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Can Inter-organizational Knowledge-Sharing Improve Enterprise Innovation Performance? The Mediator Effect of Innovation Capability and the Moderator Effect of Network Characteristics

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This study investigates the relationship between inter-organizational knowledge-sharing and innovation performance based on the resource-based theory and network embedded theory. It aims to examine the mediating effect of network characteristics in the relationship between inter-organizational knowledge-sharing and innovation performance. Through quantitative study, data is collected from 275 firms and analyzed through regression analysis. The results reveal that inter-organizational knowledge-sharing has a positive effect on enterprise innovation capability. Innovation capability has a positive effect on enterprise innovation performance. The link between inter-organizational knowledge-sharing and innovation performance is mediated by enterprise innovation capability. Evidence in support of full mediation is found. Connection strength and network scale play a positive moderator role in the relationship between inter-organizational knowledge-sharing and innovation capability. The findings provide a theoretical basis for inter-organizational knowledge-sharing and help enterprises establish innovative advantages. These also guide the inter-organizational knowledge-sharing among members in practice.

Keywords: inter-organizational knowledge-sharing, innovation ability, innovation performance, network scale, connection strength

INTRODUCTION

As the main force in China's technological innovation, high-tech enterprises play an important role in its development (Yang et al., 2012). Although the Chinese government has issued policies to encourage high-tech enterprises to improve their level of innovation, low-level innovation performance is still the main problem hindering the development and survival of many high-tech enterprises. Against the background of implementing an innovation-driven strategy in China, how to share knowledge with external organizations through knowledge-sharing networks, to enhance the knowledge stock of enterprises and improve innovation performance, has attracted the attention of enterprise managers and researchers.

Knowledge as a valuable asset of organizations is increasingly incorporated into thinking about strategy (Venkitachalam and Willmott, 2015). Knowledge-sharing within inter-organizational environments is crucial for connecting people, promoting problem-solving approaches, improving innovation and creating new business opportunities (Grant, 1996a; Tang et al., 2008; Yam et al., 2011; Aljuwaiber, 2016; Andrade et al., 2018). Van Wijk et al. (2008) described inter-organizational knowledge-sharing as the activities through which organizational players-teams, units or organizations-share, use and are inspired by others' backgrounds and knowledge. Carlsson (2003) discussed knowledge from external networks helped to develop new products. Quintane et al. (2011) argued that a knowledge-based, outcome-oriented definition of innovation provides a common theoretical ground for such operationalization and facilitates comparisons across the wide range of existing knowledge-based measures of innovation. Kaminska and Borzillo (2016) suggested that sustained innovation was enhanced by effective knowledge flows within and between the different organizational communities. Qi Dong et al. (2017) showed that collaborating with more partners who were more central in alliance networks was better for breakthrough innovation. Vătămănescu et al. (2020) discussed that knowledge sharing among organizations was an effective way for small and medium enterprises (SMEs) to cope with fierce competition and improve their innovation performance.

Participating cooperatively to establish a knowledge-sharing network becomes a firm's important vehicle for improving innovation performance (Hamel, 1991; Khanna et al., 1998; Gassmann et al., 2010; Franco and Haase, 2015; Yildirim, 2017; Gomezel and Rangus, 2018), but recurring to external knowledge within companies is usually complicated. Indeed, inter-organizational knowledge-sharing processes encompass the involvement of at least two dimensions. The first is the organizational level, according to which externally acquired knowledge needs to be absorbed within the company's boundaries (Lotti Oliva, 2014; Venkitachalam and Bosua, 2014). The second is the inter-organizational level, knowledge is shared with external partners and the knowledge-sharing between different organizations can result in complex processes because of the diversity of the parties involved that may be characterized by different characteristics of innovation network (Yao et al., 2020). At the organizational level, knowledge itself needs to be converted and adapted to permeate organizational boundaries (Marra et al., 2017). Zahara and George (2002) pointed out that knowledge-sharing for the pure purpose of knowledge acquisition had no direct impact on enterprise innovation performance. The shared knowledge could only affect innovation results after enterprises applied it effectively. External knowledge must go through internalization and integration to form incremental knowledge, thus improving enterprise innovation performance. Inter-organizational knowledge-sharing only covers the spread of knowledge (Pavlovich and Corner, 2006). Enterprises need to transform the shared knowledge to form their capabilities to serve the actions undertaken within the organization (Prabhakar and Savinkina, 2018). At the inter-organizational level, Yao et al. (2020) reported that it was not

entirely possible to transfer knowledge only through technology, inter-organizational interaction was necessary too. Veenswijk et al. (2010) revealed that more openness to external knowledge was not always better. Estrada et al. (2016), and Usoro et al. (2007) showed that competitor collaboration had a significantly positive impact on product innovation performance only when trust and formal knowledge-protection mechanisms are present.

However, at least two key issues appear in this literature. First, while a proliferation of studies investigated the relationships between inter-organizational knowledge-sharing and innovation performance, they lacked consensus on the core mechanisms this relationship involved (Sanchez et al., 2010). Second, empirical research investigating innovation performance has yielded mixed results (De Zubielqui et al., 2015). Yet, to date, no systematic review brings together and synthesizes the evidence-base relating to inter-organizational knowledge-sharing and innovation performance in high-tech enterprises. This paper aims to fill these gaps by systematically and critically reviewing the literature on the relationship between inter-organizational knowledge-sharing and innovation performance, setting our main inquiry: How does inter-organizational knowledge-sharing affect innovation performance? Does it influence innovation performance through other variables? Are there any variables that significantly moderate these relationships?

This paper is structured as follows. The next section is the literature review. Then, the paper proposes the study hypotheses. Next, it introduces the research method. Fourth, the study shows the empirical results. Thereafter, it discusses the research findings, including theoretical and practical implications. Finally, the conclusion appears, with a statement of the study's limitations.

LITERATURE REVIEW

Resource-Based Theory

The relationship between the effective resources that enterprises own or control and their competitive advantages is the core issue of resource-based theory investigations, namely, researching how enterprises transform advantageous resources into sustainable competitive advantages (Grant, 1991; Teece and Pisano, 1994; Maritan and Peteraf, 2011). The firm's current resources are defined as those assets which are tied semi-permanently to a firm like brand names, knowledge of technology, employment of skilled personnel, trade contacts, machinery, efficient procedures, capital, etc. Different types of resources including tangible assets, intangible assets and skills have been identified as underlying the distinctive or core competencies of a firm (Prahalad and Hamel, 1990). Enterprises merely possess scarce resources that are difficult to replace and imitating in the market is still not adequate. If enterprises want to maintain their competitive advantages, the ability to integrate and utilize resources is indispensable (Sirmon et al., 2007; Furrer et al., 2008; Wang et al., 2018). Paswan et al. (2014) proposed the concept that advancing knowledge dissemination and sharing could boost the constant improvement of value co-creation capabilities within social networks. Mokhtarzadeh et al. (2020) further noted that the application of inter-organizational knowledge-flow mechanisms

to carry out learning activities could promote technology-sharing and capability-transformation that reinforced enterprise resource coordination capability and advanced noticeable improvement in enterprise innovation performance. Knowledge transfer and acquisition have become an important approach for enterprises in constructing heterogeneous resources (Venkitachalam and Ambrosini, 2017; Lovallo et al., 2020). Due to the uniqueness of knowledge and the difficulty of replication, the company has greater advantages than its competitors. The heterogeneity of knowledge leads to varying enterprise innovation ability and diverse innovation results. Thus, based on resource-based theory, this paper takes inter-organizational knowledge as the source of constructing heterogeneous resources and studies how enterprises transform knowledge resources into a sustainable competitive advantage.

The resource-based theory further explains the relationship between resources and capabilities, holding that resources are the foundation of the innovation capability that, in turn, enables innovation performance. According to enterprise resource theory, an enterprise's ability comes from its unique resources that other enterprises lack (Teece et al., 1997). The development of unique heterogeneous resources enables enterprise innovation capability or leads to the enterprise improving its innovation performance (Barney, 1996; Andrea, 2008; Venkitachalam and Willmott, 2017). Firms can reinforce their technological innovation capability by importing technologies, then diffusing, assimilating, communicating and absorbing them into organizations (Hamel and Prahalad, 1990). Teece et al. (2015) also ascertained that the ability of a firm to acquire, utilize and develop valuable resources and capabilities was largely related to its acquisition of external knowledge and its integration of such knowledge. The knowledge that is unique and difficult to replicate gives companies an edge over their competitors. The heterogeneity of knowledge leads to differences in enterprise innovation capability and different innovation results. Enterprises integrate external knowledge resources through organizational knowledge-sharing, to develop innovation capability (Ferriani et al., 2013; Healey et al., 2021). Organizational knowledge-sharing constitutes an important source of accumulating enterprise competence and plays a significant role in shaping enterprise innovation capability (Barney, 1996). Thus, this study introduces the concept of innovation capability to verify the effect of inter-organizational knowledge-sharing on innovation performance. It proposes that organizational knowledge-sharing affects enterprise innovation capability, in turn affecting enterprise innovation performance. Together, they form the logical sequence of 'knowledge-sharing ability developing performance improvement'. This study further discusses inter-organizational knowledge-sharing and the effect of innovation capability on innovation performance.

Network Embedded Theory

Network embedded theory opens up new horizons for the study of inter-organizational knowledge-sharing. It posits that all enterprises exist in a complex economic and social-relation network whose characteristics would significantly affect the efficiency of innovation activities (Partanen

et al., 2014). Therefore, to obtain valuable knowledge from the network relationship, enterprises must focus on the network characteristics to more effectively recognize and judge external knowledge resources (Ritter and Gemunden, 2003). Embeddedness refers to how relationships between actors and whole networks will affect that economic activity and its consequences (Granovetter, 1985). The characteristics of enterprises embedded in the network could hold back the acquisition and utilization of resources and affect the behavior of enterprises afterward, which will differentiate enterprise performance and competitive advantages. The earliest classification of network embeddedness is to divide it into relationship embeddedness and structure embeddedness (Granovetter, 1985). The former focuses on relationship characteristics (Rowley et al., 2000), such as trust, the latter focuses on the characteristics of relationship structure, such as centrality, network density and network scope. Network researchers believe that both relationship embedding and structural embedding will affect enterprises' behaviors and performances (Rowley et al., 2000). Nevertheless, to conduct research, most studies focused on either relational embedding or structural embedding. For instance, Andersson et al. (2002) measured network embedding from relational embedding. Granovetter (1985), Burt (1992) and Gulati (1998) focused on the structural dimension of network embedding. Baum and Dutton (1996), Gulati (1998) and Hagedoorn (2006) encouraged to consider structural embedding and relational embedding jointly. According to contingency theory, external environmental characteristics and internal organizational characteristics can be important situational variables to use in explaining different types of organizational innovation performance (Donaldson, 2001). Inter-organizational knowledge-sharing has complex network characteristics with multiple subjects and objectives. Purely emphasizing either the structuralism that focuses on the shared structure or the connectionism that only pays attention to the relationship cannot completely reflect the overall characteristics of the network. Therefore, researchers must comprehensively investigate the characteristics of an inter-organizational knowledge-sharing network. We should consider the overall structure of the network and examine the cooperation and communication relationship of multiple subjects. In this light, this research studies the effect of inter-organizational knowledge-sharing on innovation performance, from the angles of structural embeddedness and relational embeddedness.

Measurement of relationship embeddedness mainly occurs in terms of the content, direction and degree of relationship reciprocity. Burt (2000) divided relationship embedding into strong relationships and weak relationships, according to the strength of the embedding. Strong relationships and weak relationships are important variables by which to measure relationship characteristics (Capaldo, 2007; Kowlaser and Barnard, 2016). Based on the research results of scholars such as Burt (2000), this study used relationship strength to express the degree of relationship embedding. Network scale is an important index for measuring the characteristics of enterprise network structure, representing the total number

of connections between network members. Powell et al. (1996), Andersson et al. (2002), and Kim (2014) used network scale to express the degree of structural embeddedness. This research borrows the research results of those scholars and used a network scale to express the degree of structural embeddedness. As a key indicator of network relationship characteristics, connection strength plays an important role in the measurement of communication and cooperation in inter-organizational knowledge-sharing. Connection strength directly influences the effect and quality of the innovation subject's access to knowledge, technology and resources (Alkhuraiji et al., 2016). The higher the connection strength is, the easier it is to develop cooperation viscosity between knowledge-sharing subjects. This is also more conducive to forming information-sharing habits and patterns among innovation subjects. Network scale reflects various organizational relationships as well as the amount or number of resources embedded in the enterprise's knowledge-sharing network (Semrau and Werner, 2014). The larger the network scale is, the more complex the enterprise's external network relationship is. Furthermore, the more abundant the resources embedded in the network relationship, the greater the chance of getting knowledge resources from outside. This study introduces the two variables of connection strength and network scale and discusses the different influences of inter-organizational knowledge-sharing on innovation capability under the influence of these variables.

Research Model

Given the above analysis, based on the dual perspective of structuralism and connectionism, this paper integrates the related research results of resource-based theory and embeddedness theory. This paper studies the relationship between inter-organizational knowledge-sharing and innovation performance, exploring the different effects of this process on innovation performance under the influence of network structural characteristics (which mainly manifest as network scale and connection strength). Taking the high-tech manufacturing enterprises in Shandong province as the research object, this study tries to answer the following questions: What is the impact of inter-organizational knowledge-sharing on innovation performance? How do network characteristics moderate the relationship between inter-organizational knowledge-sharing and innovation performance? What is the role of innovation capability in the relationship between inter-organizational knowledge-sharing and innovation performance? **Figure 1** shows the research framework.

HYPOTHESIS

Effects of Inter-organizational Knowledge-Sharing on Innovation Capability

Not only factors internal to firms but also an interactive process involving relationships between firms and different actors in the firm innovation system determines innovation (Kumaraswamy and Chitale, 2012). Enterprises cannot innovate

only by relying on their resources and capabilities. They tend to complement their ability to create knowledge "in-house" by utilizing knowledge from external sources of innovation (Sheng et al., 2015). External knowledge sources are crucial assets for firms in terms of helping to complement their internal knowledge base (Liao and Marsillac, 2015). Knowledge-sharing can occur in different layers and take place both within formal inter-organizational relationships and through informal interactions and channels. The shared content not only includes explicit knowledge, such as technology and management (Sanchez et al., 2010; Gupta and Polonsky, 2014), but also the implicit knowledge existing in the bilateral relationship and cooperation (Tamer Cavusgil et al., 2003; Dekker and Van den Abbeele, 2010; Cerchione et al., 2015). The influence of inter-organizational knowledge-sharing on innovation capability manifests in two aspects. First, innovation capability originates from enterprise resources, and the essence of the formation process of innovation capability is the process of enterprise resource combination (Grant, 1996b). As for new knowledge that enterprise technology innovation requires, 30% of it must come from outside. An enterprise gets and learns valuable knowledge and skills through the external network, expands the enterprise's knowledge base, gradually forms valuable knowledge assets, expands the use of knowledge value and produces the effects of knowledge, to speed up enterprise innovation. Next, inter-organizational knowledge-sharing can reduce obstacles in the process of building an enterprise's innovation capability (Chang and Shih, 2005; Al-Busaidi and Olfman, 2017). In the process of improving an enterprise's innovation capability, the biggest obstacle is the lack of knowledge and experience. An enterprise gets valuable knowledge and skills through its external learning network, expands the enterprise knowledge base and increases its stock of knowledge. This overcomes such obstacles as knowledge accumulation deficiency and lack of experience in the process of improving enterprise innovation capability. In short, inter-organizational knowledge-sharing constitutes the source of enterprise innovation capability that enables an enterprise to break through its resource bottlenecks, to find and solve innovation problems. Therefore, this paper proposes the following hypothesis.

H1: Inter-organizational knowledge-sharing has a positive effect on enterprise innovation capability. The stronger inter-organizational knowledge-sharing is, the higher the level of enterprise innovation is.

Effects of Innovation Capability on Innovation Performance

According to Lawson and Samson (2001), innovation capability connotes the ability to mold and manage several capabilities. Arguably, firms with innovation capability can integrate important capabilities and resources to successfully foster innovation. Enterprises with innovative abilities can better integrate, develop and transform resources, to provide customers with valuable products and services (Dasai et al., 2016). On one hand, the enterprise's innovation capability is an important factor in achieving differences in enterprise innovation performance.

FIGURE 1 | Theoretical model.
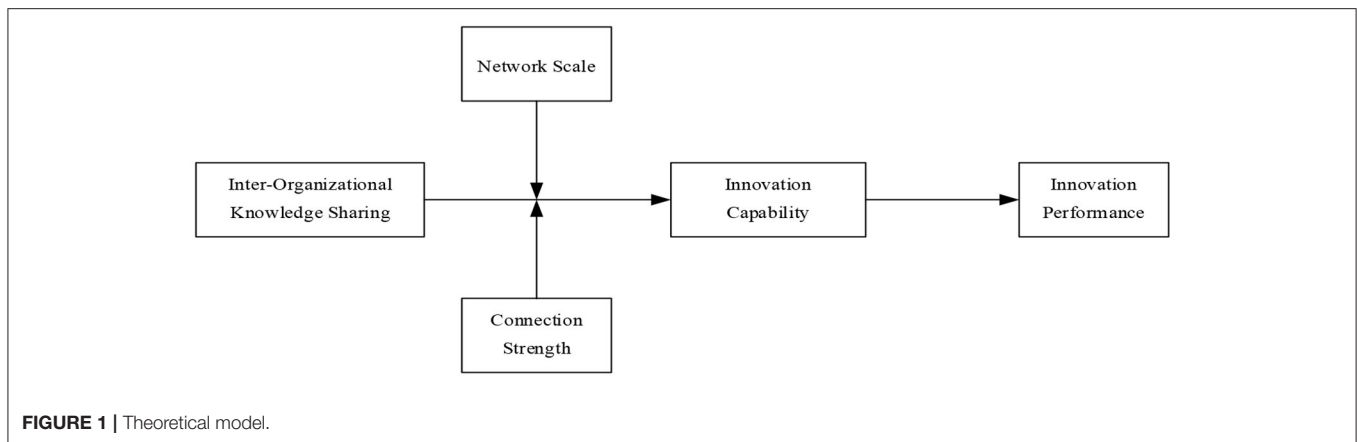
It has a direct impact on the enterprise's innovation activities, exploration and development opportunities, as well as the realization of products and production process innovation (Van Hemert, 2012). Due to the complexity of innovation capability and the fuzziness of causality, competitors find this system difficult to duplicate, forming the enterprise's innovation advantage and improving its innovation performance. The stronger the enterprise's innovation capability, the more easily it can obtain the information on resources and consumer market demand in the relationship network, very important for the enterprise to transform the innovation concept and ability into innovation performance. On the other hand, the innovation capability of enterprises can match the knowledge that organizations acquire from the market situation. In other words, enterprises can transform and store acquired knowledge by developing and utilizing other organizations' internal knowledge. That can become the enterprise's innovation resource for adapting to changing market demand and improving innovation performance. The higher the level of the enterprise's innovation capability, the more inclined it is to break the original resource combination or product production process and carry out resource reconstruction, organizational change, transformation and upgrading, to use less investment to obtain higher innovation performance (Wang et al., 2020). Enterprises improve their innovation capability to improve enterprise product productivity by abandoning old development ideas, redesigning the original industrial chain, product line and production process and upgrading the product. Therefore, this paper proposes the following hypothesis.

H2: Innovation capability has a positive impact on enterprise innovation performance.

Mediator Effect of Innovation Capability

According to resource-based theory, the unique capabilities of an enterprise are the core elements of its high performance, and the resources it owns are the key to the formation of its unique capabilities (Barney, 1996). As a participant in the open innovation ecosystem, an enterprise puts out knowledge to the network to meet the external demand of other members for heterogeneous knowledge resources. At the same

time, an enterprise can obtain the knowledge resources that its innovation development requires through other members. Some scholars have pointed out that both internal R&D investment and external knowledge searches can significantly impact innovation performance (Cai and Zhou, 2014), but if an enterprise lacks innovation ability and cannot transform externally absorbed knowledge into products that the market accepts and needs, it will still fail to achieve ideal innovation performance. Against the background of rapid environmental change, the rigidity of organizational innovation capability becomes increasingly prominent. Therefore, enterprises must further build innovative capabilities responsive to the complex external environment. Enterprises can meet organizational innovation expectations to improve resource productivity by reallocating and combining internal and external resources (Lee and Yoo, 2019). Companies with good innovation ability can develop new products faster than their competitors. Therefore, improving innovation ability is the key to improving enterprise innovation performance for enterprises (Chen et al., 2018). In summary, knowledge acquired from external networks cannot directly produce performance. Companies only through the transformation of innovation capacity can ultimately improve enterprise innovation performance. Accordingly, we propose the following hypothesis:

H3: Inter-organizational knowledge-sharing through innovation capability has a significant impact on innovation performance.

Moderator Effect of Connection Strength

Granovetter (1973) defined connection strength as a combination of time, emotional engagement, degree of intimacy (mutual trust), and reciprocal services in some connection. Connection strength directly affects the depth and breadth of information and technology transfer between organizations (Lavie and Miller, 2008). This manifests as the trust among subjects (consistently shared attitudes, claims and beliefs) as well as the coordination mechanism (sharing the cost and risk of information transmission). According to network embedded theory, relationship and relationship structure can generate trust and prevent fraud. Trust usually represents an important

condition for the acquisition of relationship ability among enterprises (Ahuja, 2000). Both parties in the relationship strive to obtain value and control possible risks which require a certain degree of trust, commitment and flexibility in the relationship. When both sides of the transaction have high levels of trust, the enterprise considers not only its short-term interests. Trading partners who build trust with each other want to make additional efforts beyond the contract (McEvily and Marcus, 2005). Saxton (1997) defined the partner relationship as a strong connection and the relationship with known companies as a weak connection. The strong relationship between enterprises is conducive to promoting the willingness to engage in mutual knowledge transmission, promoting the timeliness of hidden information transmission and reducing search costs (Dayasindhu, 2002). Generally, knowledge-sharing is greater when parties have a close relationship (Porter Panteli and Sockalingam, 2005; Hartley and Benington, 2006; Shazi et al., 2015). In the process of inter-organizational knowledge-sharing, the higher the trust is, the greater the amount of knowledge shared with (Faems et al., 2010). With greater trust, knowledge creation and the transfer would be smoother, so more implicit knowledge would be shared and more conducive development of innovation capability would be realized. On the other hand, the higher degree of coordination between organization subjects leads to a wider knowledge-sharing scale and increases the diversity of information that enterprises can use and transfer (Grewal et al., 2006). It is also helpful for enterprises in obtaining and making use of rare information, integrating information and developing external knowledge to improve the enterprise's innovation capability. A stronger relationship orientation between organizations makes the relationships between partners more intimate and elevates the degree of knowledge-sharing (Cheung et al., 2011; Bevan et al., 2012; Omar et al., 2012; Kim and Shim, 2018; Gao et al., 2019). Inter-organizational cooperation brings more differentiated knowledge, increases the diversity of views, and helps the team explore more innovative solutions (De Wulf et al., 2003; Park et al., 2007; Gnyawali and Park, 2010; Tomlinson, 2011; Kumaraswamy and Chitale, 2012; Vuori et al., 2019). Therefore, this study proposes the following hypothesis.

H4: Connection strength plays a positive moderator role between inter-organizational knowledge-sharing and innovation capability. The higher the connection strength is, the stronger the effect of knowledge-sharing on an enterprise's innovation capability is.

Moderator Effect of Network Scale

Network scale refers to the number of partners related to key enterprises in a knowledge-sharing network (Schilling and Phelps, 2007). In short, network scale means the extent to which organizational relationships and resources are embedded in the enterprise's external network. The larger the network scale is, the more external network relations there are and the richer the resources in them (Swierczek, 2019). The innovation performance of enterprises depends on the abundance of external resources (Woschke et al., 2017). Due to the limitation of enterprise resources, external knowledge has become a potential

resource in the process of enterprise innovation. The knowledge resources obtained from outside provide information and direction for enterprise innovation. The large scale of the network means that the wider the source of knowledge resources is and the greater accuracy is (Yan and Guan, 2018). Specifically, the larger the scale of the network is, the more external relationships there are to which the network members can link, and the more heterogeneous knowledge enterprises can obtain (Xie et al., 2016). The larger the network scale, the more resources are embedded in the enterprise's external network relationship, and the easier it is to obtain all kinds of resources necessary for survival and development. Inter-organizational knowledge-sharing provides opportunities for mutual learning, exchange and cooperation, and stimulates the creation and innovation of enterprises (Isaac et al., 2019). The larger the network scale is, the easier it is to realize scale innovation and break the threshold limit on innovation activities. In the process of inter-organizational knowledge-sharing, an enterprise may maintain a large network scale to help ensure the diversification of information and knowledge. The result is to improve the enterprise's ability to recognize resources and solve problems (Powell et al., 1996) and to help in sharing more public knowledge platforms with collaborators, reducing opportunistic behaviors and the risks of cooperative parties (Ahuja, 2000). This has a positive effect on the knowledge-sharing between enterprises, further promoting the innovation capability of those enterprises who share. Therefore, this study proposes the following hypothesis.

H5: Network scale plays a positive moderator role between inter-organizational knowledge-sharing and innovation capability. The wider the network scale is, the stronger the effect of knowledge-sharing on an enterprise's innovation capability.

METHODS

This study collects data in the form of questionnaire surveys. It carries out statistical analysis for those collected questionnaires, such as reliability and validity, validation and multiple regression analysis. The research uses statistical analysis software SPSS for the measurement of variable reliability and verification of proposed assumptions and AMOS for confirmatory factor analysis and model fitting degree analysis.

Data Collection

High-tech enterprises produce tangible products. Compared with other types of enterprises, they have relatively high levels of innovation identification and a high degree of marketization. The external learning network plays an important role in their product innovation process, thus high-tech enterprises as research objects fit the theme of the study. High-tech enterprises in Shandong Province are developing rapidly, in that respect, they are representative of China (Source: China Statistical Yearbook 2020). There are 1,516 high-tech enterprises in Shandong Province (Source: Science and Technology Department of Shandong Province), and the number of manufacturers is 1,374 among them. Shandong Province has 16 administrative divisions. The eastern administrative division is close to South

District	Number	Ratio (%)	Sample size
Jinan	185	20	37
Liaocheng	67	20	13
Heze	67	20	13
Dezhou	62	20	12
Jining	59	20	11
Zaozhuang	89	20	17
Taian	43	20	8
Binzhou	86	20	17
Linyi	98	20	20
Zibo	63	20	13
Dongying	56	20	11
Weifang	94	20	19
Rizhao	76	20	15
Qingdao	116	20	23
Yantai	124	20	25
Weihai	89	20	18
Total	1,374	275	275

Korea and Japan. Unlike the central and western administrative divisions, the high-tech manufacturing industries concentrate in Shandong's eastern administrative division. To ensure that the sample covers all administrative regions of Shandong and exclude the possible impact of unbalanced regional development on the research results, we used stratified proportion sampling to sample 1,374 high-tech manufacturing industries. The sample was divided into 16 strata by province administrative division. According to the research of Park et al. (2007), each stratum is sampled to a 20% standard, to reduce the impact of data variability of each sampling stratum and ensure that the samples are sufficiently representative. The sampling results appear in **Table 1**. We distributed 275 questionnaires and recovered 215 questionnaires. The recovery rate is 78%. In this study, we eliminated respondents whose answer time was <150 s (online questionnaires), and whose answers to the questionnaire were incomplete, regular or distorted. There were 45 questionnaires with invalid results or poor quality. Therefore, the final number of effective questionnaires was 170. The effective questionnaire recovery rate was 61.8%.

The respondents had to have a deep understanding of the enterprise innovation strategy. Therefore, this study selected middle and senior managers and the heads of R&D departments as respondents. This study also limited respondents to those with at least 3 years of working experience in the current enterprise to eliminate errors, due to they would have a deeper understanding of the enterprise's situation (Liu et al., 2007).

Measurement of Variables

To ensure the reliability and validity of the study, the scale comes from the mature scale developed by previous scholars. This study uses the Likert five-point scale to measure these items.

We explain the measurement of inter-organizational knowledge-sharing as follows. According to knowledge-sharing sources, knowledge-sharing can be divided into inter-organizational knowledge-sharing and knowledge-sharing within the organization. Existing scales are mainly used to measure knowledge sharing within organizations, with few measurements from the perspective of knowledge-sharing among organizations. Because knowledge-sharing in this study refers to inter-organizational knowledge-sharing, it agrees with Lee (2001) on the definition of inter-organizational knowledge-sharing. This study uses Lee's research results to measure inter-organizational knowledge-sharing. The items include: The company is willing to share market information or customer demand with its partners; The partners are willing to share industry experience with the company; The partners are willing to share market information or customer demand with the company.

Measurement of Innovation Capability

Most scholars measured innovation capability from the perspective of output. Hurley et al. (2015) took the number of new ideas the organization adopted as an indicator of organizational innovation capability. Porter and Stern (2001) used the number of an organization's patents as an indicator to measure innovation capability. Zabala Iturriagagoitia et al. (2007) took the ratio of patents to new product sales as the innovation-capability indicator. To distinguish it from innovation performance measurement and avoid confusing concepts, this study defines innovation capability from the perspective of ability. Considering that the research object is the high-tech manufacturing enterprise, this study adopts the scale developed by Li and Peng (2008) and measures innovation capability with two aspects including thinking and action. The main items include how quickly the organization becomes receptive to the idea of innovation and how quickly the organization innovates.

Measurement of Innovation Performance

Innovation performance generally involves the evaluation of the efficiency and effect of enterprise innovation activities. Gemünden et al. (1996) proposed two dimensions of innovation performance which include product innovation and technological innovation. Measurement items of product innovation are market success rate, product improvement and new product development. Measurement items of technological innovation include the reduction in labor costs, productivity improvement, reduction in order delivery time and decrease in resource consumption. This measurement method has laid the foundation for innovation performance measurement, with which other scholars have since made improvements. Scholars measure innovation performance from the perspective of output in a single enterprise. The concept of 'dual comparison' makes the innovation performance measurement more operable. Therefore, this study adopts the research results of Stuart (2015) and uses six items to measure innovation performance which includes the following six items. (1) Compared to peers, we often take the lead in launching our new products/services in the

industry; (2) Compared with counterparts, our product/service innovation and improvement won good market response; (3) Our new product/service is highly technical; (4) Compared with our peers, we introduce more new production/service operation methods; (5) In the new product/service development, we have high input and output efficiency; (6) We have a first-class technology or service process.

Measurement of Connection Strength

Granovetter (1978) used the time spent on a connection and the degree of emotional engagement, intimacy and reciprocity to define the connection strength of an individual network. He regarded contact at least twice a week as a strong connection. Kraatz (1998) used the duration of a partnership to measure connection strength. Rowley et al. (2000) used connection strength as the category variable. Rindfleisch and Moorman (2001) set four items to measure connection strength by the Likert 7 scale. Stuart and Sorenson (2007) measured connection strength from the two dimensions which include resources and society. Based on the above research results and taking into account the features of the field investigation of the enterprises and the research purpose, this study adopts the research result of Kraatz (1998) to measure the strength of relationships. The items include the frequency of cooperation and exchange with main suppliers, the frequency of cooperation with key customers, and the frequency of cooperation with other enterprises.

Measurement of Network Scale

Jarillo (1988) used the total number of relationships between different resources in the enterprise network to represent the network scale. Zhao and Aram (1995) took Chinese enterprises as the research object and used the number of entrepreneurs' relationships to measure the network scale. Batjargal (2007) measured the network scale with the number of local units directly connected with individuals. Most scholars use the diversity of partners for measurement of the network scale, which helps them to reflect the heterogeneity of a network. Considering the accessibility of data, this study adopts the research results of Jarillo (1988) to measure the scale of the network, including the number of exchanges and cooperation with major suppliers, key customers and other enterprises.

To avoid the influence of irrelevant variables on correlations, this study used the enterprise nature, scale and age as control variables. The study divides enterprises into state-owned enterprises, private enterprises, Sino-foreign joint ventures, and wholly foreign-owned enterprises. The study also set up three virtual variables by taking state-owned enterprises as the reference objects. The enterprise size variable was based on the number of people in the enterprise, which was divided into below 20, 20–100, 101–300, 301–1,000, and more than 1,001. According to the rank order, the size variable was assigned a value between 1 and 5. The age of the enterprise was a continuous variable expressed in years. The development stage was divided into the introduction period, growth period, maturity period and decline period assigning each a value of 1–4, according to the enterprise's life cycle. The measurement of variables is shown in **Table 2**.

TABLE 2 | Measurement of variables.

Variable	Items
Inter-Organizational Knowledge Sharing (K)	K1: The company is willing to share market information or customer demand with its partners.
	K2: The partners are willing to share industry experience with the company.
	K3: The partners are willing to share market information or customer demand with the company.
Innovation Capability (N)	N1: How quickly does the organization receptive to the idea of innovation?
	N2: How quickly does the organization innovate?
Innovation Performance (S)	S1: Compared to peers, we often take the lead in launching our new products/services in the industry.
	S2: Compared with our counterparts, our product/service innovation and improvement won a good market response.
	S3: Our new product/service is highly technical.
	S4: Compared with our peers, we introduce more new production/service operation methods.
	S5: In the new product/service development, we have high input and output efficiency.
	S6: We have a first-class technology or service process.
Connection Strength (L)	L1: The frequency of cooperation and exchange with main suppliers.
	L2: The frequency of cooperation with key customers.
	L3: The frequency of cooperation with other enterprises.
Network Scale (W)	W1: The number of exchanges and cooperation with major suppliers.
	W2: The number of exchanges and cooperation with key customers.
	W3: The number of exchanges and cooperation with other enterprises.

Reliability Analysis

This study use Cronbach's α coefficient to test the internal consistency of the scale. Kline (2015) pointed out that a reliability estimation of Cronbach's α coefficient of above 0.7 was a high-reliability value. As **Table 3** shows, the internal consistency reliability coefficient of each questionnaire is above 0.7, which indicates that the reliability of each scale is within the acceptable range and has good internal consistency. The results show in **Table 3**.

Confirmatory Factor Analysis

This study used AMOS software to perform a confirmatory factor analysis for key variables. We adopted the model comparison method to check the combination validity and convergence validity of each scale.

TABLE 3 | Reliability analysis.

Research variables	Contained project	Cornbrash's α
Knowledge sharing	3	0.765
Connection strength	3	0.877
Network size	3	0.865
Innovation capability	2	0.868
Innovation performance	6	0.768

TABLE 4 | Factor analysis results.

Fitting index	Factor	X^2	X^2/df	GFI	AGFI	RMSEA	NFI	CFI
Standard Value		>0.5	<5	>0.9	>0.9	<0.1	>0.9	>0.9
Basic Model	K, N, S	389.273	2.163	0.992	0.824	0.092	0.863	0.899
Two Factors Model	K+N, S	561.832	3.956	0.809	0.746	0.103	0.742	0.827
One Factor Model	K+N+S	606.341	5.281	0.621	0.651	0.123	0.653	0.746

Using the criteria of Gatignon (2010), this paper performed a confirmatory factor analysis on this model. The results show that model validation indexes, such as the value of X^2/df, RMSEA, NFI, and CFI reach an acceptable level, which indicates that the model has good adaptability. This study also uses the nested model to further confirm the validity of the scale. According to the results shown in **Table 4**, the fit effect of the three-factor model is better than that of other nested models. Therefore, the latent variables have good discriminant validity.

CR (combination validity) value is an important criterion for determining the intrinsic quality of the model. It reflects whether the measurement term of the latent variable consistently explains that variable. **Table 5** shows that the combined validity CR is >0.7, which is above the standard 0.60, indicating that the scale used in this study has good internal consistency. The AVE value is the mean-variance extraction quantity, which is used to explain how much variation in the latent variable derives from measurement error, reflecting the convergence validity of each dimension of the scale. The larger the AVE value is, the larger the variation percentage of the measured variable in its interpretation of the latent variable is, and the smaller the measurement error is. AVE values of this study are >0.5, following the criteria that Fornell and Larcker (1981) recommended. These data show that the scale used in this study has a good combination of validity and convergence validity. The results show in **Table 5**.

Correlation Analysis

Correlation between two variables is the premise of a regression analysis. To further research the relationship between variables, this study adopts the Pearson correlation analysis method. A significant correlation exists between the variables. The dependent variable "innovation performance (s)" significantly correlates with the independent variable "inter-organizational knowledge-sharing (K)" at the level of 1%, which verifies the correlation between the two variables. To eliminate the multicollinearity problem that may affect the results, we test the VIF value and find the VIF value below the threshold (10) and the

TABLE 5 | Combination validity and convergent validity.

	Path		Λ	C.R.	AVE
K1	<–	K	0.854	0.617	0.826
K2	<–	K	0.946		
K3	<–	K	0.897		
L1	<–	L	0.806	0.650	0.780
L2	<–	L	0.946		
L3	<–	L	0.763		
W1	<–	W	0.696	0.918	0.798
W2	<–	W	0.697		
W3	<–	W	0.677		
N1	<–	N	0.853	0.708	0.792
N2	<–	N	0.894		
S1	<–	S	0.854	0.931	0.803
S2	<–	S	0.910		
S3	<–	S	0.761		
S4	<–	S	0.923		
S5	<–	S	0.879		
S6	<–	S	0.902		

K, L, W, N, and S, respectively, represent inter-organizational knowledge sharing, connection strength, network scale, innovation capability and innovation performance.

TABLE 6 | Correlation test.

Variables	Mean	S.D.	1	2	3	4	5
K	4.523	0.512	1				
N	4.435	0.520	0.350**	1			
S	3.964	0.489	0.303**	0.488**	1		
L	4.562	0.540	0.216*	0.274**	0.245**	1	
W	3.911	0.430	0.224*	0.242**	0.276*	0.184*	1

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.*

absolute values of correlation coefficients between variables are <0.5, showing no multicollinearity problem between variables. The results show in **Table 6**.

RESULTS

To ensure the accuracy and scientific status of the regression results, this study diagnoses collinearity and heteroscedasticity of the sample data. First, the critical values of correlation levels between the variables are all below 0.6, and the variance inflation factor is <2, so there is no significant collinearity problem in this study. Secondly, this study uses Eviews software to test the heteroscedasticity problem. The Obs*R^2 values are greater than the critical value of the chi-square distribution when a = 0.05. Therefore, no heteroscedasticity problem exists in the study data.

Main Effect Test

This study uses the hierarchical regression method to verify the effect of inter-organizational knowledge-sharing on innovation capability, as well as the effect of innovation capability

TABLE 7 | Main effect test.

Independent variables	Dependent variables			
	Innovation capability		Innovation performance	
	Model 1	Model 2	Model3	Model 4
Enterprise nature	0.110	0.073	0.113*	0.018
Enterprise scale	0.201*	0.149*	0.136*	0.084*
Development stage	0.135*	0.107*	0.115*	0.012
Date of establishment	0.104	0.074	0.122*	0.068
Inter-organizational knowledge-sharing		0.374*		
Innovation ability				0.523**
F	1.750	3.387*	1.002	5.124*
R^2	0.117	0.246	0.112	0.218
ΔR^2	0.117	0.129	0.112	0.106

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

TABLE 8 | Mediator effect test.

Variables	Dependent variables					
	X→ Y		X→ M		X + M→ Y	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Enterprise nature	0.115*	0.080	0.110*	0.073	0.119	0.097
Enterprise scale	0.169*	0.115*	0.201*	0.149*	0.182*	0.141*
Development stage	0.239*	0.211*	0.135*	0.107*	0.132*	0.848
Date of establishment	0.122*	0.108*	0.104	0.074	0.111*	0.334
Inter-organizational knowledge-sharing (X)		0.358**		0.374*		0.163
Innovation capability(M)						0.492**
F	1.802	3.249*	1.750	3.387*	1.016	5.819*
R^2	0.120	0.238	0.117	0.246	0.171	0.359
ΔR^2	0.120	0.118	0.117	0.129	0.171	0.239

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

on innovation performance. Model 1 included only control variables. In Model 2, the regression results show that the R^2 value has significantly increased to 0.246. The F value is 3.387 ($p < 0.05$), and the regression coefficient is 0.374 ($p < 0.05$), the results show that inter-organizational knowledge-sharing positively affects innovation capability. Model 3, with only control variables included, to check the effect on innovation performance. In Model 4, the F-value is 5.124, passing the F-test ($p = {<}0.01$). The regression coefficient is 0.523 (positive effect), passing the T-test ($p = 0.000 < 0.001$). Innovation capability has a significantly positive effect on innovation performance. H1 and H2 are verified. The results show in **Table 7**.

Mediator Effect Test

This study uses the three steps (Baron and Kenny, 1986) to test the mediator effect. First, test the effect of X on Y. Model 1 tests the effect of control variables on innovation performance. The variable of inter-organizational knowledge-sharing is added to Model 2 based on Model 1, which shows that inter-organizational knowledge-sharing ($b = 0.358$, $P < 0.01$) has a significantly positive effect on innovation performance. Second, test the effect of X on M. Model 3 test the effect of control variables on innovation capability. The variable of inter-organizational knowledge-sharing is added to Model 4 based on Model 3. Inter-organizational knowledge-sharing ($b = 0.374$, $P < 0.05$) has a significantly positive effect on innovation capability. Thirdly, test the effect of X and M on Y. Based on Model 5, the mediation variable is added to Model 6. Innovation capability ($b = 0.492$, $P < 0.01$) has a significantly positive effect on innovation performance, but inter-organizational knowledge-sharing ($b =$

0.163, $P > 0.05$) has no significant effect on innovation performance, and the explanation ability significantly decreased. Accordingly, innovation capability completely plays the mediator role in the relationship between inter-organizational knowledge-sharing and innovation performance, as **Table 8** shows. In this study, the Sobel test is used to further verify the mediator effect. $|Z| = 3.8621$, so the Z-value passes the significance test($P > |Z| = 0 < 0.05$). Thus, innovation capability plays the mediator role in the relationship between inter-organizational knowledge-sharing and innovation performance. H3 is verified, the results are shown in **Table 8**.

The Moderator Effect Test

This study uses the methods Zhonglin et al. (2005). proposed to test the moderator effect. Models 1–3 test the moderator effect of connection strength on the relationship between inter-organizational knowledge-sharing and innovation capability. Model 1 includes only four control variables. Based on Model 1, Model 2 introduces two main variables of inter-organizational knowledge-sharing and connection strength. These variables significantly improved the R^2 value of the regression equation to 0.468. Also, the F-test value is 17.071 ($p = 0.000 < 0.001$), significantly different from zero for the T-test. The regression coefficients value of inter-organizational knowledge-sharing and connection strength effect on innovation capability are 0.419 ($p = 0.000 < 0.001$) and 0.007 ($p = 0.364 > 0.05$), indicating that inter-organizational knowledge-sharing has a significant effect on innovation capability, but connection strength has no significant effect on innovation capability. Model 3 introduces

TABLE 9 | Moderator effect test of connection strength between inter-organizational knowledge-sharing and innovation capability.

Variables	Innovation capability		
	Model 1	Model 2	Model 3
Enterprise nature	0.131*	0.091	0.081
Enterprise scale	0.141*	0.120*	0.102*
Development stage	0.143*	0.105*	0.084*
Time of establishment	0.022	0.012	0.008
Inter-organizational knowledge-sharing		0.419***	0.242***
Connection strength		0.007	0.002
Inter-organizational knowledge-sharing*Connection strength			0.361**
F	1.136	17.071***	14.909***
R^2	0.047	0.468	0.782
ΔR^2	0.047	0.421	0.214

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

TABLE 10 | Moderator effect test of network scale between inter-organizational knowledge-sharing and innovation capability.

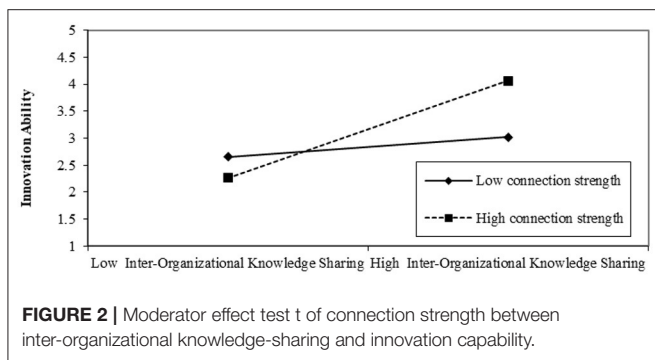| Variables	Innovation capability		
	Model 1	Model2	Model 3
Enterprise nature	0.110*	0.101*	0.078
Enterprise scale	0.103*	0.094*	0.034
Development stage	0.105*	0.095*	0.090*
Time of establishment	0.055	0.034	0.005
Inter-organizational knowledge-sharing		0.374**	0.264**
Network scale		0.026	0.020
Inter-organizational knowledge sharing*Network scale			0.401**
F	1.036	12.118***	10.679***
R^2	0.071	0.578	0.681
ΔR^2	0.071	0.507	0.103

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

FIGURE 2 | Moderator effect test t of connection strength between inter-organizational knowledge-sharing and innovation capability.
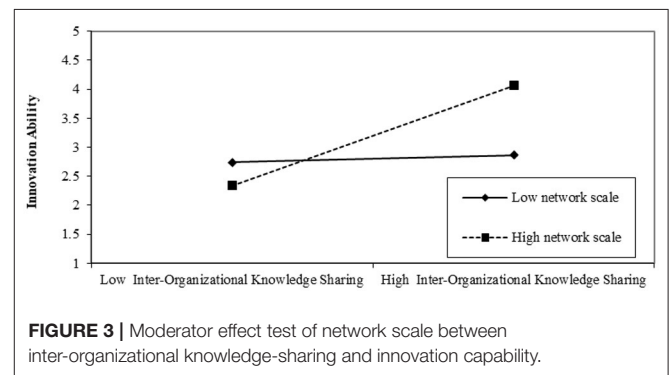

FIGURE 3 | Moderator effect test of network scale between inter-organizational knowledge-sharing and innovation capability.

the variable of interaction (decentralized processing) of inter-organizational knowledge-sharing and connection strength based on Model 2. The F test value is 14.909 ($p = 0.000 < 0.001$), the adjusted R^2 value is 0.214, and the regression coefficient value is 0.361, passing the T-test ($p = 0.027 < 0.05$), which indicates that connection strength has a moderator effect on the relationship between knowledge-sharing and innovation capability. Hypothesis 4 is confirmed. Results are shown in **Table 9** and **Figure 2**. Similarly, network scale has a significant moderator effect on the relationship between inter-organizational knowledge-sharing and innovation capability. Hypothesis 5 is confirmed. Results show in **Table 10** and **Figure 3**.

Theoretical model results show in **Figure 4**.

DISCUSSION

This study takes high-tech manufacturing enterprises as research objects. Through a nonparametric test, this paper verifies the effect of inter-organizational knowledge-sharing on innovation capability and innovation performance, under the moderator effect of network characteristics.

First, inter-organizational knowledge-sharing has a positive effect on organizational innovation capability. This result is consistent with Hartley and Benington (2006) and Ahmad and Daghfous (2010). For Chinese high-tech enterprises, this factor plays an important role in influencing the innovation capability of high-tech enterprises. Through innovation networks and strategic alliances that provide information and key

FIGURE 4 | Theoretical model with results. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
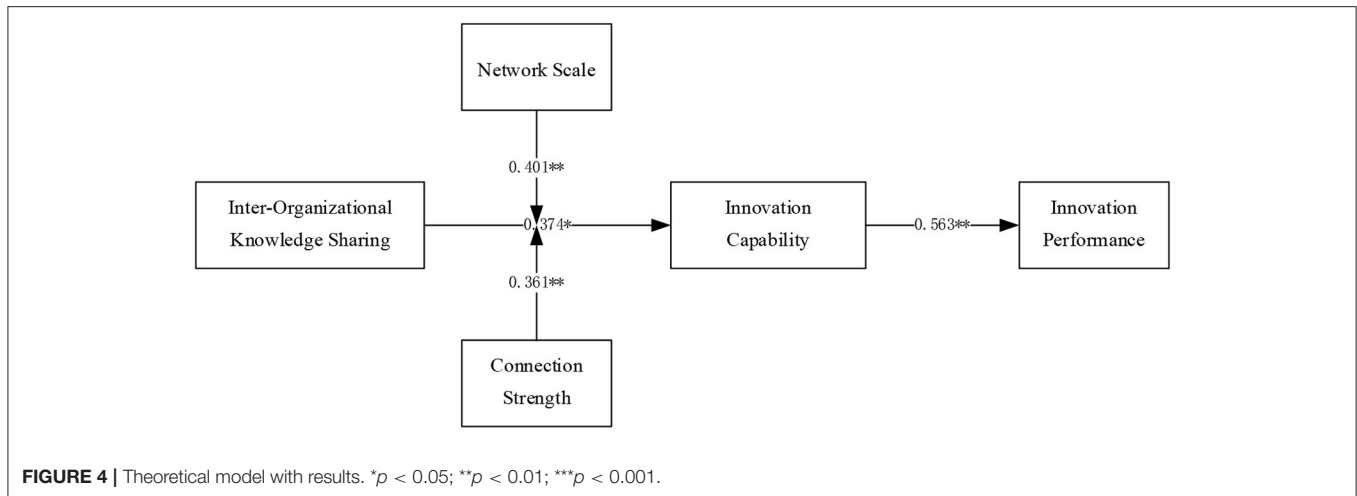
technical knowledge, Chinese high-tech enterprises learn, exchange and share knowledge with enterprises, universities and scientific research institutions, to improve organizational innovation capability.

Second, innovation capability has a positive impact on innovation performance. The empirical results verify this hypothesis, consistent with the previous research (e.g., Zhao et al., 2016). Innovation capability is a kind of dynamic ability for organizations to identify, acquire, learn and internalize valuable knowledge, to improve the quality of innovation (Enkel et al., 2010). Inter-organizational knowledge-sharing enriches the organization's knowledge base and improves the possibility of successful innovation. Innovation capability is the key reason an organization can use the knowledge innovation share among organizations to improve its innovation performance.

Third, innovation capability plays a mediator role in the interaction of knowledge-sharing and innovation performance. The empirical study results are different from common sense that some people believe (Gloet and Terziovski, 2004; Zeng et al., 2010). This study finds that inter-organizational knowledge-sharing does not directly promote innovation performance. However, innovation capability plays a mediator role in the interaction of knowledge-sharing and innovation performance. One of the reasons may be that scholars define innovation capability differently, scholars equating innovation capability with innovation performance (Lin et al., 2010; Zawislak et al., 2012). This swap between concepts brings flaws to the theory of innovation. According to the research results of Parashar and Singh (2005), this study from the perspective of ability defines innovation capability as knowledge absorption, transformation and network cooperation ability. It significantly distinguishes two concepts—innovation capability and innovation performance—while deeply exploring the relationship between inter-organizational knowledge-sharing and innovation capability. Another explanation for the empirical research result is that inter-organizational knowledge-sharing cannot be directly transformed into organizational innovation performance. It requires the process of organizational

internalization, in which innovation capability plays the role of internalizing external knowledge. This explanation is consistent with the research results of Zahara and George (2002).

Fourth, the connection strength has a positive moderating effect on the relationship between inter-organizational knowledge-sharing and innovation capability. This result is contrary to that of Uzzi (1997) and Gargiulo and Benassi (2000). The possible reason is that the strategic partners of Chinese high-tech enterprises are more clearly from heterogeneous markets, such as enterprises participating in the supply chain, universities and scientific research institutions. Inter-organizational knowledge-sharing between heterogeneous markets requires establishing close relationships. This result is consistent with Gao et al. (2019).

Fifth, network scale has a significant moderating effect on the relationship between inter-organizational knowledge-sharing and innovation capability. The empirical results show that the larger scale of the inter-organizational knowledge-sharing network is, the more positive the effect of inter-organizational knowledge-sharing on innovation capability. The possible explanation is that the larger the scale of the inter-organizational knowledge-sharing network is, and the more organization members participate in knowledge-sharing, the more organizations can obtain diversified knowledge and improve organizational innovation capability, the finding is consistent with Möller and Rajala (2007).

Theoretical Implications

With the development of the new research model, the theoretical contributions of this paper to the literature are as follows.

First, this study enriches the research on innovation. Although this is a core concept in the literature, a significant gap remains in understanding the effect of inter-organizational knowledge-sharing on innovation performance (Wagner and Buko, 2005; Im and Rai, 2008). This study attempts to bridge the gap by identifying inter-organizational knowledge-sharing behaviors and studying their impact on organizational innovation

performance. It links inter-organizational knowledge-sharing with innovation capability and suggests that inter-organizational knowledge-sharing must be transformed into innovation capability to improve organizational innovation performance, making a theoretical contribution to the discussion of organizational performance management in alliances or strategic cooperation networks.

Second, this study enriches the research on resource-based theory, to which we add the application and development of resource-based theory. The traditional resource-based theory contends that enterprises acquire and manage resources from a static perspective. It emphasizes the significance of the heterogeneous resources the enterprise owns for the construction of core competence and competitive advantage. This study explains the formation and evolution of enterprise core resources from a dynamic perspective, enriching the resource-based theory. This study proposes that the improvement of enterprise innovation performance requires enterprises to break through their network boundary and cooperate with external stakeholders, so they can enrich existing resources and build diversified resources. Enterprises benefit from integrating and utilizing external knowledge resources to improve their innovation ability and cope with the dynamic market environment.

Third, this study enriches the research on network embedded theory. This paper further discusses the relationship between inter-organizational knowledge-sharing and innovation performance under the moderation of knowledge network characteristics. In the dynamic environment, the higher the connection strength and the wider the network scale are needed to produce greater profits and positive cooperation quality (Gao et al., 2019). As previous scholars have suggested (De Wulf et al., 2001), the closer the relationship between knowledge-sharing partners is, the higher the degree of knowledge-sharing is. In addition, a large network scale promotes cooperation and supports the improvement of organizational innovation capability.

Managerial and Practical Implications

This study provides insights for managers and practices seeking to improve innovation performance.

First, managers increasingly welcome inter-organizational knowledge-sharing which helps the organization achieve enterprise innovation objectives (Im and Rai, 2008; Cheung et al., 2011). The most important management significance and practical enlightenment are that developing a positive and strong cooperative relationship is the key to strengthening knowledge-sharing among organizations. Therefore, in management practice, enterprises should make great efforts to build external network connections to advance knowledge-sharing between organizations, by establishing long-term cooperative guidance for further interaction. The establishment of strong network connections will increase tacit understanding between organizations, facilitate learning and imitation between

them, make enterprise disciplines interdependent, and realize the transfer of high-quality information and knowledge. Therefore, enterprises should maintain more external connections, to obtain diversified knowledge and information, expand the intellectual reserve of innovation and improve enterprise innovation performance. Besides, enterprises must view inter-organizational knowledge-sharing from the perspective of strategic development. They should not only focus on internal knowledge exchange and sharing activities but also focus on external knowledge-sharing, internalization, diffusion and accumulation, to provide the necessary intellectual reserve for the improvement of enterprise innovation performance.

Second, innovation capability helps enterprises to effectively deal with an external volatile environment (including customers' dynamic demands). Furthermore, innovation capability helps enterprises to obtain and integrate external resources and improve enterprise innovation performance. Therefore, enterprise managers must put a high value on the shaping of organizational innovation capability. Organizations might invest in promoting inter-unit exchanges and in creating meaningful social nets for more innovative products and better performance.

CONCLUSION AND LIMITATIONS

In this paper, we develop a new research model to understand the relationship between inter-organizational knowledge-sharing and innovation performance. We found that the effect of inter-organizational knowledge-sharing on innovation performance is realized through innovation capability. We also find that the characteristics of knowledge-sharing networks affect the relationship between inter-organizational knowledge-sharing and innovation capability. Organizations in close relationships are more conducive to the transfer of knowledge. The larger the network scale of knowledge-sharing is, the more multisource and heterogeneous knowledge organizations can obtain.

This study suffers from methodological limitations typical of most empirical surveys. The findings of the study cannot be generalized to all forms of organizations, as these findings reflect the setting of high-tech manufacturing enterprises in Shandong, China. From the perspective of the knowledge network, the research model only considers the moderator effect of connection strength and network scale on the relationship between inter-organizational knowledge-sharing and innovation capability. It does not consider the effect of industry background and cultural background. There is no further discussion about different types of knowledge-sharing in this model, such as the difference between implicit knowledge-sharing and explicit knowledge-sharing. In the future study, such issues could be brought into the model for the further exploration of the relationship between explicit and implicit knowledge-sharing, network characteristics, and innovation performance within different backgrounds. Besides, this study mainly uses cross-sectional data to verify

hypotheses. Time-series data can serve as a hypothesis test in the future.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

WD is responsible for writing the paper. ZY guides the paper. ZX is responsible for data collection and data analysis. JC is responsible for revising the language of the paper. LX and HC put forward many constructive suggestions for the paper. All authors contributed to the article and approved the submitted version.

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