

Influence Mechanism of Multi-dimensional Proximity on Cross-border Cooperative Innovation

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Abstract:

This paper takes the multi-dimensional proximity between cross-border cooperative organizations, that is, technical proximity, institutional proximity, cognitive proximity and relationship proximity as independent variables, so as to reflect the knowledge base, external support, breadth, depth and smoothness of information transmission among organizations in the process of cross-border cooperation. The theoretical model is constructed with cross-border search as the intermediary variable and cooperative innovation performance as the dependent variable. Structural equation model was used to test. This paper researches the impact of multi-dimensional proximity on cross-border cooperative innovation, and discusses the intermediary role of cross-border search in the relationship between multi-dimensional proximity and cooperative innovation performance.

Keywords: *Multidimensional proximity; Cross-border search; Cooperative innovation*

I. INTRODUCTION

With the development of digital economy, global industrial transformation continues to deepen. Under the multiple effects of new technology promotion, market demand pull and policy drive, the business process, business model and innovation model of enterprises have produced the phenomenon of "cross-border subversion" [1]. More and more enterprises acquire heterogeneous resources through cross-border means, integrate and utilize resources, and realize Inter Organizational cooperation and innovation, such as Baidu cooperating with third-party automobile manufacturers to manufacture driver-less vehicles. Cross border search helps organizations collect a wider range of technology, market and other information in a wider range and deeper degree, and carry out risk assessment and identification of innovation opportunities.

Cross border behavior refers to the process in which an organization crosses organizational boundaries, establishes contacts with external subjects and continuously interacts in order to achieve expected goals [2]. Its essence is a series of activities for many innovation subjects to promote the interactive exchange of knowledge, information and other resources in the external cooperation network, improve the efficiency of resource integration and allocation among organizations, achieve the goal of

cooperative innovation, and then establish competitive advantage. The cross-border cooperation based on heterogeneous resources among organizations has not only accelerated industrial integration, but also become an important way to realize China's innovation driven development strategy.

Previous studies have found that the differences between organizations are multi-dimensional. For example, organizations with large technical differences may have similar social relations or similar geography, institutional environment, enterprise background and culture; From a multi-dimensional perspective, the analysis of the degree of difference between cooperation subjects is not only an important basis for the selection of cross-border partners, but also an effective method and way to measure their cooperative innovation effect. There have been a lot of studies on the impact of various proximity factors on cooperative innovation, but there are still the following deficiencies. Firstly, from the perspective of research, cross - border behavior is the antecedent variable of creativity. Proximity is an indicator to measure the degree of characteristic heterogeneity between organizations [3]. Cooperative innovation is the result of the interaction of many factors among organizations. The existing research ignores the internal mechanism among proximity, cross-border behavior and cooperative innovation; the second is the measurement of multidimensional variables. Most of the existing studies measure multidimensional proximity from a single dimensional quantitative perspective. Although the accuracy of quantitative measurement is high, its coverage is limited, and it is not accurate enough for some non quantifiable variables such as institutional proximity and cultural proximity.

With the deepening of the research on multi-dimensional proximity, its connotation has been enriched, and its scope and application fields have been expanded. Among them, the more representative are the five-dimensional proximity (geographical proximity, cognitive proximity, organizational proximity, relationship proximity and institutional proximity).

Based on the existing research and combined with the research situation of this paper, this paper summarizes the multi-dimensional proximity into four dimensions: technical proximity, cognitive proximity, relationship proximity and institutional proximity. The abandonment of geographical proximity has been overcome by information technology. Organizational proximity and relationship proximity are integrated. Technological proximity, cognitive proximity and institutional proximity can summarize the hardware and software environment of enterprises. Taking the cooperative organizations in the region as the research object, this paper integrates the dimensions of multi-dimensional proximity in previous studies, and selects the multi-dimensional proximity between cooperative organizations, namely technical proximity, institutional proximity, cognitive proximity and relationship proximity as independent variables. These four independent variables cover the consideration of various software and hardware foundations for the establishment of Inter Organizational cooperation. Technology proximity represents the knowledge technology distance between organizations. Cognitive proximity represents the smoothness of cooperative information transmission between organizations. relationship proximity

represents the extent to which organizations can share their information with each other. Institutional proximity represents the degree of external support for inter - organizational cooperation. This dimension covers the knowledge base, external support, breadth, depth and smoothness of information transmission among organizations in the process of cross-border cooperation. It is more comprehensive for the cross-border behavior between organizations for the purpose of knowledge and technical cooperation. In addition, the theoretical model is constructed with cross-border search as the intermediary variable and cooperative innovation performance as the dependent variable. These four variables are tested by structural equation model this paper obtains the impact of multi-dimensional proximity on cross-border cooperative innovation, and discusses the intermediary role of cross-border search in the relationship between multi-dimensional proximity and cooperative innovation performance.

II. THEORETICAL ANALYSIS

The multi-dimensional proximity between organizations makes them have similar knowledge base, social relations or similar institutional environment, enterprise background and culture, which plays a positive role in the depth and breadth of cross-border search of their respective markets and technical knowledge. The proximity between organizations is not a resource without heterogeneity and complementarity, but can have more similar cognition, understanding and management of the same knowledge and technology. At the same time, it is of great significance for the in-depth cooperation of knowledge and the transmission of invisible knowledge.

2.1 The impact of technological proximity (TP) on Cooperative Innovation (CI)

Technology proximity reflects the similarity of technical knowledge structure between organizations, and the correlation and overlap of knowledge base and technical structure between organizations. Enterprises with similar knowledge bases can exchange and acquire external knowledge more easily and efficiently. Xiang XY. and Pei YL. (2015) demonstrated that technological proximity plays a positive role in shortening the cooperation distance between cooperative enterprises and improving innovation performance [4]. The higher the similarity of technical knowledge among cooperative members, the greater the possibility of knowledge acquisition, sharing and utilization among their organizations, which can significantly promote cooperative innovation activities. The knowledge diffusion efficiency between innovation subjects with similar technologies is high, which is easy to form cooperative relations, leading to intra regional and cross regional cooperative innovation behavior. However, the rapid development of the new generation of information technology makes the technological innovation of all walks of life more and more complex. The organization is ready to face and deal with technical and market problems caused by various environmental uncertainties. Technological proximity can enable organizations to carry out in-depth cooperation in the same field, promote the transfer of invisible knowledge and achieve the purpose of cooperative innovation. Therefore, this paper proposes H1:

technological proximity has a positive impact on the performance of cross-border cooperative innovation.

2.2 The impact of cognitive proximity (CP) on cooperative innovation (CI)

To some extent, innovation depends on the complementarity of knowledge in heterogeneous organizations, but it is not easy to bring external knowledge or technology into their own knowledge system. Therefore, in order to improve the performance of cooperative innovation, each innovation subject should have a certain knowledge absorption ability. Cognitive proximity can be explained by the similarity of knowledge and technology among regions. When the innovation subjects have similar knowledge system and experience, they can easily realize the knowledge exchange between organizations. Some scholars believe that there is a positive correlation between organizational cooperative innovation performance and cognitive proximity, that is, cooperative innovation performance improves with the increase of cognitive proximity. Some scholars have also proposed that the impact of cognitive proximity on cooperative innovation performance is not a simple linear relationship. When the two organizations have similar cultural background, language habits and traditional ideas, the possibility of contract innovation will be greatly improved. The improvement of cognitive proximity will promote the willingness of both parties to cooperate and strengthen their cooperative relationship. It can be said that higher cognitive proximity is like the adhesive of cooperative innovation. When the cognitive proximity is too low, the two sides will have communication obstacles due to the great differences in their areas of expertise. Therefore, this paper proposes that H2: cognitive proximity has a positive impact on the performance of cross-border cooperative innovation.

2.3 The impact of relationship proximity (RP) on cooperation innovation (CI)

Relationship proximity is mainly due to the closeness brought by relationship capital and good interaction between organizations. It reflects the similarity of friendship, kinship and experience among organizations. The trust generated by the proximity of organizational relations is the natural advantage of Inter Organizational cooperation, which can reduce the uncertainty of cooperation caused by too large cognitive distance or spatial distance and too little communication. The higher the relationship proximity between organizations, the stronger the incentive effect brought by social factors such as reputation and prestige. [5] Relationship proximity can reduce communication costs, promote the absorption and internalization of knowledge, and then realize innovation. Xue W. (2010) and others explained the relationship capital theory from the dimensions of trust, transparency and joint action, and verified that social relationship capital is the key factor to improve the performance of R & D cooperative enterprises [6]. Song J. et al. (2019) explained that individuals can obtain resources and promote innovation activities through social relations from the perspective of entrepreneurship. Interpersonal networks across organizational boundaries can accelerate information spillover and improve Inter Organizational

innovation ability [7]. Xu J Z et al. (2017) believe that high-quality relationship quality can ensure smooth information exchange and technological innovation cooperation [8]. At the same time, relationship proximity plays the greatest role in the selection of partners, so that the cooperative subjects can quickly reach consensus goals and establish cooperative relations. Based on common goals and clear technical paths, cooperative members need to exchange or share a large number of core technologies. Relationship proximity can promote the flow, interaction and absorption of complementary resources. Especially when the proximity is very high, this kind of communication can be similar to the internal behavior of the enterprise, which greatly improves the efficiency of cooperation and transformation and reduces the risk of cooperative innovation cooperation [9]. Therefore, this paper proposes H3: relationship proximity has a positive impact on the performance of cross-border cooperative innovation.

2.4 The impact of institutional proximity (IP) on cooperative innovation (CI)

Institutions include informal constraints, traditional customs, formal rules, laws, etc. Institutional proximity reflects the similarity between enterprises constrained by formal or informal rules. Organizations with similar incentive mechanism, system and behavior rules are considered to be adjacent in system. The higher the institutional proximity, the smaller the knowledge distance between scientific partners and the higher the degree of knowledge compatibility. Institutional proximity plays a role of "adhesion and fixation" between organizations. Institutional similarity is conducive to creating a stable cooperation environment, and the transfer of tacit knowledge among scientific partners is more smooth. Based on the common practice, the cognitive barrier of both parties is small and the transaction cost is low. Further stimulating the willingness and motivation of both parties to cooperate to form a stable scientific cooperative relationship is the most basic factor for establishing cooperative relations between organizations, which can reduce the uncertainty and conflict of organization cooperation [10]. Organizations with institutional proximity are easier to establish cooperative relationships, facilitate knowledge management and control, and timely communicate and feedback between organizations. When the institutional proximity is high, it can promote the effective transformation of a large number of complex tacit knowledge brought by the conclusion of strong relationships, and make greater use of the knowledge spillover of scientific partners and benefit from it. Through frequent exchanges and interactions with scientific partners close to the system, we can have a clearer understanding of market demand and industry status. At the same time, we can have a deeper understanding of the basic scientific knowledge and theoretical background in the technical field, which is conducive to the organization to supplement and improve the existing knowledge base, apply scientific knowledge to the enterprise's technological R & D and breakthrough, and further improve the performance of cooperative innovation. Therefore, this paper proposes H4: Institutional proximity has a positive impact on the innovation performance of cross-border cooperation.

2.5 Intermediary role of cross-border search (CBS)

The essence of cross-border behavior is a process in which an organization crosses organizational boundaries, establishes contact with external subjects and interacts continuously in order to achieve expected goals [11]. Its essence is a series of activities for many innovation subjects to promote the interactive exchange of knowledge, information and other resources in the external cooperation network, improve the efficiency of resource integration and allocation among organizations, achieve the goal of cooperative innovation, and then establish competitive advantage. The purpose of cooperation between organizations is to achieve the growth and breakthrough of knowledge and technology. Cross border search helps organizations expand market and technical knowledge in the same field in breadth and depth under the constraints of similar cultural cognition, systems, trust, harmonious social relations and similar rules and systems, so as to achieve the goal of cooperative innovation. Therefore, the cooperation between organizations based on multi-dimensional proximity needs to be connected by cross-border search behavior. Cross-border search plays an intermediary role in the cooperation of technology and market knowledge between organizations. Therefore, this paper proposes that H5: cross-border search plays an intermediary role between multi-dimensional proximity and cooperative innovation.

The conceptual model diagram obtained according to the above theoretical description is shown in Figure 1.

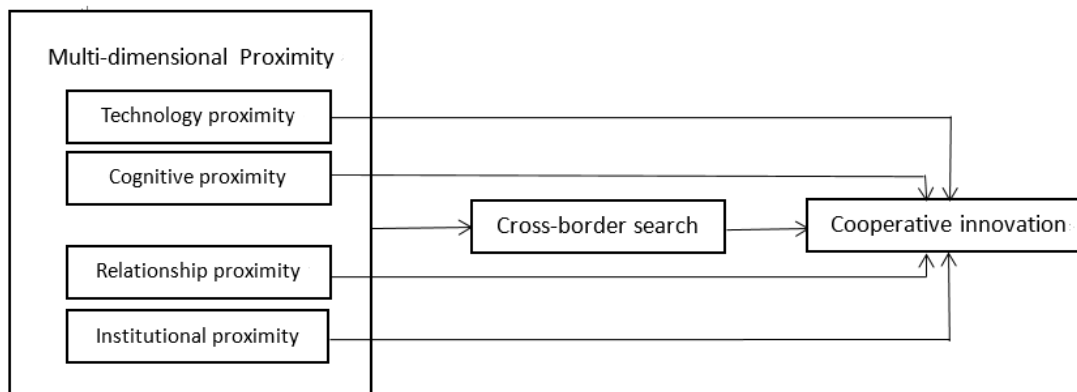


Fig.1: Conceptual model Diagram

III. RESEARCH DESIGN

This paper selects organization size, enterprise age and cooperation experience as control variables. Because the enterprise size, age and previous cooperation experience will have an impact on the organization's choice of cooperation objects, cooperation methods and cooperation contents. Technological proximity, cognitive proximity, relational proximity and institutional proximity are took

as independent variables, cross-border search as intermediary variables and cooperative innovation as dependent variables. Then, the above conceptual model is analyzed.

3.1 Data collection

The purpose of this study is to collect the data of each variable by questionnaire, which is different from previous studies. The designed questionnaire adopts Likert 5-point scale method. The purpose of the study is to explore the impact mechanism of multi-dimensional proximity on cross-border cooperation. Because there are many types of organizations participating in cross-border cooperation, and the cooperation at various levels and in various ways is different, the scope of the surveyed enterprises is wide when the questionnaire is distributed. The questionnaire is mainly filled in by middle and senior managers of enterprises.

The questionnaire is distributed on site and online. By entrusting relatives and friends, EMBA and MBA resources to distribute, the network distribution relies on the questionnaire star website, which limits the respondents to the questionnaire. Among them, the respondents are middle and senior managers in the organization, and their organizations have experience in participating in cross-border cooperation. A total of 450 copies were distributed, 360 copies were recovered and 325 copies were effective. Because the survey question involves the cooperation between organizations, we deliberately investigated the organization and other organizations cooperating with it at the survey time, and adopted the paired network survey method. During data screening, the questionnaire answers between cooperative organizations shall be screened. If the answers differ greatly, they shall be eliminated, so as to ensure the corresponding relationship between the data and improve the pertinence of the research and the reliability of the conclusions.

3.2. Reliability and validity analysis

The Cronbach's coefficients of technical proximity, cognitive proximity, relationship proximity and institutional proximity, cross-border search and cooperative innovation performance are 0.920, 0.915, 0.912, 0.835, 0.920 and 0.885 respectively, which are greater than the standard of 0.7, indicating that the measurement scale of each variable has good reliability.

Using the principal component factor extraction method, through the orthogonal rotation of the maximum variance, after 6 iterations, the composition reliability is greater than 0.7 and the average variance precipitation is greater than 0.5, which all meet the standard of convergence validity, and the matching degree is also in the acceptable range.

3.3 SEM analysis

Through the collected data, amos24.0 is used to test the relevant assumptions involved in the above conceptual model. In the fitting test, CMIN/DF is 1.228, RMR is 0.047, RMSEA is 0.027, GFI, AGFI, NFI, RFI, IFI, TLI, CFI are all greater than 0.9. Each index has the very good fitness. Model fitting results, hypothesis test and mediating effect test are obtained as following figure 2, table 1 and table 2.

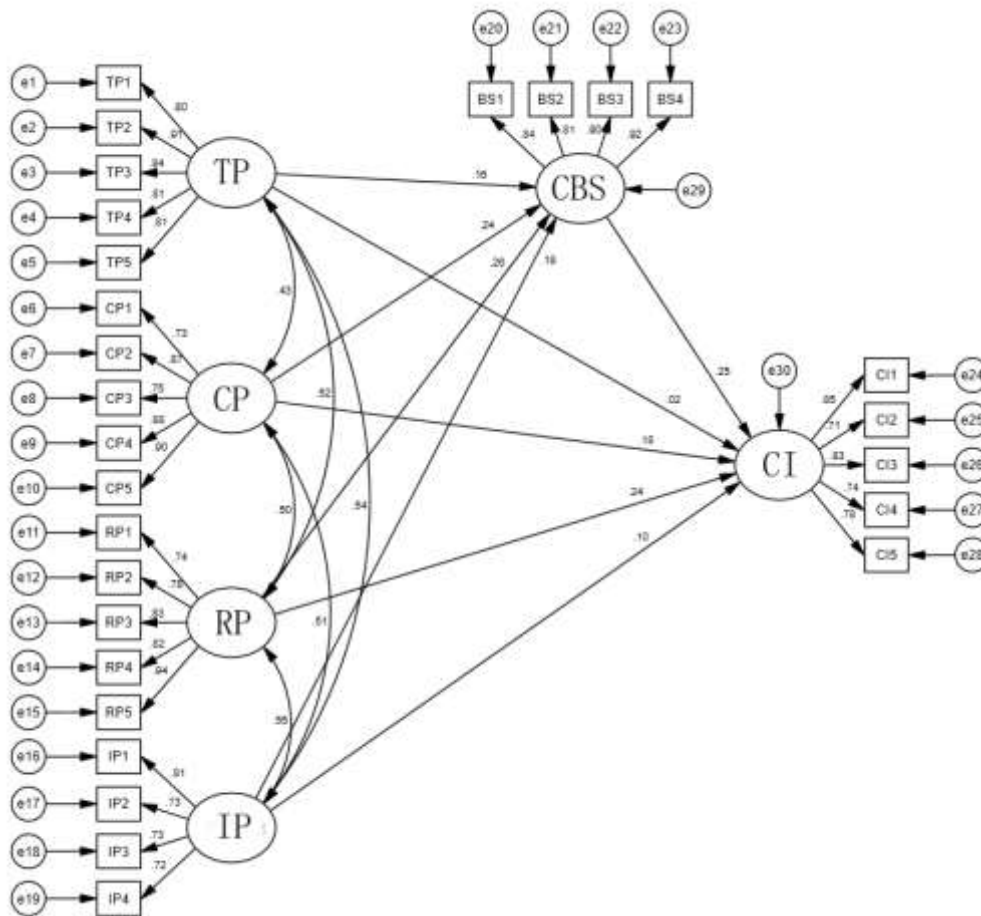


Fig. 2 Model fitting results

Tab.1 Hypothesis test

			Standardized Estimate	Estimate	S.E.	C.R.	P	Support or not
CBS	<---	TP	0.164	0.158	0.058	2.71	0.007	√
CBS	<---	CP	0.243	0.358	0.088	4.074	***	√
CBS	<---	RP	0.26	0.295	0.072	4.11	***	√
CBS	<---	IP	0.191	0.189	0.068	2.782	0.005	√
CI	<---	TP	0.022	0.02	0.057	0.344	0.731	×

CI	<---	CP	0.182	0.246	0.088	2.809	0.005	√
CI	<---	RP	0.244	0.255	0.072	3.523	***	√
CI	<---	IP	0.102	0.092	0.067	1.367	0.171	×
CI	<---	CBS	0.25	0.229	0.064	3.558	***	√

Tab.2 Mediating effect test

	Estimates	Bias-Corrected		Percentile	
		95%CI		95%CI	
		Lower	Upper	Lower	Upper
Total Effects					
TP-CI	0.063	-0.091	0.206	-0.078	0.219
CP-CI	0.243	0.088	0.401	0.087	0.397
RP-CI	0.309	0.152	0.459	0.149	0.455
IP-CI	0.15	-0.024	0.305	-0.015	0.314
Indirect Effects					
TP-CBS-CI	0.041	0.004	0.102	0.004	0.1
CP-CBS-CI	0.061	0.015	0.134	0.011	0.127
RP-CBS-CI	0.065	0.014	0.147	0.009	0.139
IP-CBS-CI	0.048	0.006	0.12	0.003	0.109
Direct Effects					
TP-CI	0.022	-0.118	0.152	-0.11	0.159
CP-CI	0.182	0.014	0.36	0.011	0.354
RP-CI	0.244	0.087	0.404	0.075	0.397

The following conclusions can be drawn from Figure 2 and table 1-3: Technology proximity has a positive impact on cross-border cooperative innovation performance (H1) is not tenable; Cognitive proximity has a positive impact on cross-border cooperative innovation performance (H2); Social proximity has a positive impact on the innovation performance of cross-border cooperation (H3); Institutional proximity has a positive impact on the innovation performance of cross-border cooperation (H4) is not tenable; Cross border search plays a partial mediating role between multi-dimensional proximity and cooperative innovation performance(H5).

IV. CONCLUSION

(1) Different dimensions of proximity have different effects on cross-border cooperative innovation. Cognitive proximity and social proximity contribute to cross-border cooperation and innovation. The definition of cognitive proximity is more inclined to the perception of aesthetics and the similarity of world outlook. Cognitive proximity balances the knowledge distance and knowledge overlap between organizations, optimizes the knowledge distance between enterprises, and keeps the cooperative relationship between organizations efficient communication and innovation output. The close affiliation

or investment relationship in social relations provides a basic guarantee for cooperative innovation.

(2) The impact of technological proximity on cross-border cooperative innovation failed to pass the test. From the perspective of impact effect, too small technology proximity is not conducive to the interaction and absorption of technology among organizations. Too much technology proximity leads to serious homogenization of technical knowledge among organizations, which limits the effect of cooperative innovation.

(3) The impact of institutional proximity on cross-border cooperative innovation failed to pass the test. This may be because when the institutional proximity is low, there are great differences in strategic orientation and objectives between organizations, and organizations can contact a large amount of heterogeneous knowledge. With the gradual enhancement of institutional proximity, there may be competitive pressure between organizations adjacent to the system. In order to avoid accidental knowledge leakage and ensure their competitive position in the industry, the scientific partners adjacent to the system may reserve their knowledge when sharing, and there is a risk of opportunity. In addition, the organizations adjacent to the system have great commonalities. Too many scientific partners adjacent to the system provide a large amount of homogeneous scientific knowledge, which is easy to produce the negative effect of knowledge locking, leading to the solidification of enterprise innovation thinking, which hinders enterprises from carrying out innovation activities and is not conducive to the improvement of their technological innovation performance.

V. DISCUSSION

The research of this paper theoretically complements the deficiency of the existing literature on the impact mechanism of cross-border cooperative innovation. In the process of cross-border cooperation, it has some enlightenment on how to effectively use external resources according to their own basic situation, so as to reap good innovation effects of cross-border cooperation and realize cross-border collaboration.

Firstly, from the research results, when cross-border cooperation with external members of the organization, the impact of multi-dimensional proximity on cooperative innovation shows different trends. Therefore, when carrying out cross-border innovation projects and selecting partners, we should not only expand the scope of cross-border search, but also evaluate the current innovation environment, such as the institutional and technical differences between partners.

Secondly, this study expands the research perspective of innovation and the perspective of cross-border behavior by confirming the promotion of multi-dimensional proximity to cooperative innovation and the intermediary role of cross-border search on its relationship. The research conclusion

shows that innovation subjects should give full play to the driving role of cognition and social proximity in cooperative innovation, but they should not expand unprincipled in order to strengthen the proximity of organizational relations. They need to take into account the similarities and differences in technical level and system.

Thirdly, managers can better realize the impact of multi-dimensional proximity between organizations on cooperative innovation through cross-border search. On the premise of multi-dimensional proximity, organizations also need to achieve real cooperation through cross-border search behavior. The state can formulate corresponding policies to encourage cross-border cooperation among enterprises, guide relevant organizations to participate in cross-border innovation activities, make full use of the aggregation effect and scale effect of cooperation networks, break the "dilemma of homogeneous competition", innovate service modes and improve the collaborative innovation ability of cooperative alliances.

Finally, this paper of course has some research limitations. In the research process, a questionnaire is used to measure the variables of multi-dimensional proximity, which is different from previous studies. The measurement items of the questionnaire need to be further refined. Expand the survey scope and quantity of samples to strengthen the representativeness of data. The impact of organizational technology cycle and different stages of cooperation on multi-dimensional proximity, cross-border search and cooperative innovation performance should also be considered in future research.

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REFERENCES

- [1] Zhang X, Wu Q, Yu X. The logic of cross-boundary disrupt innovation of enterprises at internet age. *China Industrial Economics*, 3:156-174.
- [2] Xue H J. 2010. Review and prospect of foreign research on team cross border behavior. *Foreign Economics & Management*, 32(9):10-15.
- [3] Zhang J Y. 2018. A research on the impact of multi-proximity of entrepreneurial firms on synergetic innovation relationship. *Science Research Management*, 39(9):78-85.
- [4] Gao CY., Zhang X X., Zhang SC.2021. Research on the impact of multi-dimensional proximity on collaborative innovation in cross-border alliances - Data analysis5:100-117.
- [5] Xiang X Y, Pei Y L. 2015. Research on the moderating effect of technological proximity in international patent collaborative network. *Journal of Management Science*, 28(1):111-121.
- [6] Xue W, Lei J S, Yi N. 2010. Empirical study over the performance relationship between relational capital, organizational learning and R&D alliance. *China Industrial Economics*, 4:89-99.

- [7] Song J, Chen J. 2019. Entrepreneur social network, organizational legitimacy and entrepreneurial enterprise resources bricolage. *Studies in Science of Science*, 37(1):86-94.
- [8] Xu J Z, Li F S, Li L, et al. 2017. The effect of external relationship quality on low carbon technology innovation: Knowledge perspective. *China Soft Science*, 2:183-192.
- [9] Balland P A, Boschma R, Ferenken K. 2015. Proximity and innovation: From statics to dynamics. *Regional Studies*, 49(5): 907-920.
- [10] Balland P A. 2012. Proximity and the evolution of collaboration networks: Evidence from research and development projects within the Global Navigation Satellite System (GNSS) industry. *Regional Studies*, 46(6):741-756.
- [11] Casper S. 2007. How do technology clusters emerge and become sustainable? Social network formation and inter-firm mobility within the San Diego biotechnology cluster. *Research Policy*, 36(4): 438-455.