Investigating Land-Use and Land-Cover Changes of Failaka Island: A Study in Geography and Geoarchaeology

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Abstract: In an innovation driven business environment, cross-border access to resources is important for companies to improve innovation capabilities and development performance. Based on the previous research, it shows that there are barriers to cross domain communication among alliance firms because of the restriction of multidimensional ties and dyads. Simmelian ties, as a form of alliance network with ternary connections, it effectively restrained opportunism and self-interest in the cooperation process and take a crucial role to evaluate innovation related performance in corporation. Based on the theory of Simmelian, this paper builds a theoretical framework and proposes corresponding research hypotheses between Simmelian ties and enterprise innovation performance. After designing questionnaires, collecting data and conducting empirical analysis to test theoretical models and hypotheses. Results have shown that: (1) Simmelian ties generally have a positive impact on enterprise innovation performance. (2) Knowledge capturing and knowledge integration play a partial intermediary role between Simmelian ties and enterprise innovation performance, and the mediating chain formed by the two variables plays a serial mediating role in the effect. (3) Network routines significantly positively moderates the relationship between Simmelian ties and knowledge capturing. And also, the positive relationship between Simmelian ties and enterprise innovation performance is also actively moderated by network routines. The conclusion of this study is meaningful for companies to establish of Simmelian ties, improve knowledge management capabilities and further promote enterprise innovation performance.

Keywords: Simmelian ties, enterprise innovation performance, knowledge capturing, knowledge integration, network routines

1. Introduction

With the trend of economic globalization and enterprise internationalization, innovation becomes an important source for companies to create and maintain a competitive advantage in the global market[1] . However, considered the complexity and uncertainty of the innovation process, companies are more difficult to innovate effectively if only rely on their own capabilities[2]. In order to follow the rapid change of technology and the continuous acceleration of innovation, enterprises start to build alliances to cooperate innovation. Enterprise strategic alliance is a mode of competition and cooperation between enterprises, which is a product under political economy. The alliance is built after signing cooperation agreements with other companies to share knowledge, exchange resources and achieve

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coordinate enhancement of their individual innovation capabilities[3]. Besides that, the alliance network is an important carrier of innovation incubation and a key factor to improve the innovation ability of enterprises[4]. The alliance network can be treated as an organization model independent of the enterprise, which can supply and promote the internal development of the enterprise [5].

Existing research has shown the alliance network has a positive impact on the innovation performance of enterprises. This is due to the interaction and resource commitment within the alliance can encourage network members to share resources and promote the flow of core values[6]. There are various forms of alliance networks, such as binary relations, ternary relations, and cluster -level relations etc. These relations can all be treated as "substructures" within the network[7]. Taking the binary relationship as an example, it is a strong connection which can bring trust and other relationship capital to the enterprise, but it is easy to cause knowledge and information redundancy. Moreover, if the comparative resource advantage party pursues maximizing its own interests, cooperative innovation is difficult to sustain. In the multi-dimensional alliance partnership, the diversity of embedded organizations will affect the commitment and trust of alliance members, which will lead individual opportunistic behaviour and reluctance to share technical resources and ultimately affect the improvement of enterprise innovation performance[8]. Therefore, it is necessary to explore another type of alliance for the enterprise to improve its innovation performance.

Simmelian ties, as a new topic in the field of alliance innovation, is highly valued by academia and industry. Simmelian ties means that the two parties are interactively connected and each party interacts with the same third party, as a result, the three elements form a ternary model with a small circle embedded alliance relationship[9,10]. Sheng and Li (2012) pointed out that the three-dimensional relationship structure of Simmelian ties enables enterprises to form a highest trust pattern when make cooperation and knowledge sharing[11]. This is beneficial for enterprise innovation after the transmission of core knowledge and the diffusion of innovation information between enterprises alliance group. Giuseppe et al. (2004) believes the closed nature of Simmelian ties can enhance the stability of the alliance, and contribute more on corporate innovation activities than non-Simmelian ties alliance network[12]. It can be seen that Simmelian ties takes the respective advantages of the strong connections in binary relations and multidimensional weak connections with a unique three-way connection.

Innovation is the process of knowledge application, and knowledge application is one of the important part of innovation subjects in alliance relationships. Therefore, in order to enhance competitive advantage and innovation performance ability, companies must improve their knowledge management capabilities and update their knowledge reserve continuously. Knowledge capturing and knowledge integration are important approaches on knowledge management [13]. Knowledge capture is the process of searching, identifying and selecting valuable new knowledge through the analysis of the organization's external environment. Enterprise innovation not only needs to acquire heterogeneous knowledge, but also needs to integrate and generate new knowledge. Therefore, after enterprises get exposure to any untouched area knowledge, the key is how to integrate and internalize the external knowledge into its own knowledge system and then build up core capabilities to improve innovation performance. Transfer of knowledge between different entities usually would face numerous difficulties, such as the lack of a common knowledge base, unwillingness to share, and communication barriers[14]. Simmelian ties is a good option to solve those contradictions through its specific microstructure embedded characteristic in the alliance network[15,16] . In addition, network routines, as a code of conduct and normative consensus generally recognized by all parties in cooperation. It is also a good way to have positive impact on innovation performance through maintaining the relationship between alliance network members, reducing communication costs and improving learning efficiency. However, scholars rarely

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explore the impact of Simmelian ties on enterprise innovation performance from the perspective of network routines.

Based on above analysis, this article will take knowledge capture and knowledge integration as the start point and empirically analyze the mechanism of Simmelian ties' effect on enterprise innovation performance. And explore whether knowledge capture and knowledge integration play a mediating role in this relationship. We will also introduce network routines as a moderating variable to further reveal the "black box" of Simmelian ties's mechanism through empirically analysis, and provide theoretical and practical guidance for improving enterprise innovation performance.

Compared with previous studies, this paper has following differences to be noticed:

- Previous scholars mostly analyzed the influence of alliance networks on enterprise innovation performance from the two aspects of strong and weak alliance relationship, but rarely from the perspective of Simmelian ties in the form of tripartite relationship.
- Existing studies have analyzed the impact of Simmelian ties on individual innovation, but there is no discussion on the impact of Simmelian ties on organizational innovation performance. This article will fill this gap.
- This research expands and deepens the understanding of the scope and process of Simmelian ties, thus enrich the existing research on alliance networks and corporate innovation.

The remainder of this paper is organized as follows. Section 2 discusses the theoretical framework and hypotheses development, Section 3 and 4 describe the methods and data analysis results in the empirical research respectively. Section 5 discusses the findings and implications of the study.

2. Theoretical framework and hypotheses development

2.1. Simmelian ties

Simmel's social theory had an important influence on modern social network theory[9]. Simmelian ties is an extension of Georg Simmel's sociological theory. Simmel's research mainly analyzed the relationship structure between three individuals. He believed that complete social analysis unit must include three or more individuals rather than only two individuals. When two parties are interactively connected and both have a connection with the same third-party organization, the overall connection is Simmelian ties[17], as shown in Figure 1. Krackhardt mentions main difference between Simmelian ties and binary connections is that binary connections are isolated connections, which are likely to cause collapse in the process of cooperation. The tripartite connections can form a close network structure, which in turn promote the durability of cooperation[10]. The superiority of Simmelian ties can reflect in three aspects: Firstly, Simmelian ties can restrain the self-interested pursuit of individuals and maintain the alliance and cooperation relationship. Secondly, Simmelian ties help to weaken the ability of individuals to negotiate. It is easy for either party to conduct hash negotiation for maximizing own interest in a group composed of two individuals. But for a group of three individuals. If one party cannot meet their self needs may be kicked out of the alliance network, it will lose more since the other two entities are still connected and cooperated. Thirdly, Simmelian ties help promote cooperation and resolve conflict since the third party can play a role of "mediate" and " referee" between two parties.

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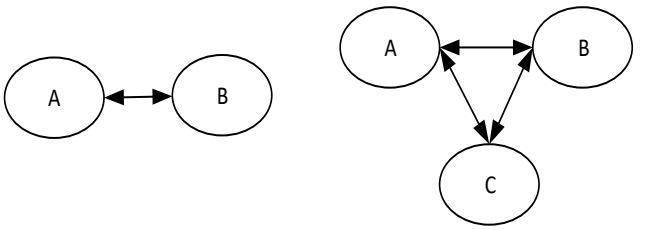

A&B binary interactively connected

A&B are interactively connected and both have a connection with C, the overall connection is Simmelian ties

Figure 1. Simmelian ties diagram

2.2. Simmelian ties and enterprise innovation performance

Simmelian ties is a relatively stable and common interest-oriented alliance network formed between the tripartite organizations and can result in a synergy effect of 1+1>2[18]. In the binary connection relationship, if a conflict occurs during the cooperation process, it is easy to interrupt the cooperation. In the multi-dimensional alliance relationships, it is easy to lead to opportunistic behaviors and difficult to establish a stable and durable trust-commitment relationship among participated entities. Simmelian ties combine the advantages of binary connection and multiple alliances, especially the characteristic of high trust and mutual restraint are conducive to enterprise innovation performance improvement.

Firstly, Simmelian ties can effectively reduce competition and self-interested behavior and contribute to sharing interests and setting up common goals among business partners. In the process of enterprise cooperative innovation, any participant implement opportunistic behavior or hide key knowledge will limit the benefit of alliance innovation. Simmelian ties embedded group with close connections among three parties limit the self-interested behavior of each enterprise[9] . The negative cooperation or opportunistic behavior of one party will not only harm others and also seriously affect the success rate of its own innovation performance[11]. In Simmelian ties, individuals have the possibility to willing make decisions that sacrifice their own interests to safeguard collective interests when faced with a conflict of interest. This tripartite connection pattern promotes open and diversified knowledge sharing, and therefore, is more conducive to improve enterprise innovation performance.

Secondly, Simmelian ties can weaken the individual's negotiation power and in turn strengthen the stability of the alliance to help promote enterprise innovation performance. In general, participants in a binary connection have equal status, and the negative behavior of either party will inhibit the normal spread of core knowledge. If one party in the binary connection maximizes its own interests, it will force the other party to make concessions through unequal negotiation and even lead contact cancellation[16]. However, in Simmelian ties, the autonomy and negotiation ability of any party are reduced. The common third party serves as a guarantee to safeguard the interests of both parties with a highly cohesive tripartite structure, which is helpful to promote enterprise innovation performance[16].

Finally, as we all know, it is difficult to avoid conflict in any cooperative relationship. Once conflicts occur in the binary connection, the conflicts tend to intensify and easily lead to the interruption of cooperation between the two parties. However, in the form of Simmelian ties, a common third party will promptly adjust and alleviate conflicts from an objective and fair perspective to stabilize the entire tripartite alliance. This in turn will promote the communication among different participants and increase understanding of the partners on the same issue, thereby promoting the successful integration of different views and ultimately benefit the enterprise's innovation activities. Considered factors mentioned above, we propose the following research hypotheses:

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Hypothesis 1 (H1): Simmelian ties exerts a positive effect on enterprise innovation performance.

2.3. The mediation effect of knowledge capturing

Knowledge management is an effective way for enterprises to improve their innovation capabilities and innovation performance. As an important part within knowledge management, knowledge capture reflects the knowledge exchange and dissemination among different organizations. Knowledge capture is a behavior in which an enterprise cooperates with external organizations to combined related new knowledge into current knowledge structure. The purpose is to make knowledge can be widely shared and appropriately applied throughout the organization to achieve the expansion and update current knowledge system[19]. Knowledge, like other resources, will become obsolete. Especially in the long-term development process, an enterprise's cognitive structure and dominant logic will become more and more rigid. In addition, the organization's "knowledge memory" will be lost when key personnel leave entity[20]. Therefore, in order to make organizational knowledge can be spread, filtered, stored, and updated continuously in the new environment, organizations need to keep capture new knowledge through external knowledge channels, and use appropriate technologies and strategies to retain knowledge[21].

Heterogeneous knowledge is difficult to obtain through market transactions directly, so most companies rely on cooperative relationships to obtain complementary knowledge. Alliance networks have unique advantages in acquiring external heterogeneous knowledge. Theory and practice show that Simmelian ties, as a tripartite alliance relationship, can significantly promote enterprise knowledge capture [22].

First of all, Simmelian ties is a small circle relationship network formed by interactive connections, which helps to increase the trust between knowledge suppliers and buyers. The relationship becomes more stable after the basic trust is established. Then it is more easy to form a consistent value concept and sense of identity, which is conducive to the search and acquisition of knowledge. Secondly, in the alliance network, R&D personnel from different companies are easy to suspect of abusing their research result, distrust behavior such like this is the biggest obstacle to knowledge sharing and technology exchange[23]. Lack of trust among alliance parties hinders the dissemination and capture of knowledge, Simmelian ties can contribute to converting previous competitors become nowadays cooperation. When trust and positive expectations for the future are established, participants tend to increase their willingness to share knowledge, which in turn strengthens their exchanges and communication, and gradually forms a special knowledge-sharing path, which is known as, partner-specific knowledge-sharing Routines[24]. The new pattern sharing path, along with dedicated communication modes and problem-solving mechanisms will further increase the success rate of knowledge capture. Simmelian ties can also help stabilize the emotions and attitudes of both knowledge suppliers and demanders, promote a more objective and calm expression of the views and interests of participants. These characteristics help smooth the channels and gain the power for knowledge capture. Therefore, we propose the hypothesis:

Hypothesis 2 (H2): Simmelian ties exerts a positive effect on knowledge capturing of enterprise

Knowledge is the fundamental source for companies to gain sustained competitive advantage and improve innovation performance[25]. If the enterprise cannot obtain external new knowledge and new technology, it will prevent updating of enterprise knowledge in time and to insufficient enterprise knowledge reserves. Then will finally affect innovation performance.

Based on the research perspective, strengthening of knowledge capture can enrich enterprise's knowledge base, improve the organization's knowledge structure, and thereby

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improve innovation skills and innovation performance[26]. Phelps et al. believe that strong knowledge capture helps companies obtain valuable knowledge from external networks, then contribute to promoting enterprise innovation performance[27]. By capturing new knowledge and updating knowledge reserves in time, enterprises deepen and expand their internal knowledge base, which has a positive effect on the improvement of enterprise innovation performance. Especially in an open innovation environment, when company can acquire external knowledge with high intensity and efficiency, it can overcome organizational inertia and capability traps in the innovation process, which is conducive to timely technological changes and promotes the improvement of innovation capabilities and innovation performance. These discussions lead to the following hypothesis:

Hypothesis 3 (H3): Knowledge capturing exerts a positive effect on enterprise innovation performance.

Companies in Simmelian ties have long term close interactions with other members, forming a strong relationship cohesive alliance network form which will expand the channels for corporate knowledge capture. The capture of enterprise knowledge means breaking the original knowledge boundary, absorbs diversified advanced technologies and heterogeneous knowledge to increase the possibility of innovative technology combinations. The closed interactive relationship formed by Simmelian ties is more conducive to the communication of tacit knowledge between participants. In addition, individuals in Simmelian ties have a higher fairness and a stronger willingness to innovate, which is more likely to transform their ideas into innovation results and enhance the company's innovation performance. Finally, companies with strong knowledge capture capabilities can acquire high-value heterogeneous knowledge through cross-border search, which enriches the diversity of corporate knowledge resources, helps companies follow external market changes and make optimization decisions and thereby improving organizational innovation performance. These discussions lead to the following hypothesis:

Hypothesis 4 (H4): The positive relationship between Simmelian ties and enterprise innovation performance is mediated by knowledge capturing.

2.4. The mediating effect of knowledge integration

There is a certain difference between the new knowledge searched by the enterprise and the existing knowledge structure. In order to smoothly transform new knowledge and take effect it into the organization's innovation capability and sustainable competitive advantage, the organization's integration ability of knowledge is also very important. Zahra et al. defined knowledge integration as the process of an organization to process and apply newly acquired knowledge on existing system[28]. Smith et al. believe that knowledge integration is a combination of series of learning behaviors that companies match new knowledge from different sources with internal knowledge into a whole system[29]. Specifically, knowledge integration can be widely shared and appropriately applied throughout the organization by inputting external related knowledge into an existed knowledge structure, and performing identification, decoding, fusion, and reconstruction, so as to expand and update the current knowledge system.

The relationship between the three organizations in Simmelian ties is relatively stable. Besides that, long-term cooperation prompted partners to form a similar corporate culture and cooperation model, which helps companies to integrate external knowledge more efficiently. Simmelian ties is a three-party tightly connected alliance network structure. The cognitive difference among participants are small, which is conducive to reaching consensus on knowledge and technology and reducing the knowledge absorption obstacles. In addition, the tripartite enterprises in Simmelian ties are all equal-level units. There is no situation where the

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core enterprise absolutely controls innovative knowledge. The equal and efficient absorption pattern of new knowledge by the tripartite organizations will ultimately enhance the knowledge integration capabilities of the alliance individuals. From the perspective of cooperation and trust, Simmelian ties can increase the degree of trust between knowledge suppliers and demanders. When employees form a common and consistent values, they are conducive to the sharing and integration of knowledge.

Knowledge integration is not a static process. It is a dynamic process to match and absorb knowledge elements from the supply to the demand side. Knowledge integration needs two key steps, they are knowledge matching and knowledge absorption. Knowledge matching and knowledge absorption are dependent with each other in the organizational knowledge management system. Three participant in Simmelian ties are easier to acquire innovative knowledge which compatible with their own knowledge structure and will increase the knowledge absorption success rate[30]. Similar knowledge system and inertial thinking way of both sides of knowledge supply and demand also increase the knowledge integration effect. Moreover, the inter-firm interaction and frequent exchanges in Simmelian ties promote the tacit degree of cooperation and ultimately have a positive effect on knowledge integration. Based on above analysis, we can propose Hypothesis 5:

Hypothesis 5 (H5): Simmelian ties exerts a positive effect on enterprise knowledge integration

In the era of knowledge economy, the innovation activities of enterprises need the support of technology and knowledge from different fields. Enterprises can create some basic conditions for the development of new products and the promotion of new technologies through integrating the knowledge resources from the alliance relationship. Enterprises need to continuously integrate internal and external knowledge in the innovation process, and through effectively manage to understand mainstream technologies, new concepts and development trends under the minimum cost of knowledge flow. Knowledge integration helps to improve the competitive advantage of enterprises. Enterprises absorb and refine external knowledge, and integrate with internal knowledge to create new concept and promote organizational innovation capabilities, thereby enhancing the innovation performance of the enterprise. Pisano believes that knowledge integration can improve the enterprise knowledge matching efficiency and has a positive impact on enterprise innovation performance[31]. Boer et al. believe that strong knowledge integration capabilities can help companies to identify opportunities in a rapidly changing competitive environment, apply advanced technologies and novel knowledge to new product development to consolidate their market position[32]. Enterprise knowledge integration can guide enterprises to make products adopt to market in a rapidly changing environment, and to develop new products quickly and effectively to meet different market needs. Knowledge integration can maximize the value contained in different knowledge piece, enhance the core competitiveness of enterprises, and promote the innovation performance of enterprises. Thus, the following hypothesis is proposed:

Hypothesis 6 (H6): Knowledge integration exerts a positive effect on enterprise innovation performance.

Innovation openness emphasizes that the improvement of enterprise innovation performance not only depends on internal R&D, but also depends on the ability to use external knowledge resources, and effectively absorb them into the innovation process. Obstfeld research shows that the effective integration of heterogeneous knowledge dependent on the trust, norms and common language generated by a closer relationship network, especially for those complex knowledge and tacit knowledge[33]. Therefore, on the one hand, companies need to build a relationship network to obtain external heterogeneous knowledge. On the other hand, they need a closer network structure to complete the effective absorption and integration

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of heterogeneous knowledge. Simmelian ties support the acquisition of external heterogeneous knowledge with a unique tripartite alliance relationship, and finally promotes enterprise innovation performance after an integrated process of knowledge absorption and application. Those evidences lead us to formulate our seventh hypothesis:

Hypothesis 7 (H7): Knowledge integration mediates the relationship between Simmelian ties and enterprise innovation performance.

2.5 The Chain Mediation of Knowledge Capture and Knowledge Integration

Knowledge capture and knowledge integration are two closely related parts in organizational knowledge management system. Knowledge capture is the first step for companies to integrate new and old knowledge and make further update[34]. Knowledge integration, in a certain extent, determines whether the exogenous knowledge captured by the enterprise can become an internal resource for the organization, and also can inspect and evaluate the quality of captured knowledge. As a result, this study surmise that corporate knowledge capture and knowledge integration play a chain mediation role in the relationship between Simmelian ties and enterprise innovation performance.

First of all, knowledge capture and knowledge integration in Simmelian ties promote knowledge search efficiency and contribute to the enterprise innovation performance. Knowledge capture is undoubtedly an important foundation for enterprises to carry out knowledge integration. It will enrich the diversity of enterprise knowledge resources, and also provide decision maker with relevant information about the latest market change and help them to adjust the knowledge structure in a timely manner. In addition, companies with stronger knowledge integration capabilities can efficiently digest and absorb the acquired knowledge, transform the new knowledge to a way suitable with organizational needs and impact positively on enterprise innovation performance.

Secondly, knowledge management is not a static process, it should cover the sharing, absorption and reorganization of knowledge elements from the supply side to the demand side. Simmelian ties promotes the formation of a stable knowledge spread mode and sharing willingness among enterprises, which is conducive to enhancing the familiarity of the required knowledge, increasing their search experience and improving the knowledge capture degree[30] . After enterprises capture sufficient valuable heterogeneous knowledge, knowledge management will enter to next step: knowledge integration. The enterprise will strictly select and filters external knowledge to match its own knowledge structure, and then transforms to incorporate into the organization's knowledge system. This lays the foundation for the following hypothesis:

Hypothesis 8 (H8): Knowledge capture and knowledge integration play a chain mediation role in the relationship between Simmelian ties and enterprise innovation performance

2.6 The moderating effect of Network routine

Previously research defined network routine as a stable interaction mode gradually formed by repeated cooperation from multiple participate companies [35]. Scholars' understanding of the network routine has become deeper and clearer after massive detailed research. Guo et al. believe that network routine refers to the widely accepted behavior mode in cooperation network, developed in repeated cooperation process contribute its stable interaction model[36] . Lavie's research believes that network routine can enhance the trust and communication mechanisms, thus increase the frequency of mutual cooperation and knowledge sharing[37]. Kumar points out that network practices reduce conflicts and misunderstandings among partners. This inter-organizational trust lays a good emotional basis for inter-organizational learning[38].

Network routine is an informal mechanism for exchanging and interacting among

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enterprises. It will improve the knowledge transfer between enterprises in a stable cooperative relationship, which will in turn facilitate capturing external knowledge. Lavie et al. believe for a higher degree of network routine with greater understanding, trust and coordination among members, there will be a more consistent pace of knowledge transfer and will final enhance corporate knowledge capture capabilities[37]. Companies in Simmelian ties have a common consensus on cooperation, the network routine improve communication and make the transferred knowledge become easier to be recognized, understood and absorbed. Mature and stable network routine enable companies to obtain innovative knowledge from the network within established practices, and hence saving the organizations' search costs. Therefore, we believe that companies in Simmelian ties are positively affected by network routine when capturing external knowledge. Thus the study proposes:

Hypothesis 9 (H9): The network routines positively moderate the relationship between Simmelian ties and knowledge capturing.

As a kind of inertial behavior formed by the interaction between organizations, network routine helps to improve the relationship, promote the effective knowledge transfer and form an efficient collaboration model among participate entities. Simmelian ties, as a stable form of tripartite cooperation, has a very good atmosphere for members to learn, share and exchange technology. With the degree of network routine increases, there is greater possibility of knowledge creation and sharing among alliance enterprises, thus more conducive to the transfer of key technologies and core knowledge.

The cognitive models within the same innovation field are relatively close, as a result, fewer obstacles to obtaining resources within the boundary. Additionally, cooperative companies with higher network routines usually have a higher exchange frequency and share extent regards the new knowledge, which will in turn improve the success possibility of corporate innovation[39]. Cross-border access to heterogeneous new resources faces more uncertain factors. In this circumstance, as the degree of network routine increases, the more normative standards will establish between enterprises. The "rules of the game" for cooperation between members will be more clear and thereby reducing inter-organizational conflicts, increasing the degree of inter-organizational cooperation. It will also help companies to grasp new opportunities to improve innovation performance[40]. Barajas and Huergo (2010) indicate that enterprises in alliances can maximize the use of network routine, reduce coordination costs during the process and ensure the smooth progress of cooperation[41]. It can be seen that the establishment and application of network routine is conducive to create innovative thinking in the communication process within Simmelian ties. It can also apply to cooperative research and development projects to upgrade the original product design technology and positively affect enterprise innovation performance. Thus, we propose the following research hypotheses:

Hypothesis 10 (H10): Network routines positively moderate the relationship between Simmelian ties and enterprise innovation performance

The theoretical model of this study is shown in Figure 2

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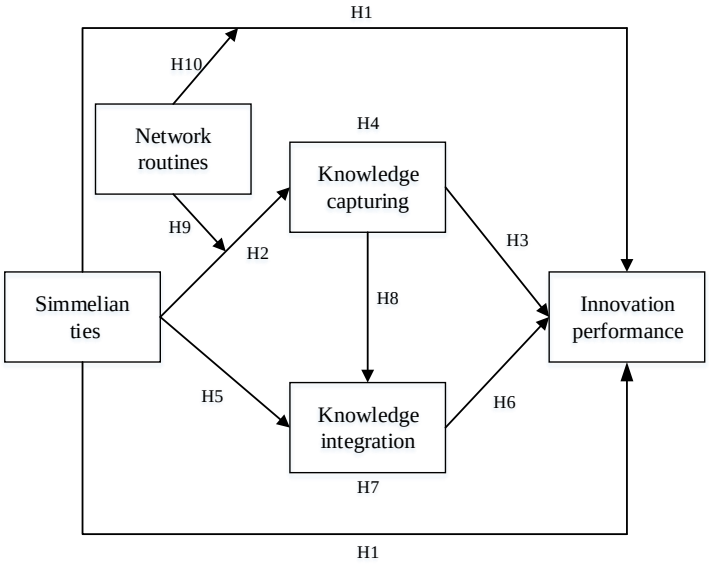

Figure 2. Research framework.

3. Methods

3.1. Sample and data collection

This paper takes high-tech companies as main research object, the author selected enterprises from the top 3 developed economic area in China: Beijing-Tianjin-Hebei Urban Agglomeration, Yangtze River Delta Urban Agglomeration and Pearl River Delta Urban Agglomeration. Most Companies are from aircraft/spacecraft industry, pharmaceutical industry, electronic communication equipment industry, etc. Sampled enterprises are highly representative no matter in terms of their location nor their alliance network. We used field surveys, virtual meeting and email to send questionnaires to obtain the data for this research. To be noticed that all companies surveyed are in a cooperative network of Simmelian ties.

We refer to the current widely acceptable content in literature to design the questionnaire and variables are based on the mature scale developed by previous scholars. The questionnaire was initial designed in English and then translated into Chinese when we presented to interviewees. In order to avoid understanding and translation bias caused by language and cultural differences, the research team adopted a translation-back translation method to improve the cultural adaptability and legibility of the questionnaire. To ensure the questionnaire is designed in a professional way, we consulted two HR directors from public listed company and applied their comment to further improve the quality of the questionnaire content. We also made a preliminary survey through issuing 178 questionnaires to MBA and EMBA students to trial fill out, and randomly interviewed 4 students to provide feedback of the questionnaire. Then we revised and re-formatted the questionnaire and get the final version to be used in the actual survey. In order to avoid the subjective bias in a single assessment, we plan to make large sample test and select at least 4 Senior Managers or Directors per enterprise to fill out the questionnaire. The final data used in our future analysis is the enterprise level data which is the average value from individual level data.

This paper is mainly focus on the innovation of cooperative enterprises in Simmelian ties, as a result, the selected enterprises must in a tripartite cooperative relationship. We firstly looked through the high-tech companies list published in the local government websites and selected all high-tech companies with Simmelian ties. For the Tianjin-Hebei Urban Agglomeration economic area, we selected 31 companies in total which satisfy the Simmelian ties condition and went in person to collect data. Four directors from each company were

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interviewed and filled out on printed questionnaire. Ten technical personnel in R&D department also were invited to fill in questionnaires. We final obtained 398 individual level and then we take the average of the data obtained by each enterprise, and finally got 31 analytical enterprise level data. For the Yangtze River Delta Urban Agglomeration and Pearl River Delta Urban Agglomeration economic areas, due to the restriction under Covid-19 condition, 41 companies we took virtual meeting and remaining 416 companies we sent email to obtain data. We got 1471 individual-level data and 457 company-level data which obtained through average calculation. In total, we had 487 useful data to be analysis over 5 months.

In terms of the composition of the survey objects in this paper, state-owned enterprises accounted for 13.2%, Sino foreign joint ventures accounted for 18.7%, private enterprises accounted for 43.1%, other types of enterprises accounted for 25%. Among the questionnaires, men accounted for 68.2%, women accounted for 31.8%; Bachelor degree or below accounted for 54.2%, master degree accounted for 43.4%, doctoral degree accounted for 2.4%. The employees surveyed accounted for 17.4% from 25-30 years old, 53.2% from 31-40 years old, 19.5% from 41-50 years old, and 9.9% over 51 years old.

3.2. Variables Measures

The measurement of the variables involved in this study adopts the mature effective scale used by previous scholars, which has been proved to have high reliability and validity. All scales used in this questionnaire were mature scales and using a 5-point Likert scale, the respondents were asked to rate each item according to the level of agreement. Among them, 1 means "strongly disagree", 3 means "basically agree", and 5 means "strongly agree". The measurement items of all variables are shown in Table 1.

(1) Simmelian ties. Simmelian ties was measured using the widely accepted items drawn from the extant literature[9,10,18,22]. We designed a total of 6 items to measure the variable, including the degree of sharing key information, the cohesion of the relationship, and the frequency of informal communication, etc. The items were as follows: " You share knowledge and key information more frequently with employees in the other two companies" and so on. **(Cronbach's=0.931).**

(2) Enterprise innovation performance (EIP). To measure EIP, we adopt the maturity scale from existing literature[36]. Respondents were inquired about their company's performance in the past three years. **(Cronbach's=0.921)**

(3) Knowledge capturing. Knowledge capture is the way companies acquire heterogeneous knowledge by depth and width search of external knowledge. We measured the depth search of external knowledge using items from the validated knowledge search scale that Zhou and Li (2012) published about market knowledge acquisition, and internal knowledge sharing[42]. The depth of external knowledge search reflects the extent to which the company obtains complex knowledge from specific external partners. In addition, we refer to the research of Zhou (2012) and Luca (2007) to measure the knowledge width search[42,43]. **(Cronbach's=0.911).**

(4) Knowledge integration. We used the validated five items drawn from the literature[44,45], that was especially explored the degree of enterprise's digestion, absorption and utilization of external knowledge. Which involves the ability of an enterprise to absorb and digest external knowledge, integrate partner knowledge and apply it to practice, disseminate the efficiency of obscure knowledge, and to develop new products with new skills **(Cronbach's=0.892).**

(5) Network routine. We followed Lavie [37], according to the the characteristics of technological innovation networks and network routine, 5 items are designed for measurement from two main aspects: behavior tacit agreement and normative acceptance. **(Cronbach's=0.920).**

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(6) Control variables. Besides the core variable of interest, four variables (firm size, firm age, industry type and ownership) were controlled to eliminate the effects they might have had on enterprise innovation performance. First, enterprise size indicates that a firm possesses more resource and capability to improve innovation performance, and it was controlled and estimated by the log values of the number of employees[46]. Second, firm age was adopted from the research of Sorensen and Stuart (2000), which may affect a firm's incentive to devote into innovation and cooperation willingness[47]. It was measured in years since a firm was established. Third, following Wang et al. (2017), this study controlled for industry type by introducing industry dummies, in which 0 indicated labor-intensive industries and 1 indicated knowledge-intensive industries[48]. Fourth, as firms with state ownership may receive more government support and leverage more resources for innovation[49], this study incorporated ownership and measured it by a dummy variable, in which 0 indicated the presence of state ownership and 1 indicated the absence of state ownership [48]. In this paper, a Harman single factor test was performed on the questionnaire to analyze the deviation from homology caused by the same person answering a set of questionnaires. We used the Harman single factor test reported by Podsakoff and Organ (1986) to perform a homologous analysis of variance[50]. By conducting an exploratory factor analysis of all variables, the first factor explained 30.84% of the variation when the axis was not rotated. Therefore, the interpretation of a single factor generally does not vary, and the deviation from homology is not substantial.

4. Data analysis and Results

4.1. Reliability and Validity Tests

In this study, the reliability and validity of the scale were tested by SPSS24.0. Reliability refers to the consistency or stability of the results obtained with test tools. Cronbach's α was used to determine the reliability of the results of the questionnaire. As shown in Table 1, the Cronbach's coefficient of all variables in the questionnaires were greater than the critical value of 0.7, indicating that the internal consistency of the scale is high and has good reliability. The minimum value of the factor load is 0.744 and the maximum value is 0.851, and they are all significant at the level of $P<0.01$, which meets the requirements of the factor load value between 0.5 and 0.95. The validity of the scale mainly includes content validity and structure validity. In this paper, we adopt the maturity scale of other scholars, and thus the validity of the content is good. The Construct Reliability (CR) is used to measure the validity of structure. Average Variance Extracted (AVE) is used to measure the validity of convergence. The AVE values of all variables are greater than 0.5 and the CR values were greater than 0.80 (as shown in table 1), it shows that the contribution of latent variable variance to the total variance is significantly higher than the measurement error, indicating that the variables had good convergent validity. Second, as shown in Table 2, the square of the variance of each variable was greater than the correlation coefficient of the row and column, indicating that the measurement had good discriminant validity. The test results in Table 1 showed KMO values that were all greater than 0.8, and the probability of Bartlett's test of Sphericity is less than 0.05, indicating that the original variables are more suitable for factor analysis.

Table1. Measurement items, loadings, validity and reliability

Variables and scale items	Standardized loading	Cronbach's alpha	Average variance extracted	Composite reliability	KMO
Simmelian ties					
1. You share knowledge and key information more frequently with employees in the other two companies	0.831				

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2. You have a strong relationship with employees in the other two companies	0.842	0.931	0.693	0.931	0.933
3. You have a higher degree of informal communication with employees in the other two companies	0.828				
4. Do you think the tripartite alliance can reduce the risk of uncertainty in cooperation	0.823				
5. Do you think the tripartite alliance has improved the level/degree of knowledge sharing and technical exchange	0.844				
6. Partner members usually contact you proactively to obtain work-related knowledge or information	0.827				
Knowledge capturing		0.911	0.671	0.911	0.899
1. Your R&D experts efficiently acquire heterogeneous knowledge with technical knowledge and skills within specialized domain	0.823				
2. You can capture market information from a diversified and wide-ranging customer portfolio	0.823				
3. Your company can frequently use specific channels to capture new knowledge	0.822				
4. Your company attaches great importance to searching and tracking new knowledge in the main business field from the outside	0.815				
5. Your Company attaches great importance to acquiring new knowledge about improving current products from outside the organization	0.813				
Knowledge integration		0.892	0.623	0.892	0.888
1. Your company can efficiently absorb and use heterogeneous knowledge from the outside world	0.825				
2. Your company can effectively match and integrate the acquired new knowledge with the original knowledge	0.744				
3. Your company can use new knowledge to develop and identify new opportunities	0.776				
4. Your company can reorganize knowledge well to achieve the effect of innovation	0.799				
5. Your company can use new knowledge and technology to solve the company's production and management problems	0.799				
Network routine		0.920	0.699	0.921	0.905
1. In the process of cooperative innovation, your company have many behaviors that can reach a tacit understanding with partners	0.851				
2. Your company has understandable steps, sequences or experience to follow in the process of working with partners	0.823				
3. When making decisions, your company takes into account the solutions to similar	0.842				

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problems that have occurred in the past cooperation process					
4. Your understanding and mastery of the "rules of the game" is gradually deepened in the interaction and cooperation with partners	0.827				
5. Many implicit and fixed cooperation regulations are accepted between your company and its partners	0.835				
Enterprise Innovation performance					
1. Compared with the rival, your firm's new product sales revenue continues to grow	0.804				
2. Compared with the rival, profits of your company's new products keep increasing	0.828				
3. Compared with the rival, the number of the company's patent applications keeps increasing	0.811	0.921	0.661	0.921	0.928
4. Compared with the rival, your firm has a higher return on assets (ROA)	0.807				
5. Compared with the rival, your firm has higher new product and service growth rates	0.809				
6. Compared with the rival, your firm has a higher market growth rate	0.817				

4.2. Descriptive statistical analysis

The descriptive statistics of main variables and Pearson correlation coefficient matrix are shown in Table 2. The results show a significant relationship between Simmelian ties and innovation performance ($\beta = 0.625$, $p < 0.01$). The correlation between mediation variables (knowledge capturing, knowledge integration) and dependent variable (innovation performance) are respectively ($\beta = 0.652$, $p < 0.01$, $\beta = 0.610$, $p < 0.01$). Simmelian ties are significantly positively related to knowledge capturing and knowledge integration ($\beta = 0.583$, $p < 0.01$, $\beta = 0.601$, $p < 0.01$). In addition, moderators (network conventions) are positively correlated with other variables. These correlations are consistent with the theoretical expectations and provide initial support for the subsequent research hypotheses. Although there is a high correlation between the variables, it is still less than the statistical standard (<0.7) and is not highly correlate[51].

Table 2. Results of the descriptive statistical analysis.

Variable	1	2	3	4	5	6	7	8	9
1. Firm size	1								
2.Firm age	.638**	1							
3.Industry type	.654**	.653**	1						
4. Ownership	.637**	.657**	.651**	1					
5. Simmelian ties	.591**	.588**	.603**	.597**	**0.833**				
6.Knowledge capturing	.637**	.658**	.641**	.632**	.583**	**0.819**			
7.Knowledge integration	.638**	.629**	.670**	.643**	.601**	.610**	**0.790**		
8. Network routine	.388**	.368**	.374**	.371**	0.030**	.409**	.382**	**0.836**	
9. Innovation performance	.666**	.657**	.654**	.668**	.625**	.652**	.610**	.392**	**0.813**
Mean	3.290	3.299	3.319	3.243	3.172	3.265	3.267	3.235	3.276

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S.D	1.044	1.044	1.037	1.039	0.922	0.899	0.882	0.928	0.886

Notes: ** Significant at the 0.01 level, the bold value is the root of the AVE in the various scales.

4.3. Hypothesis Tests

The hierarchical regression analysis was mainly used in this paper to test the research hypotheses. In order to ensure the reliability of the study, the collinearity of all independent variables was diagnosed by the variance expansion factor (VIF). The results show that the VIF values of the main variables are below 2 and far below the critical value of 3. Indicating that there is no serious multicollinearity problem.

Regarding the main effect tests, hypothesis 1 proposes that Simmelian ties exerts a positive effect on innovation performance. M2 shows that the regression coefficient of Simmelian ties on innovation performance is 0.168 (p<0.01). The results indicate that there is a positive correlation between Simmelian ties and innovation performance. Therefore, Hypothesis 1 was verified. Model 1 shows a significant positive effect of Simmelian ties on knowledge capturing ($\beta = 0.121$, $p < 0.01$), and model 3 shows a significant positive effect of knowledge capturing on innovation performance ($\beta = 0.169$, $p < 0.01$). Therefore, Hypothesis 2 and Hypothesis 3 were verified. When we put independent variables, mediating variables, and dependent variables into the regression equation at the same time. The regression coefficient of Simmelian ties on the innovation performance is reduced to 0.150($p < 0.01$) (model 4), indicating that knowledge capturing plays a partial mediating role between Simmelian ties and innovation performance. Therefore, Hypothesis 4 was confirmed.

It can be known from the estimated results of M5, M6 and M7 in Table 3, Simmelian ties has a positive impact on knowledge integration ($\beta = 0.146$, $p < 0.01$), Hypothesis 5 were verified. In a similar way, the regression coefficient of knowledge integration to the innovation performance is 0.072 ($p < 0.1$) (model 6), which validates Hypothesis 6. Based on model 2, knowledge integration is added to the regression equation, and the Simmelian ties has a positive impact on the innovation performance of enterprise, and the regression coefficient is 0.162 (p<0.01). The change indicates that the knowledge integration plays a partial mediating role in the relationship between Simmelian ties and enterprise innovation performance. Therefore, Hypothesis 7 is confirmed. Hypothesis 1 proposes that Simmelian ties exerts a positive effect on innovation performance. Hypothesis 8 proposes that knowledge capturing and knowledge integration play a chain mediating role between Simmelian ties and innovation performance. As show in M8, M9, knowledge capturing exerts a significant positive effect on knowledge integration ($\beta = 0.089$, $p < 0.01$), when both knowledge capturing and knowledge integration entered the regression analysis, the effect of Simmelian ties on enterprise innovation performance remained significant($\beta = 0.147$, $p < 0.01$). H8 were supported.

Table 3. The results of Multivariate linear regression

Variable	Knowledge capturing	Innovation performance			Knowledge integration		Innovation performance		
	M1	M2	M3	M4	M5	M8	M6	M7	M9
constant	0.687**	0.624**	0.629**	0.524**	0.706**	0.645**	0.702**	0.595**	0.506**
Firm size	0.163**	0.181**	0.180**	0.157**	0.149**	0.134**	0.198**	0.175**	0.154**
	(-5.894)	(-6.971)	(-6.851)	(-6.014)	(-5.532)	(-4.92)	(-7.468)	(-6.630)	(-5.796)
Firm age	0.207**	0.153**	0.142**	0.123**	0.121**	0.102**	0.169**	0.148**	0.120**
	(-7.388)	(-5.821)	(-5.259)	(-4.593)	(-4.436)	(-3.667)	(-6.328)	(-5.576)	(-4.455)
Industry type	0.155**	0.133**	0.135**	0.110**	0.213**	0.199**	0.148**	0.124**	0.105**
	(-5.393)	(-4.941)	(-5.018)	(-4.087)	(-7.671)	(-7.094)	(-5.311)	(-4.477)	(-3.781)
Ownership	0.142**	0.178**	0.181**	0.157**	0.155**	0.142**	0.196**	0.172**	0.153**

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	(-5.013)	(-6.719)	(-6.821)	(-5.929)	(-5.663)	(-5.153)	(-7.230)	(-6.371)	(-5.699)
Simmelian ties	0.121**	0.168**		0.150**	0.146**	0.136**		0.162**	0.147**
	(-4.155)	(-6.161)		(-5.528)	(-5.185)	(-4.778)		(-5.858)	(-5.324)
Knowledge capturing			0.169**	0.146**		0.089**			0.143**
			(-5.518)	(-4.808)		(-2.807)			(-4.707)
Knowledge integration							0.072*	0.041	0.028
							(-2.274)	(1.30)	(-0.878)
N	487	487	487	487	487	487	487	487	487
R^2	0.569	0.611	0.608	0.62	0.579	0.583	0.597	0.611	0.62
Adj. R^2	0.567	0.609	0.605	0.618	0.577	0.58	0.595	0.609	0.618
F-value	F=246.035***	F=291.974***	F=288.271***	F=252.944***	F=256.269***	F=216.448***	F=275.797***	F=243.774***	F=216.866***

Notes: * Significant at the 0.1 level, ** Significant at the 0.01 level, *** Significant at the 0.001 level.

In order to make up for the defects of traditional mediating effect test, such as poor statistical effect and poor test result, in recent years, Bootstrap method has gradually become the mainstream method in the empirical study of mediation test. We follow the recommendations of Hayes [52],set bootstrap sample size to 1000, used the non-parametric percentile method for bias correction and set a 95% confidence interval. The results are shown in Table 4, the indirect effect of "Simmelian ties - knowledge capturing - innovation performance" was 0.018, $p < 0.01$, the confidence intervals is [0.008, 0.030], excluding 0, the Z-value from indirect effect was 2.996 ($p < 0.001$), which is greater than 1.96. Hypothesis 4 was further supported by the data. Meanwhile, the indirect effect of "Simmelian ties - knowledge integration - innovation performance" was 0.006, $p < 0.1$, the confidence intervals is [0.002, 0.016], excluding 0, the Z-value from indirect effect was 2.363 ($p < 0.1$),which is greater than 1.96, which further validated Hypothesis 7.

Table 4. The mediator of knowledge capturing, knowledge integration (Bootstrapping test).

	Effect	Boot SE	Bootstrapping Percentile 95% CI		z	P
			BootLLCT	BootULCT		
Simmelian ties -knowledge integration - innovation performance	0.018	0.006	0.008	0.030	2.996	0.003
Simmelian ties - knowledge capturing - innovation performance	0.006	0.004	0.002	0.016	2.363	0.073

In addition, to verify the chain mediating effect of knowledge capturing and knowledge integration. According to the Bootstrap test results (see Table 5), There are direct paths and three indirect paths between Simmelian ties and innovation performance. The direct effect of Simmelian ties on Innovation Performance is 0.147, 95% confidence interval is [0.093, 0.201], excluding 0, which further verify Hypothesis 1. The chain mediating effect between Simmelian ties and innovation performance of knowledge integration and knowledge capturing was 0.001, excluding 0, H8 were supported.

Table 5. The results of chain mediating effect test (Bootstrapping test).

	Effect	Boot SE	Bootstrapping Percentile 95% CI	
			BootLLCT	BootULCT
Simmelian ties - innovation performance	0.147	0.028	0.093	0.201
Simmelian ties -knowledge capturing - innovation performance	0.017	0.005	0.009	0.028

Simmelian ties - knowledge integration - innovation performance	0.004	0.001	0.003	0.006
Simmelian ties - knowledge capturing - -knowledge integration-innovation performance	0.001	0.000	0.000	0.001

The path coefficient of mediation effect is shown in Figure 3.

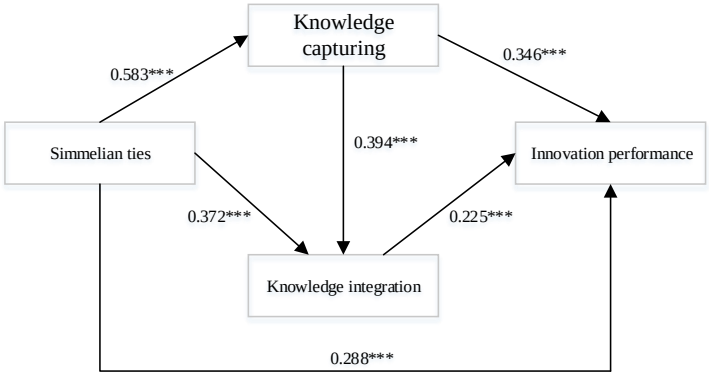

Figure 3. Mediation model structure diagram

The moderating effect tests. Before testing the moderating effect, the independent variables (Simmelian ties) and the moderate variable (network routine) were centralized to prevent multicollinearity between variables. Given Hypothesis 9 proposes that the network routine positively moderates the relationship between Simmelian ties and knowledge capturing. This paper set the knowledge capturing as the dependent variable, then introduced an independent variable (Simmelian ties) and moderating variable (network routine), and finally added the interaction term of the independent variable and moderating variable to verify this hypothesis. M3 in Table 6 shows a significant effect of the interaction between Simmelian ties and network routine on knowledge capturing ($\beta = 0.072$, $p < 0.01$), namely, network routine moderates the positive relationship between Simmelian ties and knowledge capturing. Therefore, Hypothesis 9 was supported. This indicates that with the increase of network routines, the positive correlation between Simmelian ties and knowledge capturing was stronger. which suggests that as the degree of network practice increases, the communication and sharing of knowledge and information between enterprises in Simmel ties is of higher quality and efficiency, It is conducive to the transfer of core knowledge and facilitates enterprise knowledge capturing.

For testing the following hypothesis, we examine whether the network routine is a moderating factor in the relationship between Simmelian ties and enterprise innovation performance. In support of Hypothesis 10, the coefficient of the interaction effect on the latent variable of enterprise innovation performance is significant and positive (*Model 6*: $\beta = 0.060$, $p < 0.01$). which validate Hypothesis 10. That is, the higher the degree of network routine, the more significant the positive relationship between Simmelian ties and enterprise innovation performance. That is because that higher-level network routine mean that a series of common cooperation models have been formed between enterprises. When the external environment is turbulent, network members are affected by this common behavior pattern, so that they can quickly adapt to the changes in the environment and ultimately promote the innovation performance of enterprises.

Table 6. The moderating effect of network routine.

Variable	Dependent Variable	
	Knowledge capturing	Innovation performance

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	M 1	M 2	M 3	M 4	M 5	M 6
Constant	0.687**	1.625**	1.669 **	0.624**	1.649**	1.686**
Firm size	0.163**	0.108**	0.104**	0.181**	0.138**	0.134**
Firm age	0.207**	0.091**	0.086**	0.153**	0.121**	0.117**
Industry type	0.155**	0.178**	0.177**	0.133**	0.095**	0.094**
Ownership	0.142**	0.122**	0.119**	0.178**	0.142**	0.139**
Simmelian ties	0.121**	0.241**	0.258**	0.168**	0.270**	0.285**
Network routine		0.155**	0.186**		0.168**	0.194**
Interaction: ST * NR			0.072**			0.190**
N	487	487	487	487	487	487
R^2	0.569	0.596	0.601	0.611	0.630	0.633
Adj.R^2	0.567	0.593	0.598	0.609	0.627	0.631
F-value	F=246.035***	F=228.409***	F=199.806***	F=291.974***	F=263.646***	F=229.273***

Notes: * Significant at the 0.05 level, ** Significant at the 0.01 level, *** Significant at the 0.001 level; ST*NR represents Simmelian ties * Network routine.

In addition, to further test whether the mode of action of the moderating effect was consistent with the hypotheses, Figures. 4-5 were created and show one standard deviation below the mean and one standard deviation above the mean, respectively. As shown Figure 4. the positive relationship between Simmelian ties and knowledge capturing was stronger when the network routine was higher, and the result was consistent with H9. In the same situation, which is shown in Figure 5., the indirect effects of Simmelian ties on enterprise innovation performance were moderated by the network routine such that the direct effect was strengthened as the network routine increases. H10 was supported.

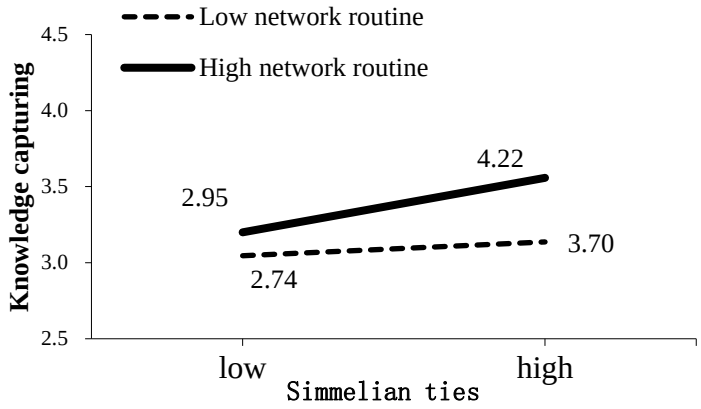

Figure. 4. Interaction effect: Simmelian ties and knowledge capturing.

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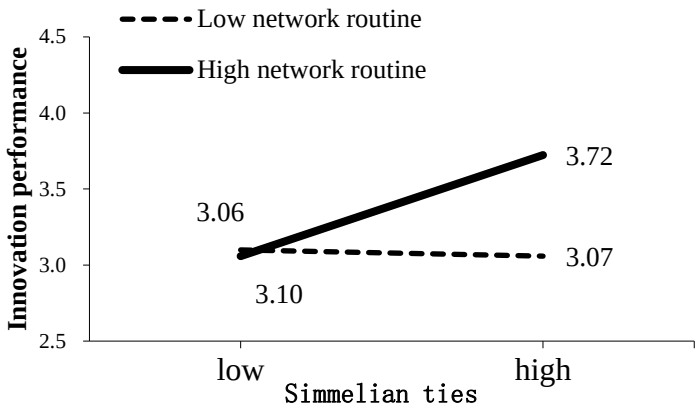

Figure. 5. Interaction effect: Simmelian ties and innovation performance

5. Conclusion.

5.1 Discussion

Based on the theory of alliance network and technological innovation, the research framework of the impact of Simmelian tie on enterprise innovation performance is constructed by taking high-tech enterprises as the research object in this paper. Based on that, the "black box" of the mechanisms of action between Simmelian ties and enterprise innovation performance is analyzed from the perspective of knowledge management. Specifically, this paper explores the mediating role of corporate knowledge capturing and knowledge integration in the relationship between Simmelian ties and enterprise innovation performance and additionally analyzes the moderating effect of network routines in the research model. The main research conclusions are as follows:

(1) Simmelian ties are positively affecting enterprise innovation performance. Since Simmelian ties is that it is a tie embedded in a clique[53], it combines the advantages of binary connection and multidimensional alliance. This solid triangular relationship promotes the efficient sharing and cooperation of knowledge and technology between enterprises, guarantees the effective allocation and integrated utilization of internal and external resources in the innovation process of enterprises, and improves the enterprise's innovation ability and innovation performance in Simmelian ties. Additionally, the companies in Simmelian ties have a close network structure and a fixed cooperation paradigm, which can locate suitable external partners and consolidate this relationship through search and in-depth exploration. More importantly, Simmelian ties can discover the core knowledge and technology required for the development of a certain stage of the company and quickly gather the innovation resources, thereby improving the innovation performance of the enterprise.

(2) Knowledge capturing plays a mediating role in the impact of Simmelian ties on enterprise innovation performance. The alliance network is considered to be a key platform for enterprises to obtain external knowledge. And Simmelian ties are the most stable and durable cooperative relationship in the alliance network. This strong bridging tie builds the most efficient path for enterprises to absorb novel external knowledge and obtain technical resources, which will surely enhance the enterprise's knowledge capturing ability. At the same time, the companies in Simmelian ties efficiently obtain the core knowledge and key technologies of partners through knowledge capturing. As a result, Simmelian ties strengthen the enterprise's innovative knowledge base, lay a foundation for the implementation of innovative development, and ultimately help to improve enterprise innovation performance.

(3) Knowledge integration plays a mediating role in the relationship between Simmelian

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ties and enterprise innovation performance. The physical distance and cognitive distance between enterprises in Simmelian ties are the shortest, which reduces the loss of information distortion and omission in the process of knowledge dissemination and improves the utilization rate of knowledge integration. At the same time, knowledge integration not only increases the possibility of multiple knowledge recombination and promotes the renewal of the knowledge base, but also helps companies accurately evaluate and use new knowledge, ensure the scientific nature of innovation activities, and promote the improvement of enterprise innovation performance.

(4) Both knowledge capturing and knowledge integration play a chain-mediating role in the relationship between Simmelian ties and enterprise innovation performance. Knowledge capturing and knowledge integration are two key abilities in enterprise knowledge management and show the trend of interactive coupling. The higher a company's knowledge capture ability, the more it can find a wealth of innovative knowledge for the company, thereby improving the efficiency of knowledge integration. Furthermore, a high level of knowledge integration ability will have an impact on knowledge capture in the next stage. It can be seen that the relationship between knowledge capturing and knowledge integration is cyclical and mutually reinforcing. Therefore, the mediating chain formed by knowledge capturing and knowledge integration plays a role between Simmelian ties and enterprise innovation performance. Moreover, this work to some extent supports the basic view that "the static resources of enterprises cannot bring sustainable competitive advantages, and it is necessary to reconfigure the acquired resources to promote innovation through dynamic capacity reconstruction"[54]. And it provides a new understanding of the mechanism of alliance network influencing enterprise innovation performance.

(5) Network routines play a positive moderating role in the research model and point out the importance of behavioral tacit understanding and normative consensus building. In the process of enterprise innovation, cross-border access to heterogeneous resources faces greater obstacles, so it is necessary to establish corresponding norms to improve the degree of cooperation between network members and promote the transfer of core knowledge. As an informal mechanism for maintaining effective communication and interaction between enterprises, network routines have a positive impact on the transfer of knowledge between enterprises in a stable cooperative relationship. Furthermore, as an effective transmission mechanism, network routines can transmit the impact of core knowledge and technology to the process of corporate innovation, and ultimately achieve the improvement of enterprise innovation performance. Therefore, network routines powerfully reveal the non-linear transformation pathway from enterprises' core knowledge to innovation performance in Simmelian ties, which highlights the important role of network routines in opening this black box.

5.2 Theoretical contributions

The theoretical contributions of this paper are: (1) Enriching the research on the relationship between alliance networks and enterprise innovation performance. Previous studies have mainly analyzed the impact of organizational binary relations and multidimensional alliances on enterprise innovation performance. However, with the development of alliance network theory, the drawbacks of binary connections and multi-dimensional alliances began to appear, and this article introduces Simmelian ties for research. Simmelian ties is a unique form of tripartite connection in the alliance network, with three notable characteristics: "inhibiting individual self-interested behavior", "weakening individual bargaining power" and "mediating and easing conflicts". Hence, exploring corporate innovation from the perspective of Simmelian ties will help enrich the form of alliance networks. (2) Extending the relevant research of enterprise knowledge management.

Knowledge capturing and knowledge integration, as two key links in the field of enterprise knowledge management, have never been included in a research system for analysis. This paper confirms that both knowledge capturing and knowledge integration promote and influence each other in the process of enterprise innovation, and then play a bridge role in the improvement of enterprise innovation performance. (3) Introducing the network routines into the research framework, which validates the moderating role of network routines in the relationship model and confirms that network routines (behavioral tacit agreement and normative consensus) are the key force to maintain the stability and efficient operation of the alliance network.

5.3 Practical significance

There are some management enlightenments of this article. Firstly, in order to enhance the overall competitiveness, companies should regard the openness and interaction of the external environment as an important resource endowment for sustainable development and make good use of the Simmelian ties in the innovation alliance to achieve strategic technological catch-up. Moreover, a stable triangular relationship can restrain individual self-interested behaviors, mediate and ease contradictions and reduce the risk of alliance termination, thereby achieving the ultimate goal of improving corporate innovation performance. Secondly, in the process of innovation and development, enterprises should attach great importance to the cyclical and mutual promotion of knowledge capturing and knowledge integration. Companies in Simmelian ties need to systematically review their own knowledge application process, and guide and train employees to capture, absorb and integrate knowledge. Finally, network routines are the key operating mechanism for maintaining the existence of network organizations. When companies identify innovative knowledge across borders, they need to actively improve network routines to capture high-value knowledge and promote enterprise innovation performance.

5.4 Research limitations and prospects

This study took the Chinese high-tech companies as a research sample and investigated the relationship between Simmelian ties and the enterprise innovation performance, it is important to note that care should be taken in transferring our findings to other sectors and regions or countries. Future research should therefore verify whether our findings also hold in other, more developed countries and regions.

Author Contributions: F.L. and Z. R. conceived and designed the experiments; F. L. designed the infrastructure of the research; F. L. and Z. R. analyzed the data and evaluated the results; F. L. and Z. R. wrote the paper; Z. R. checked the language of the manuscript for submission.

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Conflicts of Interest: The authors declare no conflict of interest.

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