International Journal of Business and Management; Vol. 17, No. 11; 2022
ISSN 1833-3850 E-ISSN 1833-8119
Published by Canadian Center of Science and Education

The Effect of Cooperative Network Dynamics of the Scientific Research Project on Project Performance: The Moderating Role of Project Leader's Network Position

Na Liu[1], Meng-bo Wang[1] & Jian-qi Mao[1]

[1] School of Business Administration, Shandong Technology and Business University, Yantai, Shandong, China;

Correspondence: Jian-qi Mao, Shandong Technology and Business University, No.191, Laishan District, Yantai City, Shandong Province, China. E-mail: ytmjq001@163.com

Received: July 31, 2022 Accepted: August 26, 2022 Online Published: September 28, 2022

doi:10.5539/ijbm.v17n11p31 URL: https://doi.org/10.5539/ijbm.v17n11p31

Abstract

Based on the data of projects initiated from 2013 to 2015 and concluded from 2017 to 2019 supported by the Department of Management Science of the National Natural Science Foundation of China, the relevant achievements of scientific research projects are collected. This article explores the influence of the decline, expansion and stability of the cooperative network of each project team on project performance from project initiation to project closure. We also demonstrate the moderating effect of project leader's network position in the higher-level global project cooperative network, including structural hole and degree centrality, on the relationship between project cooperative network dynamics and project performance. Results show that the decline of the project team cooperative network has a negative impact on project performance, the expansion of the project team cooperative network has an inverted U-shaped impact on project performance, and the stability of the project team cooperative network has a positive impact on project performance. At the same time, the structural hole and degree centrality of the project leaders in the higher-level global project cooperative network influence the effects of project team cooperative network dynamics on project performance. This study is of great significance to guide the construction of the project member network and improve project performance.

Keywords: project team, scientific project leader, cooperative network, National Natural Science Foundation of China, innovation network

1 Introduction

In today's world, science and technology innovation has become the critical support to improve comprehensive national power. Basic research is the source of scientific and technological innovation, and the state continues to establish and improve stability support mechanisms and substantially increases the investment in basic research. As one of the main forms of government investment in basic research, the effectiveness of the investment has become a focus of government departments, social groups, and the public as the scale of national financial investment in research projects continues to expand and intensify (Liu, Zhang &Zhu, et al,2014).

In 2001, China promulgated and implemented the "Regulations on the Implementation of Project-based Management in National Research Programs", which clarified that the team of project members centered on the project leader is the most fundamental component of research project activities (Wu, Zhang, & Zheng,2010). Consequently, scholars' studies on the factors influencing the performance of research projects have mainly focused on project leaders, such as their age, title, education, and experience (Ma, Wu, & Shi,2012). In addition, some scholars have also analyzed the impact of the project leader's network location on the innovation performance of the project by constructing a research teamwork network (Pan, Zhao, & Ding,2021). However, these studies ignore the impact of the entire project team members and the dynamic characteristics of the team members on project performance.

In the process of a research project, from project inception to final closure, the knowledge needs of project members, the environment, and other objective factors change over time, resulting in the withdrawal of the original members to terminate cooperation, the maintenance of cooperation by the original members, and the entry of new members to generate new cooperation. This behavior of project members to reconstruct the project network makes the project network change continuously, resulting in the decline, expansion, and stability of the

project team cooperation network with project members as the basic unit (Liu, Wu, & Mao, 2019).

Currently, for the dynamic evolution of innovation networks and the impact they generate, scholars mainly focus on firms or inventors, such as Liu and Guan (2015) and Guan et al. (2017) studied the micro-dynamic mechanisms of institutional self-network evolution. Sytch (2014) investigated the impact of community membership turnover and firm cross-community activities in firm network communities on firm invention productivity; Wei Long and Dang Xinghua (2017) explored the impact of organizational cross-community actions and organizational membership mobility on binary innovation in technology innovation networks from an asymmetric perspective. Regarding the boundary conditions of network membership dynamics on innovation performance, most existing studies focus on the moderating role of the network at the same level. Liu Na et al. (2020) investigated how network embedding, including relational and structural embedding, moderates the role of inventor self-network dynamics on inventor innovation performance, and Wei Long and Dang Xinghua (2017) found that asymmetry in organizational technology and location within the same community moderates the impact of technology innovation network community dynamics on organizational binary innovation. However, is the effect of membership dynamics at lower network levels on innovation performance moderated by higher level networks? Liu Na et al. (2019) explored the role of meso-level network community dynamics in regulating self-network dynamics on knowledge search. Sytch (2014) confirmed that the role of network community dynamics on firm invention productivity is moderated by global network coverage.

It can be seen that the research paradigm of scholars on innovation networks has shifted to the study of dynamism, and a few scholars have explored the moderation of the action mechanisms of high-level networks on low-level networks. However, there are few studies on the role mechanism of member dynamics with the research project team members as the target. In summary, this study explores the impact of the decline, expansion, and stability of each project team cooperation network on project performance from project inception to project closure based on a sample of closed projects in the Department of Management Sciences of the National Natural Science Foundation of China, and empirically demonstrates the regulation of the relationship between the network position of the project leader in the higher-level global network, to guide the construction of project member networks, enhancing the performance of research projects, and improving the efficiency of China's financial inputs and outputs to basic research, and continuously promote scientific and technological innovation in China. The dynamics of the project team cooperation network and the regulation of the global project cooperation network are shown in Figure 1.

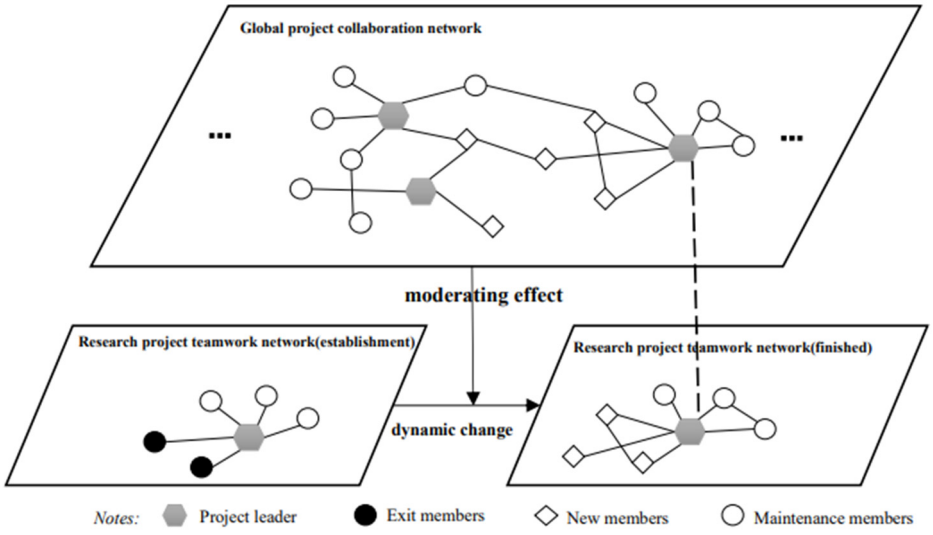

Figure 1 Schematic diagram of project teamwork network dynamics and global network moderation

2. Theory and Assumptions

2.1 Impact of Project Member Dynamics on Project Performance

The decline of research project teamwork networks implies a high percentage of withdrawing members during the implementation of research projects. In the process of scientific research project teamwork, each member

plays an indispensable role, and when project members withdraw, it leads to the loss of project team knowledge and information resources, which will hinder the research process of scientific research projects, especially when the withdrawing project members have unique knowledge and information resources, which will seriously affect the research process of scientific research projects.

When a large number of project members drop out, it will cause a shock to the original cooperative relationship of project members, and even break the original cooperative relationship and destroy the original network structure. At the same time, the broken network relationship breaks the information resource transmission channel (Liu, Wu, & Mao, 2020). Therefore, it will cost a lot for project members to compensate for the lost knowledge and information resources and repair the broken transmission channel, inhibiting the project performance output.

Accordingly, Hypothesis 1a is formulated.

Hypothesis 1a: The decline of teamwork networks in research projects inhibits project performance outputs.

The expansion of the teamwork network in scientific research projects implies that new entering members account for a relatively large proportion of the implementation process of scientific research projects. The entry of new project members brings novel heterogeneous knowledge and information resources, which can avoid the homogenization of the original project members' knowledge and information resources, and also facilitates the sharing of knowledge and information resources among project members. At the same time, the combination of new incoming heterogeneous knowledge and the original knowledge will generate new knowledge, which is beneficial to acquiring more heterogeneous knowledge (Cannellajr, & Mcfadyen,2016). However, when there are too many new incoming members, the new entrants bring too much new knowledge, causing knowledge overload in the project team, and then project members in the innovation process, leading to a decrease in the efficiency of knowledge innovation combination. In addition, the entry of too many new members will destroy the original cooperation practice of the project team, leading to a decrease in the efficiency of knowledge and information sharing and inhibiting scientific research output. Accordingly, Hypothesis 1b is proposed.

Hypothesis 1b: The expansion of teamwork networks in research projects has an inverted U-shaped effect on project performance.

The stability of the research project teamwork network means that the original sustaining members account for a larger proportion of the research project implementation process. Sustaining project members are familiar with each other and share common practices and action patterns. Knowledge transfer is faster and easier during the research collaboration, especially the transfer of tacit knowledge, with high efficiency of knowledge sharing and low time cost. The maintained project members have a set of corresponding methods to deal with similar problems in the past, and problem-solving is efficient and conducive to project performance output (Duysters, & Lemmens, 2003). Accordingly, Hypothesis 1c is proposed.

Hypothesis 1c: The stability of teamwork networks in research projects promotes project performance output.

2.2 Moderating role of project leader network location

According to Burt's (1992) definition of structural holes, if the project leader occupies more structural holes, it means that the project leader has access to more different information flows and has robust control over the flow of heterogeneous knowledge and information resources. This provides more heterogeneous knowledge and information resources for the research project teamwork network, which helps compensate for the loss of knowledge and information resources caused by the withdrawal of many project members. At the same time, project leaders who occupy more structural holes, with their control over the flow of information in the research project teamwork network, also help to consolidate the unstable cooperative relationships caused by the withdrawal of many research project members.

Project leaders who occupy more structural holes enhance the positive relationship between the initial expansion of project collaboration networks and project performance. The expanding project collaboration network brings heterogeneous knowledge and information resources to the project team and promotes project performance output. Moreover, when project leaders occupy structural hole positions, they have access to more heterogeneous knowledge and information, which is more conducive to updating the project team's knowledge base and promoting project performance output.

Project leaders who occupy a larger number of structural holes can also exacerbate the negative relationship between project collaboration network over-expansion and project performance. When the project collaboration network is overextended, it leads to a lack of trust among project members, disrupts the original collaboration practices, and exposes the team to higher information processing costs and uncertainty risks, which is not

conducive to project performance output. Furthermore, when the project leader occupies more structural holes at this time, the project leader is further exposed to a large amount of heterogeneous knowledge and information. The overloaded resources will expand information processing costs and uncertainty risks, which will exacerbate the negative impact on project cooperation network over-expansion on project performance interactions.

In a stable research project teamwork network, project members trust each other and share common behavioral norms and clear organizational knowledge-sharing practices. When project leaders occupy more structural holes, transferring the acquired heterogeneous knowledge and information resources will be more efficient, improving the project performance.

Accordingly, the following hypothesis is formulated.

Hypothesis 2a: The structural hole of the project leader in the global network negatively moderates the negative effect of the decline of the project teamwork network on project performance.

Hypothesis 2b: The structural hole of the project leader in the global network moderates the inverted U-shaped effect of the expansion of the project teamwork network on project performance, and the inverted U-shaped curve becomes steeper when the project leader occupies a high structural hole.

Hypothesis 2c: The structural hole of the project leader in the global network positively moderates the positive effect of project teamwork network stability on project performance.

If the project leader has a high degree of centrality in the global network, he or she will have direct access to a large amount of knowledge and resources. He or she can quickly transfer the knowledge and information resources to the project participants, which is conducive to the project team's knowledge acquisition and sharing and alleviates the problems of knowledge loss and broken partnerships caused by the withdrawal of project members (Badar, & Hite,2013).

A more central project leader enhances the positive impact of the initial expansion of the collaborative network on project performance. The initial expansion of the collaborative network brings heterogeneous knowledge and information resources to the project team. A highly centralized project leader has extensive access to the external knowledge base, while a highly centralized project leader has high authority and influence and can bring support to the project team as a priority, which will strengthen the positive impact of the initial expansion of the collaborative network on project performance.

Project leaders with a higher degree of centrality can also exacerbate the negative effects of project collaboration network over-expansion on project performance. Over-expansion of project collaboration networks can disrupt existing collaboration practices while facing higher information processing costs and uncertainty risks. In addition, the relationship maintenance costs of highly centralized project leaders will be elevated, exacerbating the negative impact due to the expansion of project collaboration networks.

Stable project teamwork networks bring partners in close contact with each other while promoting trust-building among members and preventing opportunism. In addition, the heterogeneous knowledge and information resources brought about by the high centrality of project leaders are more conducive to project performance output in a stable project teamwork network with stable transmission channels and higher efficiency.

Accordingly, the following hypothesis is formulated.

Hypothesis 3a: The project leader's degree centrality in the global network negatively moderates the negative effect of project teamwork network decline on project performance.

Hypothesis 3b: The degree centrality of the project leader in the global network moderates the inverted U-shaped effect of project teamwork network expansion on project performance, and the inverted U-shaped curve becomes steeper when the project leader occupies a high degree of centrality.

Hypothesis 3c: The degree centrality of the project leader in the global network positively moderates the positive effect of project teamwork network stability on project performance.

In summary of the above analysis and hypotheses, this study constructs a theoretical model as shown in Figure 2.

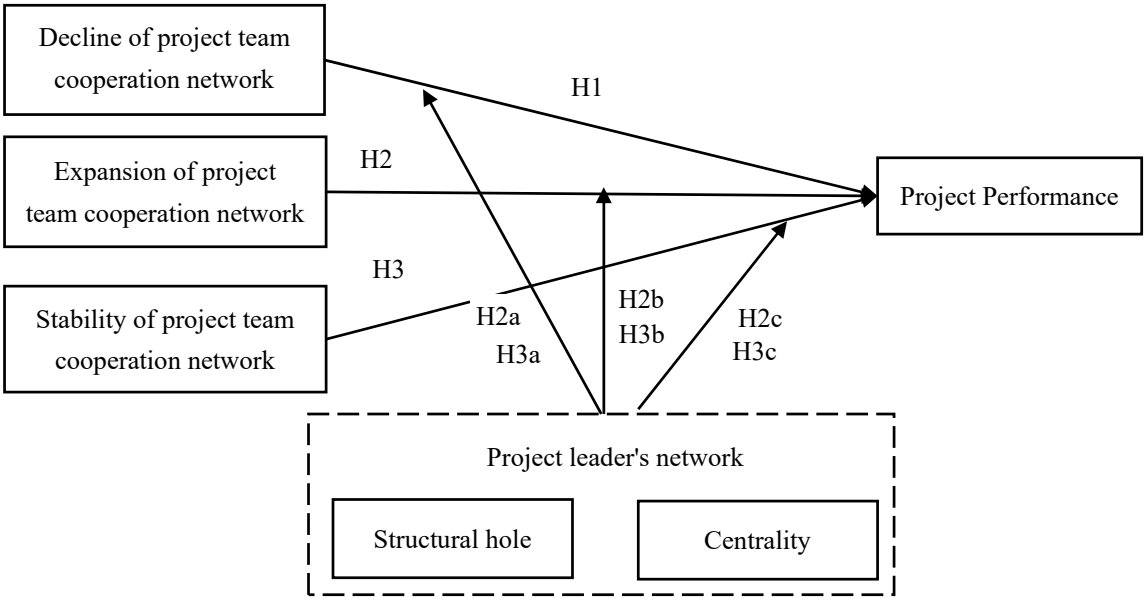

Figure 2 Research model

3. Date, Variables and Method

3.1 Data

The data of this study was obtained from the Big Data Knowledge Management Service Portal of the National Natural Science Foundation of China (http://kd.nsfc.gov.cn/), collecting 2060 general projects with 18170 project members of the Management Science Department, established from 2013-2015 and closed from 2017-2019. At the same time, we collected 32794 project-funded research results involving 40546 authors, and established the collaborative network of project members and the collaborative network of project outcome members respectively. In this paper, we used the Sci2 Tool software to construct the network and the Pajek software to measure the network index.

3.2 Variables

The dependent variable is the project performance. In the existing scholars' studies, the research project performance is measured by the number of patents (Lariviere, et al.,2011), the number of papers (Eslami, Ebadi, & Schiffauerova,2013) etc. In this study, because the data is a surface project of the Management Science Department of the National Natural Science Foundation, journal papers are the most significant expression of results in management science projects. Therefore, in this paper, project performance is defined as the number of papers produced by the research project.

The independent variables are the decline, expansion, and stability of the project team collaboration network. By comparing each project initiation member with the project achievement member, the new members are those who do not exist in the project initiation list but exist in the project achievement list; the exiting members are those who exist in the project initiation list but not in the project achievement list; and those who exist in both the project initiation list and the project achievement list are maintainers. In this study, we draw on the network dynamics tracking method proposed by Sytch (2014) and Liu (2019) to measure the project teamwork network's expansion, exit, and stability. Specifically, it is measured by the proportion of the number of newly added, withdrawn and maintained in the number of project initiation and achievements union. The initiation team members' set and the achievement team members' set of project i are denoted byA_i andB_i. The project teamwork network expansion is calculated as: $(Bi - Ai \cap Bi)/(Ai \cup Bi)$ project teamwork network decline is calculated as:$(Ai - Ai \cap Bi)/(Ai \cup Bi)$. The stability of the project teamwork network is calculated as follows: $(Ai \cap Bi)/(Ai \cup Bi)$

The moderating variable is the network position occupied by the project leader in the global network, including two indicators: degree centrality and structural hole. We use the number of nodes directly connected to a node to measure the degree of centrality of the project leader, which was proposed by Barabási (1999); the structural

hole occupied by the project leader in the global network is calculated according to the structural hole theory proposed by Burt (1992), which is calculated as follows:

$$S_i = 2 - \sum_j \left(P_{ij} + \sum_{q,q\neq i,q\neq j} P_{iq}P_{qj}\right)^2$$

Control variables. To avoid the influence of other factors on project performance, project funding and project member size were used as control variables in this study (Ganguli,2017).

3.3 Model specification

The dependent variable, project performance, is the non-negative integer. Therefore, we choose the counting model. Since the Poisson model requires the expectation and variance of the data distribution to be consistent, i.e., "equally dispersed"; however, the sample data are excessively dispersed, thus we choose the negative binomial model. According to the Vuong test result, the Vuong value |V|=0.35, which is much smaller than 1.96. As a consequence, we choose the standard negative binomial model.

4. Results

4.1 Descriptive Statistics and Correlation Coefficients

Table 1 presents the descriptive statistics and correlation coefficients of the variables. It shows that the project member network decline is negatively related to the project performance, while both expansion and stability are positively related to the project performance. The maximum value of variance inflation factor (VIF) for each variable is 3.166, which is lower than 10, indicating that there is no multicollinearity among the variables.

Table 1. Descriptive statistics and correlation analysis

Variables	1	2	3	4	5	6	7	8
1 Performance	1							
2 Recession	-0.608**	1						
3 Expansion	0.628**	-0.853**	1					
4 Stable	0.133**	-0.122**	-0.413**	1				
5 Structural holes	0.322**	0.498**	0.519**	-0.132**	1			
6 Centrality	0.289**	-0.315**	0.341**	-0.109**	-0.509**	1		
7 Research funding	0.045*	-0.040	0.012	0.046	-0.010	-0.006	1	
8 Membership size	0.760**	-0.651**	0.792**	-0.372**	0.413**	0.437**	0.022	1
Mean	15.920	0.251	0.569	0.180	1.786	24.610	54.610	24.520
SD	11.580	0.167	0.182	0.096	0.162	25.500	5.51	12.14
Min	0	0	-0.667	0	0.720	0	25.800	6
Max	121	1	0.919	1.143	1.980	238	69	107
Vif	-	1.989	3.166	1.184	1.630	1.490	1.003	3.012

Note. **p< 0.01, *p<0.05.

4.2 Regression Results

Table 2 reports the negative binomial regression results. Hypothesis 1a predicts that the decline of the project teamwork network inhibits project performance. Model 1 provides statistical support for this hypothesis at the significant level of p<0.01). Hypothesis 1b forecasts the inverted U-shaped relationship of the expansion of the project teamwork network with the project performance. According to the reported regression results of Model 2 and 3, Hypothesis 1b is confirmed at the significant level of p<0.01. Hypothesis 1c assumes that the stability of the project teamwork network promotes project performance. The reported regression results of Model 4 support the Hypothesis 1c at p<0.01.

Hypothesis 2a proposes that the structural hole of the project leader in the global network negatively moderates the negative relationship between the decline of the project teamwork network and the project performance. According to the reported regression results of Model 5, the coefficient of the interaction term between the decline of project members and the structural hole has the expected sign and is significant at p<0.01. Therefore, Hypothesis 2a is confirmed. Haans et al. (2016) stated that the moderating variable steepens the inverted U-shaped relationship if the coefficient of the interaction term between the moderating variable and the quadratic term of the first-order effect is negative and statistically significant. Hypothesis 2b assumes that the structural

hole of the project leader in the global network moderates the inverted U-shaped relationship between the expansion of the research project teamwork network and project performance, occupying a high structural hole of the project leader in the global network makes the inverted U-shaped curve steeper. According to the Model 7, the interaction term between the squared term of project member network expansion and the structural hole is significantly negative at $p<0.01$, so Hypothesis 2b is confirmed. Hypothesis 2c predicts that the structural hole of the project leader in the global network positively regulates the positive relationship between the stability of the project teamwork network and the project performance. According to the Model 9, the interaction term between project teamwork network stability and the structural hole is significantly positive at $p<0.01$, and Hypothesis 2c is supported.

Hypothesis 3a argues that the project leader's degree centrality in the global network negatively moderates the negative relationship between the decline of project teamwork network and the project performance. The Model 6 shows that the interaction term between project member decline and degree centrality has the expected sign and is significant at $p<0.05$. Therefore, Hypothesis 3a is supported. Hypothesis 3b proposes that the project leader's degree centrality in the global network moderates the inverted U-shaped relationship between the research project teamwork network expansion and the project performance, and the inverted U-shaped curve becomes steeper when the project leader occupies a high structural hole. The reported regression results of Model 8 shows that the coefficient of the interaction term between the squared term of project member expansion and degree centrality is significantly negative at $p<0.01$, and Hypothesis 3b is confirmed. Hypothesis 3c predicts that the degree centrality of the project leader in the global network positively moderates the positive relationship between the project member cooperative network stability and the project performance. As shown in Model 10, the coefficient of the interaction term between project members' cooperative network stability and degree centrality is significantly positive at $p<0.01$, so Hypothesis 3c is supported.

Table 2. Negative binomial regression results

	Project Performance									
Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
Recession	-2.264***				-2.110***	-2.168***				
	(-26.926)				(-23.101)	(-24.122)				
Expansion		1.899***	4.425***				4.109***	4.370***		
		(18.484)	(13.672)				(10.611)	(12.163)		
Expansion²			-2.952***				-2.753***	-3.016***		
			(-8.416)				(-6.959)	(-8.099)		
Stable				1.536***					1.519***	1.582***
				(12.545)					(12.450)	(12.914)
Structural Cave					-0.063		-0.037		0.496***	
					(-0.751)		(-0.409)		(6.371)	
Recession x structural hole					1.160***					
					(3.306)					
Expansion x structural hole							3.871***			
							(4.883)			
Expansion² x structure hole							-5.505***			
							(-6.423)			
Stable x structural hole									3.239***	
									(4.883)	
Centrality						-0.002***		-0.002***		-0.002***

						(-4.038)		(-3.395)		(-4.384)
Decline x Centrality						0.005**				
						(1.849)				
Expansion x Centrality								0.048***		
								(3.686)		
Expansion² x centrality								-0.047***		
								(-4.246)		
Stability x Centrality										0.024***
										(5.113)
Research funding	0.003*	0.005***	0.005***	0.003	0.003*	0.003*	0.005***	0.005***	0.003*	0.003
	(1.930)	(2.752)	(2.796)	(1.622)	(1.904)	(1.890)	(2.750)	(2.656)	(1.761)	(1.378)
Member Size	0.021***	0.019***	0.029***	0.045***	0.023***	0.024***	0.031***	0.033***	0.042***	0.047***
	(22.529)	(13.838)	(16.144)	(45.114)	(22.194)	(22.638)	(16.596)	(16.786)	(39.796)	(42.886)
Constant term	2.478***	0.824***	0.184	1.105***	2.542***	2.448***	0.332	0.188	0.289*	1.124***
	(24.792)	(7.770)	(1.401)	(10.264)	(14.006)	(24.197)	(1.557)	(1.349)	(1.707)	(10.583)
Maximum	-6	-6	-6	-6	-6	-6	-6	-6	-6	-6
Likelihood Estimation	400.583	569.602	532.500	653.002	358.893	350.522	475.727	475.283	561.467	577.002
Cardinality	2 222.176	1 884.139	1 958.342	1 717.339	2 168.488	2 185.231	1 934.820	1 935.708	1 763.341	1 732.272

Note. *** p< 0.01, ** p<0.05,* p<0.1.

5. Conclusion and Discussion

This study explores the impact of the decline, expansion, and stability of each project team collaboration network on project performance from project inception to project closure, and empirically demonstrates the moderating effect of the project leader's network position in the global project collaboration network, including structural hole and degree centrality, on the relationship between the two. The study shows that project team collaboration network decline inhibits project performance, project team collaboration network expansion has an inverted U-shaped effect on project performance, and project team collaboration network stability positively effects on project performance. In the global network, the structural hole and degree centrality of project leaders negatively moderates the relationship between project teamwork network decline and project performance, and positively moderates the relationship between project teamwork network expansion, stability, and project performance.

The contributions of this study are that: (1) it focuses on the contribution of all members of the research project team to project performance from the perspective of the research project team, while at the same time emphasizing the importance of the project leader's position in the global network and refining the influence of the project team cooperation network members. (2) The dynamic nature of project members during the research project is studied, broadening the research perspective of project team cooperation network. (3) We focus on the moderating role of higher-level global networks on the relationship between research project team networks and project performance, and enrich the mechanism of innovation networks' influence on innovation performance.

The following insights were obtained from this study: project leaders and project members should pay attention to the changes of project team members during the project research cycle, ensure the participation of the original project team members in the project as much as possible, eliminate the phenomenon of "free-riding" of project participants, and appropriately increase the number of project participants to inject fresh blood into the project team. The project leader should convene more project members for communication and discussion to promote more heterogeneous knowledge and information resources to be transferred and absorbed within the project team. At the same time, the project leader should conduct cross-project and cross-institutional academic exchanges,

such as increasing the frequency of participation in academic exchange and discussion meetings, and in-depth exchanges and cooperation with the participating experts, which have a positive effect on improving the performance of research projects.

Shortcomings and prospects of this study: The sample selected was from the surface project of the Department of Management Science of the National Natural Science Foundation of China. The specificity of the area of concern may affect the research results. Therefore, future research should be conducted in other departments of NSFC to improve the applicability of the research results. In addition, the influence factors on the quality of project innovation can be explored in the future to subdivide the project performance and improve the rigor of the research results.

Acknowledgments

Thanks to the National Natural Science Foundation of China "Research on the structure, evolution and performance impact mechanism of multi-level innovation network in frontier science and technology fields oriented to innovation chain" (Project Number: 72174112) and Taishan Scholars Project "Special Fund for Taishan Scholars and Young Experts" (Project Number: tsqn201909149) for supporting the paper.

References

Badar, K., & Hite, J. M., (2013). BADIR Y F. Examining the relationship of co-authorship network centrality and gender on academic research performance: the case of chemistry researchers in Pakistan. *Scientometrics*, *94*(2), 755-775. https://doi.org/10.1007/s11192-012-0764-z

Barabasi, A. L., & Albert, R. (1999). Emergence of scaling in random networks. *Science*, *286*(5439), 509-512. https://doi.org/10.1126/science.286.5439.509

Burt, R. S. (1992). Structural holes: the social structure of competition. *Cambridge: Harvard University Press*.

Cannellajr, A. A., & Mcfadyen, M. A. (2016). Changing the exchange: the dynamics of knowledge worker ego networks. *Journal of Management*, *42*(4), 1005-1029. https://doi.org/10.1177/0149206313511114

Duysters, G., & Lemmens, C. (2003). Alliance group formation enabling and constraining effects of embeddedness and social capital in strategic technology alliance networks. *International Studies of Management & Organization*, *33*(2), 49-68. https://doi.org/10.1080/00208825.2003.11043683

Eslami, H., Ebadi, A., & Schiffauerova, A. (2013). Effect of collaboration network structure on knowledge creation and technological performance: the case of biotechnology in Canada. *Scientometrics*, 97(1), 99-119. https://doi.org/10.1007/s11192-013-1069-6

Ganguli, I. (2017). Saving Soviet science: the impact of grants when government R&D funding disappears. *American Economic Journal: Applied Economics*, *9*(2), 165-201. https://doi.org/10.1257/app.20160180

Guan, J. C, Zhang, J. J., & Yan Y. (2017). A dynamic perspective on diversities and network change: partner entry, exit and persistence. *International Journal of Technology Management*, *74*(1-4), 221-242. https://doi.org/10.1504/IJTM.2017.10004289

Haans, R. F., Pieters, C., & He, Z. L. (2016). Thinking about U: theorizing and testing U- and inverted U-shaped relationships in strategy research. *Strategic Management Journal*, *37*(7), 1177-1195. https://doi.org/10.1002/smj.2399

Lariviere, V., Vignola-Gagne, E., & Villeneuve, C., et al. (2011). Sex differences in research funding, productivity and impact: an analysis of Québec university professors. *Scientometrics*, *87*(3), 483-498. https://doi.org/10.1007/s11192-011-0369-y

Liu, F., Zhang, C., & Zhu, W. D., et al. (2014). A comparative study of funding management of science foundation research projects in China and the United States. *Science and Technology Management*, *35*(4), 50-56. https://doi.org/1002-0241(2014)04-0050-07

Liu, N., Wu, X. Y., & Mao, J. Q. (2019). The impact of inventor self-network dynamics on knowledge search. *Scientology Research*, *37*(4), 689-700. https://doi.org/10.16192/j.cnki.1003-2053.2019.04.013

Liu, N., & Guan, J. C. (2015). Dynamic evolution of collaborative networks: evidence from nano-energy research in China. *Scientometrics*, *102*(3), 1895-1919. https://doi.org/10.1007/s11192-014-1508-z

Liu, N., Wu, X. Y., & Mao, Z. Q. (2020). Study on the influence of inventor self-network dynamics on innovation performance. *Journal of Shandong Institute of Technology*, *34*(5), 62-70. https://doi.org/1672-5956(2020) 05-0062-09

Ma, L., Wu, J. N., & Shi, Z. Y. (2012). Factors influencing the performance of scientific research projects: an empirical analysis of medical science foundation surface projects. *Science and Technology Management*, *33*(7), 12-20. https://doi.org/1002-0241(2012)07-0012-09

Pan, W. H., Zhao, P. W., & Ding, X. F. (2021). The influence of network location of research project leaders on project innovation. *Research Management*, *42*(5), 207-217. https://doi.org/10.19571/j.cnki.1000-2995.2021.05.023

Sytch, M., & Tatarynowicz. (2014). A Exploring the locus of invention: The dynamics of network communities and firms' invention productivity. *Academy of Management Journal*, *57*(1), 249-279. https://doi.org/10.5465/amj.2011.0655

Wei, L., & Dang, X. H. (2017). A study on the emergence of technological innovation network community structure and its impact on dual innovation from an asymmetric perspective. *Operations Research and Management*, *26*(10), 188-199. https://doi.org/10.12005/orms.2017.0252

Wu, J. N., Zhang, L., & Zheng, Y. H. (2010). Research on the relationship between the characteristics of scientific research project leaders and project performance: an empirical analysis based on science foundation projects. *Science and Technology Management*, *31*(12), 163-169. https://doi.org/1002-0241(2010)12-0163-07