn. Organ. 30 (4) (2023) 426–445, https://doi.org/10.1108/TLO-12-2021-0146.
[42] S.B. Liu, J.K. Cheng, X. Wang, A study of the double-edged sword effect of shared leadership in virtual teams: a perspective based on debugging structural theory, Adv. Psychol. Sci. 30 (8) (2022) 1770–1784.