

RESEARCH ARTICLE

The Influence of Organizational Social Network on Enterprise Collaborative Innovation—Mediating Role of Knowledge Sharing and Moderating Effect of Digital Construction

BIN MIAO, YINGJIE LIANG^{ID}, AND YUEYUE SUO

School of Management and Economics, North China University of Water Resources and Electric Power, Zhengzhou 450046, China

Corresponding author: Yingjie Liang (1483722870@qq.com)

This work was supported in part by the Philosophy and Social Science Planning Project of Henan Province under Grant 2019BJJ050, in part by the Key Scientific Research Projects of Universities in Henan Province under Grant 20A630023, in part by the Henan Science and Technology Research Project under Grant 202102310212, and in part by the Graduate Innovation Project of North China University of Water Resources and Electric Power under Grant YK-2021-122 and Grant YK-2021-123.

ABSTRACT This paper mainly discusses the influence of organizational social network on enterprise collaborative innovation, as well as the intermediary role of knowledge sharing and the regulatory role of digital construction. Based on social exchange theory and social cognition theory, an integration model of organizational social network influencing enterprise collaborative innovation is constructed. The hierarchical regression analysis was used to sample the high-tech enterprises in China's Yangtze River Delta. Statistical analysis of 212 questionnaires was performed using SPSS and AMOS. It is found that organizational social network has a significant positive impact on enterprise collaborative innovation. Knowledge sharing plays a partially mediating role in the relationship between the organizational social network and enterprise collaborative innovation. Digital construction positively moderates the relationship between organizational social network and enterprise collaborative innovation. In general, the research findings show that improving the construction of organizational social networks and enhancing employees' knowledge sharing behavior can improve enterprises' collaborative innovation ability. In addition, in the context of highly digital construction, the effect of organizational social networks on improving enterprise collaborative innovation is more obvious.

INDEX TERMS Organizational social network, enterprise collaborative innovation, knowledge sharing, digital construction.

I. INTRODUCTION

With the emergence of a new round of scientific and technological revolution and industrial reform, the market environment in which enterprises are located has changed greatly, the industry boundary is gradually blurred, the mode of market competition has changed from internal competition to cross-border competition, and cross-border robbery occurs

The associate editor coordinating the review of this manuscript and approving it for publication was Daniela Cristina Momete^{ID}.

almost every day [1]. The complex and changeable market environment puts forward higher requirements for the innovation ability of enterprises. However, no enterprise has all the technical resources and capabilities required for innovation [2], so it has to strengthen cooperation with other enterprises to improve its innovation capability by means of collaborative innovation. At present, researches on collaborative innovation have attracted extensive attention from scholars in the field of innovation. Collaborative innovation is a cross-border multi-agent collaborative innovation mode,

in which various cooperative entities achieve collaborative goals through resource sharing and risk sharing [3]. The development of science and technology provides new and convenient channels for enterprises to conduct cross-border exchanges [4], so that single fighting innovation can no longer meet the development needs of current enterprises. Only relying on cooperative and collaborative innovation of multiple enterprises can help enterprises comprehensively use market forces to improve their performance. Collaborative innovation can not only significantly reduce the risk of innovation failure and enable enterprises to achieve higher research and development goals, but also form advantages that are difficult for competitors to imitate in collaborative cooperation [5], [6]. In addition, the improvement of collaborative innovation ability helps to expand new functions of existing products. Therefore, how to effectively improve the collaborative innovation capability of enterprises is an urgent problem in both academic and practical circles.

China is a traditional "relationship-oriented" society, and organizational social networks play an important role in the operation of enterprises [7]. In recent years, with the progress of technology, many enterprises are actively building organizational social networks, trying to build new channels for organizations to acquire diverse resources, so as to reduce the restrictions of resource constraints on enterprise innovation activities. With the deepening of research, scholars began to explore the relationship between organizational social network and enterprise collaborative innovation. Shan et al. [8] pointed out that internal organizational social network can bring new knowledge and new ideas to enterprises, thus improving their innovation ability. Jiao et al. [9] constructed a conceptual model of social network and innovation performance based on the duality of organizational strategy, revealing how the social network of top team members affects the innovation performance of enterprises through organizational learning. In existing studies, most scholars carry out researches based on social network theory and resource-based theory [10], [11] and draw constructive conclusions. This paper holds that collaborative innovation, as a collective activity relying on multi domain interconnection and multi industry interaction, can better realize the exchange of knowledge and information resources of enterprise organizations under the organizational social network. Therefore, different research perspectives are selected based on the social exchange theory, to highlight the role of organizational social network in promoting the collaborative innovation ability of enterprises [12]. Social exchange theory points out that the implicit condition for actors to exchange is that each party has special resources that are difficult to obtain by others, and all actors can benefit from the exchange. Then, according to the social exchange theory, enterprises must obtain the resources lacking in innovation and development through social exchange when carrying out collaborative innovation. The stability and reliability of organizational social network provide favorable channels for enterprises to carry out social

exchange behaviors and guarantee the implementation of enterprise innovation activities. Therefore, based on the social exchange theory, this paper concludes that there is a logical relationship between organizational social network and firm collaborative innovation.

The impact of organizational social network on enterprise collaborative innovation is realized through resource exchange. Li et al. pointed out that knowledge sharing is the key to information exchange between organizations, because it can accelerate the knowledge flow within organizations, maximize the effectiveness of knowledge resources, and be a source of power to promote innovation. Social cognitive theory points out that individual behavior is affected by environment and cognition [13], so members within the same organizational social network are more likely to have knowledge sharing behaviors, because each other aims to improve collaborative innovation capability, so this paper infers that knowledge sharing plays a mediating role between organizational social network and enterprise collaborative innovation. Lubit et al. [14] pointed out that knowledge is the key factor for enterprises to generate competitiveness in the current era. Knowledge flows among different innovation subjects through social networks, and the spillover effect generated is the foundation and source of the whole scientific and technological activities and technological innovation. However, no studies have proved the mechanism of knowledge sharing between organizational social network and corporate collaborative innovation, and only preliminary correlation studies have been conducted. Based on the social capital theory, Choi et al. [15] pointed out that social network can promote the level of knowledge sharing. Mehdi et al. [16] pointed out that knowledge sharing can provide channels for organizations to obtain external resources, thus improving the innovation performance of enterprises. Therefore, this paper will make a supplementary research on this research gap. Based on the social cognitive theory, this paper puts knowledge sharing, organizational social network and enterprise collaborative innovation into the same research framework, and clarifies the relationship between the three through practical research.

At present, digital technology is affecting enterprises at an unprecedented speed of development and accelerating enterprises to enter a new era of digital construction. Therefore, the research on enterprise collaborative innovation needs to be combined with the background of the digital economy era. In the era of digital construction, the application of ABCD (artificial intelligence, block chain, cloud computing, and distributed computing) and other digital technologies breaks organizational boundaries, empowers enterprises to develop across boundaries, and becomes a new driving force for enterprises to achieve economic growth [17]. Applying digital technology to the construction of organizational social network to improve the ability of enterprise digital construction, not only expands the business activities of enterprises from the physical environment to the virtual network space,

greatly enriching the types and quantities of cooperation objects that enterprises can contact, but also builds an open innovation network management system inside enterprises, reducing the operating costs of enterprises. Existing research shows that the social network quality and resource advantages built by enterprises with high degree of digital construction are significantly higher than those with low degree of digital construction [18]. The rich strategic resources significantly reduce the difficulty of establishing cooperative relations between enterprises and external organizations, and provide enterprises with more options for choosing innovation partners. Based on the above analysis, this paper takes digital construction as a situational variable to explore the boundary conditions between organizational social network and enterprise collaborative innovation.

To sum up, this paper is based on social exchange theory and social cognitive theory to explore the organizational social network, knowledge sharing, enterprise cooperative innovation as well as the logic relations between the digital construction, and tries to improve enterprise collaborative innovation ability from the three aspects of organizational social network construction, knowledge interaction and social context. For the measurement of the above variables, the method of questionnaire survey is used to collect data, which is not only convenient to collection, but also convenient for statistical processing and analysis of the results collected by the questionnaire, with high efficiency. The research conclusion of this paper enriches the academic achievements of the existing organizational social network, and more clearly explains the path mechanism and boundary conditions of the impact of organizational social network on enterprise collaborative innovation. The adoption of quantitative analysis method helps to enhance the universality of the research conclusions. Explaining the impact of organizational social network on enterprise collaborative innovation from the perspective of digital construction will not only help enterprises deepen their understanding of digital transformation, but also speed up the process of enterprise digital construction, which has practical significance for improving the ability of enterprise collaborative innovation.

II. LITERATURE REVIEW

A. ORGANIZATIONAL SOCIAL NETWORK

Social network includes the collection of social actors and all their relationships, which contains knowledge, information, interpersonal relationships and other factors that help to improve the work performance of network members. Organizational social network is an important carrier of enterprise social capital, which can be divided into internal network and external network [19]. The former is formed by employees within the company, and the latter is formed by the connection between internal members and individuals or groups outside the enterprise. Berkowitz and Knoke [20] believe that organizational social network refers to social actors establishing connections between organizations through mobile

networks in order to obtain various resources of other social actors. Organizational social network can not only open up the scope of cooperation and expand the channels to obtain more available resources [11], but also improve organizational status and create organizational economic benefits [21]. Existing studies have not yet reached a consensus on the dimension division of organizational social networks. From the perspective of network structure, scholars most often use the three indicators of network size, heterogeneity (also expressed as network scope) and connection strength to divide them [22], [23]; from the perspective of network subjects, they can also be divided into formal and informal networks; from the perspective of relationship quality, relationship trust is a commonly used indicator. Considering that this paper intends to investigate the relationship between social network and collaborative innovation, which includes multi-field and multi-industry exchanges and cooperation, it can more accurately describe the cooperation network established by organizations from the perspective of network structure, and then put forward targeted suggestions for the establishment of social network. From the perspective of network structure and integrating the research results of Collins [24] and Zhu [25], this paper proposes to use the three indicators of network size, network heterogeneity and connection strength to measure organizational social networks. Network size refers to the range of resources that enterprise can access; network heterogeneity refers to the degree of differentiation between a firm and its partners in the relationship network in terms of scale, products, and services; and connection strength refers to the closeness between an enterprise and other partners in the relationship network.

B. ENTERPRISE COLLABORATIVE INNOVATION

Collaborative innovation emerged from the fact that the traditional linear and chain innovation paradigm was gradually replaced by the networked innovation paradigm, therefore, collaborative innovation is a new type of cooperation, through which enterprises can achieve resource sharing and risk sharing, and finally achieve the effect of "1+1>2" [26]. Throughout the collaborative innovation in the field of study, from the research on the subject can be divided into three types: one is the organization or the space-time evolution of the city as the main research cooperation network [27], the second is research how to promote cooperation between college and enterprise innovation performance [28], the third is a collaboration between the enterprise and the enterprise as the main body, studies how to realize the development goal of each other. Compared with the first two kinds of research, the third kind of research focusing on enterprise cooperation has not received enough attention, and most scholars focus on the construction of collaborative innovation network, and pay less attention to how to improve the collaborative ability of enterprises. In addition, collaborative innovation can be divided into vertical collaboration and horizontal collaboration from its cooperation mode. In the past research, many

scholars studied these two innovation modes separately and compared the differences between them. However, with the deepening of the research on collaborative innovation, the separation research of vertical collaboration and horizontal collaboration is no longer popular. Based on the perspective of social interaction, this paper regards enterprise collaborative innovation as ability of mutual cooperation and collaboration between enterprises and other nodal enterprises, which is manifested in three aspects: knowledge collaboration, organizational collaboration and strategic collaboration. Knowledge collaboration can realize technology upgrading and innovation by improving the transmission efficiency of explicit or tacit knowledge among cooperative organizations; organizational collaboration is to form alliances with different enterprises by signing contracts, which helps to transfer resources across different individuals and organizations; strategic collaboration accommodates the differences in values and cultures of different cooperative subjects, and lays the foundation for long-term cooperation.

C. KNOWLEDGE SHARING

Knowledge sharing is a form of social network interaction within an organization. Organizations that establish social connections always hope to obtain more knowledge resources through the interaction between networks, and then provide more resources and advantages for enterprise innovation. That is to say, knowledge sharing is the main expression of organizational social network to improve innovation advantages [29]. Knowledge sharing refers to the transfer and exchange of knowledge among organizations, and the specific transmission content can be experience, ideas, skills, etc. Knowledge can be divided into explicit knowledge and tacit knowledge [30]. Explicit knowledge is transmitted through direct communication, and tacit knowledge is transformed into explicit knowledge through knowledge sharing, and then transmitted. Knowledge sharing promotes the increase of the total amount of knowledge, so that all members of the organizational social network can enjoy the benefits of knowledge resources. From the individual level, knowledge sharing helps employees accomplish their tasks faster; from the organizational level, knowledge sharing promotes the full flow of resources within the organization and improves the overall performance of the organization; from the social level, knowledge sharing can effectively realize the rational distribution of resources and improve the overall resource utilization rate of the society. In the era of knowledge economy, the knowledge resources owned by organizations are the cornerstone for enterprises to achieve future development and innovation, so knowledge sharing has received more and more attention from scholars and entrepreneurs.

D. DIGITAL CONSTRUCTION

In the digital context, enterprise activities show the characteristics of openness, boundlessness and strong interaction. The application of digital technology can promote the

flow and overflow of knowledge, enhance the ability of enterprises to learn and absorb knowledge, and accelerate the innovation efficiency of enterprises. Enterprise digital construction refers to the improvement of product research and development, production, sales and after-sales service processes through the use of digital technologies such as big data, artificial intelligence and Internet, so as to realize the perfect combination of hardware physical facilities and software digital technology. Digital construction is of great significance to enhance the competitiveness of enterprises. On the one hand, digital construction improves organizational flexibility and agility, enabling companies to quickly adjust resource allocation and enhance their adaptability to the dynamic environment [31], and on the other hand, digital technology can provide consumers with special customized services to improve their consumer experience and enhance consumer stickiness. Therefore, with the popularization of digitization and related technologies, great changes will take place in the traditional business mode, production process and management means [32]. Enterprises must integrate into this change as soon as possible, comprehensively use various digital technologies, improve and optimize work processes, and realize the innovation of enterprise value.

III. HYPOTHESES DEVELOPMENT

A. ORGANIZATIONAL SOCIAL NETWORK AND ENTERPRISE COLLABORATIVE INNOVATION

Organizational social network is the main way for enterprises to obtain external resources. A stable organizational social network can ensure the full flow of complementary resources, so that new ideas and viewpoints can be generated in the collision of knowledge, and finally realize the appreciation of knowledge resources. Based on the theoretical analysis in the previous paper, this paper divides organizational social networks into three dimensions: network size, network heterogeneity and connection strength. The size of network determines the number of channels that enterprise can obtain resources. The larger the size, the more information channels and resources an enterprise can obtain. Moreover, the large-scale network system helps an enterprise occupy a dominant position in its social network, so that other cooperative enterprises have a higher trust and dependence on this enterprise [33], and thus provide more partners for collaborative innovation of the enterprise. Network heterogeneity indicates the degree of heterogeneity that enterprises can obtain information resources. The higher the heterogeneity, the easier it is for enterprises to obtain differentiated information. Enterprises which master heterogeneous resources tend to have better network embeddedness than those that lack heterogeneous resources [34], and are easier to establish cooperative relations with other enterprises. The strength of connection affects the degree of activity and stability of social network. The higher the strength of connection, the more frequent the communication and cooperation within the organization, and

the degree of familiarity and trust between each other will also increase [35]. In summary, this paper proposes the following hypotheses.

H1: Organizational social network has a positive role in promoting enterprise collaborative innovation.

B. MEDIATING ROLE OF KNOWLEDGE SHARING

Knowledge is the key element for enterprises to carry out innovation activities, and it plays an irreplaceable role for enterprises to improve internal competitiveness and gain competitive advantages. Based on knowledge interaction theory, Porter [36] points out that social interaction behavior can enhance employees' willingness to share knowledge. That is, social networks within organizations provide convenient channels for interaction between enterprises, significantly increasing the frequency of knowledge flow within cyberspace, help enterprises obtain complementary resources in time, and promote the iterative upgrading of products and technologies. Here, this paper further explores the impact of organizational social networks on knowledge sharing from the three subdivision dimensions of organizational social network. The large scale of the network can show that the enterprise occupies a central position and has a certain reputation to a certain extent. While the edge enterprises tend to exchange knowledge with the central enterprise in order to obtain the resources required for development. Therefore, the knowledge acquisition channel of the central enterprise will be greater than that of the edge enterprise. The stronger network heterogeneity shows that the enterprise can obtain a large number of different and scarce knowledge resources from the external environment, and a large amount of heterogeneous information can enhance the capital of knowledge exchange between enterprises and the outside world, and then promote the occurrence of knowledge sharing behavior. The high connection strength indicates that different organizations in the network interact more frequently, and the frequent interaction makes it easier to establish private contacts with each other and enhance their willingness to trust each other, open their hearts and share knowledge [37]. Thus, it can be seen that organizational social networks has built a platform for knowledge interaction, which can effectively improve the frequency of knowledge sharing.

The open social network environment provides a strong guarantee for enterprises to carry out knowledge sharing behavior, and realizes the flow of knowledge in the social network to the greatest extent, so as to promote the updating and improvement of the internal knowledge reserve of enterprises, thus laying a foundation for the innovation activities of enterprises. In addition, the different flow of knowledge can bring different benefits for enterprises. One is that external knowledge flows into the enterprise through social network, which not only improves the breadth and depth of internal knowledge resources, but also helps to understand the development concept and organizational culture of external enterprises. The other is that the internal knowledge of the

enterprise is transmitted to the external organization through the social network, and this process transmits the internal knowledge, technology and ideas of the enterprise to the external enterprise, which on the one hand increases the understanding of the external enterprise to this enterprise, and on the other hand strengthens the trust between the two enterprises. Knowledge sharing enhances the familiarity between collaborators and makes it easy to generate similar cognitive concepts. When two enterprises have more common values, it is easier to develop collaborative cooperation between these two enterprises [38], and this cooperation is based on common cognition and mutual benefit, so it is very solid. Therefore, through knowledge sharing and cross-border cooperation, enterprises in the same network can effectively realize the coordinated development of each other in knowledge, resources and relations, and improve the ability of collaborative innovation of enterprises.

Based on the above analysis, this paper infers that knowledge sharing plays a bridge role between organizational social network and enterprise collaborative innovation. Knowledge sharing is influenced by organizational social networks. The organizational social network enhances the degree of knowledge sharing with cooperative enterprises by strengthening the network size, network heterogeneity, and connection strength, promoting the central position of enterprises in the network, strengthening trust with cooperative enterprises, and increasing the total amount of resources they own. Frequent knowledge sharing increases the understanding between cooperative enterprises and establishes a strong trust relationship. Moreover, knowledge sharing can overcome the gap between different organizations due to the difference in knowledge culture, establish a common development concept, realize cross-border cooperation between different organizations, and improve the ability of collaborative innovation of enterprises. To sum up, this paper puts forward the following hypotheses.

H2: Organizational social network has a positive effect on knowledge sharing.

H3: Knowledge sharing has a positive effect on enterprise collaborative innovation.

H4: Knowledge sharing plays an intermediary role between organizational social networks and enterprise collaborative innovation.

C. MODERATING EFFECT OF DIGITAL CONSTRUCTION

Social identity as the key content of the current internal reform of enterprises, digital construction provides technical support for organizations to establish social networks and develop social capital. Firstly, digital technology has the characteristics of cross-border. Digital construction can establish an interconnected virtual platform among enterprises, provide technical support for in-depth communication among enterprises, and improve the breadth and depth of enterprise social exchange. Secondly, digital technology has the characteristics of convenience. Timeliness is the

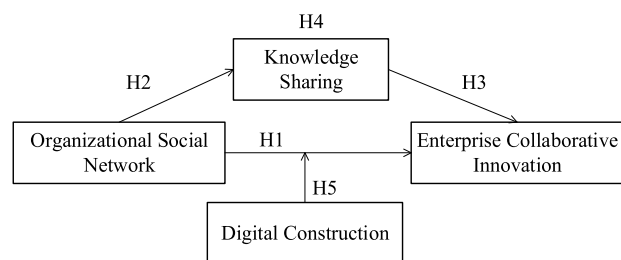


FIGURE 1. The hypothesized model.

key feature of knowledge resources owned by enterprises. Digital communication channels greatly shorten the distance between enterprises and the outside world, and provide convenience for the establishment and extension of enterprise cooperation networks. Finally, digital construction can also optimize the internal resource integration of enterprise, help the enterprise absorb and convert external knowledge resources faster, and realize the improvement and optimization of internal resources [39]. Within enterprises with high digital construction, the organizational social network tends to develop steadily, and the communication resistance and cooperation cost between enterprises and external organizations are low, which creates a favorable environment for establishing cooperation and realizing collaborative development between different enterprises. To sum up, this paper puts forward the following assumption.

H5: Digital construction positively moderates the positive relationship between organizational social network and enterprise collaborative innovation.

According to the research assumptions proposed above, the theoretical model drawn in this paper is shown in Figure 1.

IV. RESEARCH METHODOLOGY

A. RESEARCH CONTEXT AND DATA COLLECTION

The research object of this paper is high-tech enterprises, whose products have high technological content, fast technological updating, and stronger investment in research and development, generally not less than 3% of sales revenue, so they have high requirements on the innovation ability of enterprises, which is in line with the scenario of digital construction in this paper. As for the distribution area of the research object, this paper plans to investigate the Yangtze River Delta, because the investment in scientific and technological innovation in this area exceeds 30% of the country, and the Yangtze River Delta has initially formed a regional collaborative innovation network dominated by enterprises and closely connected with external organizations such as government, universities and financial institutions in the early stage. It is the main force of the national implementation of regional collaborative innovation strategy, which is in line with the research purpose of this paper.

Due to the impact of the epidemic situation, the actual data in this study were mainly obtained through the distribution of questionnaires. The respondents of the questionnaire

are middle and senior managers or key employees of the target enterprise. Such personnel have a certain degree of understanding and understanding of the enterprise, which can improve the quality of questionnaire data and ensure the reliability of survey results. There are two main ways to distribute the questionnaire. On the one hand, with the help of alumni relations in Shanghai, Nanjing and Zhejiang, they are entrusted to distribute the questionnaire to local high-tech enterprises. Among them, they contact the middle-level managers of 30 high-tech enterprises through the scientific research cooperation between schools and enterprises, and a total of 30 valid questionnaires are obtained. At the same time, the 30 managers were entrusted to issue questionnaires to high-tech enterprises associated with their own cooperation, and a total of 38 valid questionnaires were obtained. On the other hand, with the help of Internet technology, we logged on the official websites of major enterprises, found relevant information about the managers of the enterprises, made telephone communication to indicate the purpose of the research, and then completed the questionnaire data by mail in the form of e-questionnaires or telephone interviews, obtaining a total of valid data 144. The research lasted for a total of 4 months, and 212 valid data were finally obtained.

Among the 212 valid data, private enterprises accounted for 44% and state-owned enterprises accounted for 31%. These two types accounted for the main types of enterprises, and the others accounted for 25%; Enterprise scale (expressed in annual sales): enterprises with 1.01-3 million account for 42%, 3.01-5 million account for 26%, and more than 5 million account for 9%; The proportion of enterprises established for less than 3 years is 13%, that for 3-5 years is 45%, that for 6-10 years is 27%, and that for more than 11 years is 15%; The number of employees owned by the enterprise is less than 50, accounting for 7%, 50-200, accounting for 32%, 201-500, accounting for 38%, and more than 500, accounting for 23%.

B. VARIABLE MEASURES

In this paper, the Likert five point scale method is used to measure the variables of the questionnaire, in which 1 indicates complete non-compliance and 5 indicates complete compliance. The scales used in this paper are from the mature scales used by previous studies, which have been proved to have high reliability and effectiveness in the Chinese context, so they have a certain authority.

Organizational social network adopts the scale developed by Clark and Zhu, because these two scholars also use network size, network heterogeneity and network strength to measure organizational social network. Network size has five items in total; there are 4 items of network heterogeneity and 5 items of network strength.

Enterprise collaborative innovation draws on the research results of scholars Si [40], He [41] and Akhtar [42], and adjusts the translation content according to the actual situation. Finally, it is determined as 9 items.

Knowledge sharing refers to the scale prepared by scholars Hooff and Ridder [43], and is measured from two dimensions

of knowledge contribution and knowledge acquisition, which is finally determined as 5 items.

Digital construction adopts the scale used by scholar Hu [44], which integrates the research results of scholars at home and abroad and is determined as five items.

Finally, according to the research of previous scholars, the scale (expressed in annual sales), the nature of affiliation, age and number of employees of the enterprise will have a certain impact on the construction of organizational social network. Therefore, these four indicators are selected as control variables.

Control variables: Previous scholars believe that individual characteristic variables of employees may affect their behavioral performance [43]. Therefore, in this study gender, age, education level, and position level of employees were selected as the control variables.

C. RELIABILITY AND VALIDITY ANALYSIS

The reliability was tested by SPSS24.0, the results show that the Cronbach's alpha of organizational social network scale, heterogeneity, connection strength, enterprise collaborative innovation, knowledge sharing and digital construction are greater than 0.702, indicating that the reliability of the questionnaire is qualified.

The validation factor analysis of AMOS is used for validity test. All variables were analyzed by single factor analysis, two factor analysis, all the way to multi-factor analysis, and the fitting effect of the six-factor model was the best the fitting effect of the six factor model is the best. The specific fitting results are shown in Table 1. Compared with other models, the six factor model has the smallest 2/df and the lowest RMSEA, and the comparative fitting index (CFI) and incremental fitting index (IFI) are higher than the qualified critical value of 0.9. Therefore, it is proved that the six factor model is the model with the best fitting degree and also proved that the five variables of network size, heterogeneity, connection strength, enterprise collaborative innovation, knowledge sharing, and digital construction have good convergent and discriminant validity.

V. RESULTS

A. COMMON METHOD DEVIATION TEST

In the process of filling in the questionnaire, each questionnaire is completed by one person. The person who fills in the questionnaire may be affected by his personal thinking angle, emotional state and environment. There is an artificial deviation when filling in, that is, the so-called common method deviation. In order to eliminate the influence of common method deviation, this paper adopted Harman's single factor experiment to test, and according to the results, the interpretation proportion of the first principal component is 21.545%, which is far lower than the critical value of 40%. Therefore, it is judged that there is no influence of common method deviation in this study.

B. DESCRIPTIVE STATISTICS AND CORRELATIONS

Table 2 shows the descriptive statistics and correlation coefficients for research variables in this study. First, it can be seen there is a significant correlation between organizational identity and job performance. In a sense, there is a causal relationship between organizational identity and job performance. Then the same relationship between organizational identity and work value is found. There is also a significant correlation between work value and job performance.

C. HYPOTHESIS TESTS

1) MAIN EFFECTS TEST

The main effect test was done using regression analysis with the help of the plug-in PROCESS V3.3 for SPSS 24.0. Table 3 shows the test results of main effect and intermediary effect, in which the organizational social network is the weighted average after standardizing the network scale, heterogeneity and connection strength. Because these three subdivision variables have the same research perspective, have high correlation with each other and are positively correlated, this paper chooses to convert the three dimensions of the organizational social network into a total independent variable. Model 3 in Table 3 is the regression analysis of four control variables on enterprise collaborative innovation. Model 4 is the regression analysis of collaborative innovation after adding control variables and independent variables to the organizational social network. The results show that the organizational social network has a positive impact on enterprise collaborative innovation ($\beta = 0.622$, $P < 0.001$), and H1 was established. This shows that organizations can enhance the ability of collaborative innovation by expanding social networks. The size of the organization's social network expands the channels of information sources, heterogeneity reduces the homogeneity of information resources, and the connection strength increases the reliability of information content. These large numbers of reliable and scarce resources help enterprises better cooperate and collaborate with other partners and improve each other's innovation ability.

2) MEDIATING EFFECT TEST

Firstly, according to the model 2 of hierarchical regression analysis, adding organizational social network to the control variables has a positive and significant impact on knowledge sharing ($\beta = 0.642$, $P < 0.001$), indicating that H2 was supported. Secondly, knowledge sharing is added to the control variables, and according to the model 5 of regression analysis, knowledge sharing has a positive and significant impact on enterprise collaborative innovation ($\beta = 0.535$, $P < 0.001$), H3 was supported. Finally, the organizational social network, knowledge sharing and control variables are put into the model at the same time, and Model 6 is obtained. By comparing model 4 with model 6, it is found that the influence coefficient of organizational social network on enterprise collaborative innovation is reduced from 0.622 to 0.422, $P < 0.001$. It shows that knowledge sharing plays a partial intermediary

TABLE 1. Validation factor analysis.

Models		χ^2	χ^2/df	RMSEA	CFI	IFI
One-factor model	SIZE+HETER+FREQ+CI+KS+DC	651.409	1.316	0.056	0.762	0.774
Two-factor model	SIZE+HETER+FREQ; CI+KS+DC	627.978	1.271	0.052	0.796	0.806
Three-factor model	SIZE+HETER+FREQ; CI;KS+DC	614.809	1.250	0.050	0.813	0.820
Four-factor model	SIZE+HETER;FREQ; CI;KS+DC	590.022	1.207	0.046	0.847	0.855
Five-factor model	SIZE+HETER;FREQ; CI;KS;DC	571.263	1.178	0.042	0.869	0.877
Six-factor model	SIZE;HETER;FREQ; CI;KS;DC	539.698	1.124	0.035	0.909	0.915

TABLE 2. Descriptive statistics and correlations.

	SCALE	TYPE	AGE	NUM	SIZE	HETER	FREQ	CI	KS	DC
Scale	1									
Type	-0.053	1								
Age	0.090	0.509**	1							
Num	0.122	0.474**	0.570**	1						
SIZE	-0.010	0.222*	0.285**	0.243*	1					
HETER	0.057	0.281**	0.392**	0.280**	0.397**	1				
FREQ	0.053	0.311**	0.318**	0.327**	0.408**	0.428**	1			
CI	0.158	0.158	0.182	0.134	0.457**	0.454**	0.442**	1		
KS	-0.072	0.196	0.124	0.105	0.469**	0.453**	0.420**	0.538**	1	
DC	-0.135	0.039	0.116	0.042	0.384**	0.411**	0.327**	0.439**	0.449**	1
M	1.84	2.66	2.77	2.44	3.652	3.555	3.662	3.662	3.706	3.822
SD	0.884	0.966	0.903	0.886	0.506	0.580	0.474	0.336	0.501	0.467

Note: Type stands for "nature of affiliation"; Num stands for "number of employees";** means the correlation is significant at the 0.01 level (two-tailed); * means the correlation is significant at the 0.05 level (two-tailed).

role between independent variable organizational social network and dependent variable enterprise collaborative innovation, and H4 had been preliminarily verified.

In order to further verify the partial intermediary role played by knowledge sharing, this paper adopted the Model 4 of PROCESS V3.3 to verify the intermediary role, and set the Bootstrap's autonomous sampling to 5000 and the confidence interval to 95%, and the specific results were shown in the table 4. The confidence interval of the direct effect is (0.061, 0.2867) and the confidence interval of the indirect effect is (0.1379, 0.5681) both of which do not contain zero points, proving that there is a partial mediating role of knowledge sharing between organizational social network and enterprise collaborative innovation capability. The direct effect accounts for 32.18% of the total effect, and the indirect

effect accounts for 6.82% of the total effect. Combining the results of regression analysis and Bootstrap analysis, H4 has been fully verified. Organizational social network provides a wide platform for enterprise knowledge sharing and can promote the occurrence of knowledge sharing behavior, while knowledge sharing deepens the mutual understanding between internal and external enterprises and paves a good foundation for them to realize mutual cooperation and collaboration.

3) MODERATING EFFECT TEST

To verify the moderating effect of H5, the interaction term between the independent variable organization social network and the digital construction of the moderating variable, is introduced OSN×DC in this paper. The control variable,

TABLE 3. Analysis of the impact of organizational identity on job performance.

Var	KS					
	M1	M2	M3	M4	M5	M6
Scale	0.034	-0.128	0.034	0.015	0.092	0.055
Type	0.085	0.082	0.085	-0.004	-0.008	-0.029
Age	0.124	-0.137	0.124	-0.049	0.102	-0.006
Num	0.020	-0.076	0.020	-0.063	0.015	-0.039
OSN		0.642***		0.622***		0.422***
KS					0.535***	0.312**
R ²	0.040	0.373	0.040	0.343	0.312	0.404
F	0.999	11.190	0.999	9.806	8.520	10.495
Max VIF	1.672	1.673	1.672	1.770	1.672	1.939

Note: *** denotes P<0.001, ** denotes P<0.01, * denotes P<0.05.

TABLE 4. Mediating role of knowledge sharing (Bootstrap test).

	Coeff	Std error	Lower limit	Upper limit	Effectiveness Ratio
Indirect effects	0.166	0.057	0.061	0.287	32.18%
Direct effect	0.349	0.108	0.138	0.568	67.82%
Total effect	0.515	0.089	0.349	0.694	

TABLE 5. Moderating effect of digital construction.

Var	CI				
	M1	M2	M3	M4	M5
Scale	0.034	0.015	0.059	0.058	0.030
Type	0.085	-0.004	0.020	0.028	0.001
Age	0.124	-0.049	-0.049	-0.083	-0.017
Num	0.020	-0.063	-0.043	0.003	0.006
OSN		0.622***	0.500***	0.515***	0.312**
KS					0.173*
DC			0.214*	0.238*	0.138**
Interaction OSN×DC				0.246**	0.355**
R ²	0.040	0.343	0.375	0.432	0.472
F	0.999	9.806	9.288	10.010	10.179

Note: *** denotes P<0.001, ** denotes P<0.01, * denotes P<0.05.

independent variable, regulatory variable and their interaction terms were gradually introduced into the regression equation, then Table 5 was obtained. According to model 4, the interaction between organizational social network and digital construction has a positive impact on enterprise collaborative innovation ($\beta = 0.355, P<0.01$), so H5 was supported. Finally, all variables, including control variables, independent variables, intermediary variables, moderating variables, and the interaction term between independent variables and moderating variables, were introduced into the regression model, and the model 5 was obtained, and H1, H4, and H5 were verified again.

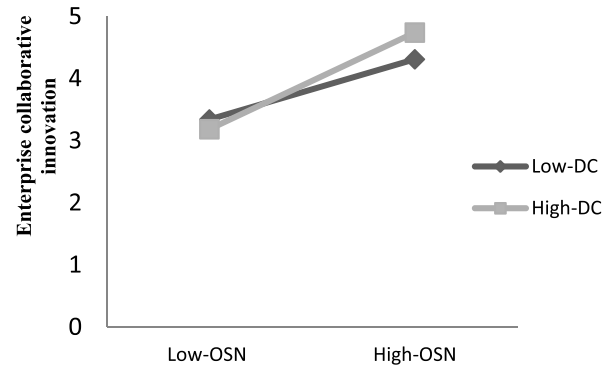


FIGURE 2. Moderating role of digital construction.

To further verify the moderating effect of digital construction, Model 1 of PROCESS V3.3, Bootstrap’s autonomous sampling was set 5000 times, and chose to demonstrate the moderating effect on the dependent variable at two levels of high and low, which was drawn as Figure 2. It can be easily seen from the moderating effect diagram that the slope of high level digital construction is greater than that of low level digital construction, that is, with the improvement of digital construction level, the positive impact of organizational social network on enterprise collaborative innovation will increase, and H5 was confirmed again.

VI. DISCUSSION AND CONCLUSIONS

A. CONCLUSIONS

Based on the social exchange theory and social cognition theory, this paper explores the impact of organizational social network on enterprise collaborative innovation, and tests the role of knowledge sharing and digital construction. Based on the survey samples of 212 middle and senior managers or key employees of high-tech enterprises, the following empirical results are obtained.

(1) Organizational social networks positively influence enterprise collaborative innovation. The main reason is that the size, heterogeneity, and connection strength of organizational social networks provide capital for extensive cooperation of enterprise, including technical support and information assistance. Technical support helps enterprises and partners achieve better division of labor and cooperation and achieve each other’s goals, while information resources help enterprises break the barriers of cooperation and deepen mutual trust. Enterprises with rich resources often have better network embeddedness than those with poor resources, so as to establish stable cooperation and realize innovative development. Therefore, organizational social networks provide a solid support for enterprises to develop collaborative innovation capabilities.

(2) Knowledge sharing plays a partial intermediary role between organizational social network and enterprise collaborative innovation. Specifically, it is explained in two aspects. First, organizational social network promotes the occurrence of knowledge sharing. In order to obtain the resources needed

for their own development, organizations in social networks will take the initiative to exchange and share knowledge with other enterprises, and the size, heterogeneity and connection strength provide sufficient information capital for enterprise knowledge interaction, thus increasing the behavior of enterprise knowledge sharing.

Second, knowledge sharing has a positive impact on enterprise collaborative innovation. In the transmission of knowledge inside and outside the enterprise, it not only realizes value appreciation innovation, but also helps organizations in the same knowledge network to enhance mutual understanding, overcome cooperation obstacles and realize collaborative innovation.

(3) Digital construction positively moderates the impact of organizational social network on enterprise collaborative innovation. Digital construction provides technical support for enterprises to build a stable social network. Establishing a virtual social network platform through digital technology not only effectively reduces the constraints of space on the development of the organizational network, but also enables the fastest transmission of information in the virtual network. The more perfect the internal digital construction of the enterprise, the more effective the organization can manage the social network, sort out the resources owned by the organization, and provide resource help for enterprise collaborative innovation in time.

B. THEORETICAL IMPLICATIONS

First, this paper uses a unique theoretical perspective to study the antecedent variables of corporate collaborative innovation. Based on social exchange theory, the social network of the organization is studied as the antecedent variable of corporate collaborative innovation. Previous scholars mostly chose to study based on synergetic theory or social capital theory. Since this paper classifies enterprise collaborative innovation as social behavior, social exchange theory is introduced, and this theory has a high correlation with organizational social network, therefore, social exchange theory can provide a very consistent theoretical support for the study of the relationship between organizational social network and enterprise collaborative innovation. Second, this paper reveals the mechanism between organizational social network and enterprise collaborative innovation. That is, based on social cognitive theory, knowledge sharing is introduced into the research of organizational social network and enterprise collaborative innovation. From the perspective of social cognitive theory, existing scholars put forward that organizational social network can promote the occurrence of knowledge sharing behavior. On the basis of inheriting predecessors, this paper brings organizational social network, knowledge sharing and enterprise collaborative innovation into the same research framework, and verifies that knowledge sharing plays an intermediary role between organizational social network and enterprise collaborative innovation through empirical analysis. It is an important enrichment and deepening of social network theory and collaborative innovation theory.

Finally, starting from the macro environment background of enterprises, this paper takes the digital economy era as the situational variable of enterprise collaborative innovation, which not only enriches the research results of digital construction, provides reference significance for subsequent research, but also defines the boundary conditions of organizational social network affecting enterprise collaborative innovation ability.

C. PRACTICAL IMPLICATIONS

The research conclusions of this paper have the following enlightenment to the innovation practice of enterprises. (1) Expand the construction of social network under the condition of ensuring the stability of organizational social network relations. Organizational social network is the main way for enterprises to obtain external resources, and it plays a promoting role in improving the collaborative innovation capability of enterprises. Enterprises should, in combination with their own objective situation, select enterprises with their own lack of resources, establish social networks with them, obtain information resources through mutual communication, absorb them after internal filtering, and give full play to the greatest advantage of collaborative innovation. (2) Create a good working atmosphere for improving employee knowledge sharing. Enterprises should build appropriate communication channels for employees' knowledge sharing, and should also take incentive measures to enhance employees' willingness to interact with knowledge. At the same time, enterprises should take the initiative to communicate with their partners in the social network to gain their trust, and then update their internal resources through knowledge interaction, while paying attention to integrating the resources they have, improving the utilization efficiency of existing resources, and maximizing their value within the validity period of resources. (3) Build an Internet communication platform with the help of digital technology. In the construction of social networks, digital technologies such as artificial intelligence and the Internet are applied to establish a virtual online communication platform or a data sharing service center to provide a safe and convenient place for all enterprises that need to exchange information, so as to promote cross organizational communication and cooperation and realize large-scale collaborative innovation.

D. LIMITATIONS AND FUTURE RESEARCH

First, the research sample of this paper has the shortcomings of single research object and insufficient research area. The current research objects are high-tech enterprises, and there is a lack of research on collaborative innovation in other industries such as service industry. Since the reform and opening up, the proportion of China's service industry in GDP has been rising, from 24.6% in 1978 to 54.5% in 2020. It has made outstanding contributions to economic development and is worth studying in the future. Similarly, the study area also needs to be expanded, and the sample number of several cities can be increased in the future. Second, the research

methodology is slightly traditional. In future research, we can try to use the method of case study to get more realistic and accurate first-hand data by going deeper into enterprise practice. In addition, case studies may find special phenomena outside the study during the interviews. Finally, future research should continue to expand the research perspective. Perhaps starting from the leader, the influence of leadership style on collaborative innovation of enterprises is studied, which may expand or reduce the ability of collaborative innovation of enterprises.

APPENDIX

A questionnaire on the relationship between organizational social network, enterprise collaborative innovation, knowledge sharing and digital construction

Part I Basic information

1. The nature of the enterprise.

Private; State-owned;

Collective; Three capital enterprises

2. Scale of the enterprise (annual sales).

Less than 1 million; 1.01-3 million;

3.01-5 million; More than 5 million

3. Years of establishment of the enterprise.

Less than 3 years; 3-5 years;

6-10 years; More than 10 years

4. Number of employees of the enterprise.

Less than 50 people; 50-200 people;

201-500 people; More than 500

Part II Organizational Social Network

5. There are a lot of family and friends that the enterprise can contact.

1= strongly disagree; 2= relatively disagree; 3= uncertain; 4= relatively agree; 5= strongly agree

6. There are many banks and financial institutions that the enterprise can contact.

1= strongly disagree; 2= relatively disagree; 3= uncertain; 4= relatively agree; 5= strongly agree

7. There are many intermediaries (such as accounting firms) that the enterprise can contact

1= strongly disagree; 2= relatively disagree; 3= uncertain; 4= relatively agree; 5= strongly agree

8. There are many business groups and individuals that the enterprise can contact.

1= strongly disagree; 2= relatively disagree; 3= uncertain; 4= relatively agree; 5= strongly agree

9. There are many government agencies that the enterprise can contact.

1= strongly disagree; 2= relatively disagree; 3= uncertain; 4= relatively agree; 5= strongly agree

10. The main customers of the enterprise have a large gap with the enterprise in terms of enterprise scale.

1= strongly disagree; 2= relatively disagree; 3= uncertain; 4= relatively agree; 5= strongly agree

11. The main customers of the enterprise have a large gap with the enterprise in the main business.

1= strongly disagree; 2= relatively disagree; 3= uncertain; 4= relatively agree; 5= strongly agree

12. The main cooperative suppliers of the enterprise have a large gap with the enterprise in terms of enterprise scale.

1= strongly disagree; 2= relatively disagree; 3= uncertain; 4= relatively agree; 5= strongly agree

13. The main cooperative suppliers of the enterprise have a large gap with the enterprise in the main business.

1= strongly disagree; 2= relatively disagree; 3= uncertain; 4= relatively agree; 5= strongly agree

14. The enterprise keeps frequent and close contact with family and friends.

1= strongly disagree; 2= relatively disagree; 3= uncertain; 4= relatively agree; 5= strongly agree

15. The enterprise maintains frequent and close contact with the personnel of banks and other financial institutions.

1= strongly disagree; 2= relatively disagree; 3= uncertain; 4= relatively agree; 5= strongly agree

16. The enterprise maintains frequent and close contact with intermediary personnel.

1= strongly disagree; 2= relatively disagree; 3= uncertain; 4= relatively agree; 5= strongly agree

17. The enterprise maintains frequent and close contact with business groups and other enterprises.

1= strongly disagree; 2= relatively disagree; 3= uncertain; 4= relatively agree; 5= strongly agree

18. The enterprise maintains frequent and close contact with government agencies or personnel.

1= strongly disagree; 2= relatively disagree; 3= uncertain; 4= relatively agree; 5= strongly agree

Part III Enterprise Collaborative Innovation

19. We can exchange and share information about technological innovation with cooperative enterprises.

1= strongly disagree; 2= relatively disagree; 3= uncertain; 4= relatively agree; 5= strongly agree

20. We can carry out joint research and development of technology with cooperative enterprises.

1= strongly disagree; 2= relatively disagree; 3= uncertain; 4= relatively agree; 5= strongly agree

21. We can meet the technical standards required by the cooperative enterprise.

1= strongly disagree; 2= relatively disagree; 3= uncertain; 4= relatively agree; 5= strongly agree

22. We can achieve good business division and cooperation with our cooperative enterprises

1= strongly disagree; 2= relatively disagree; 3= uncertain; 4= relatively agree; 5= strongly agree

23. We have established a flexible cooperation management system with our partners.

1= strongly disagree; 2= relatively disagree; 3= uncertain; 4= relatively agree; 5= strongly agree

24. We can achieve the cooperation objectives jointly formulated with cooperative enterprises.

1= strongly disagree; 2= relatively disagree; 3= uncertain; 4= relatively agree; 5= strongly agree

25. The corporate culture between us and the cooperative enterprise is integrated with each other.

1= strongly disagree; 2= relatively disagree; 3= uncertain; 4= relatively agree; 5= strongly agree

26. We have a good relationship of trust with our cooperative enterprises.

1= strongly disagree; 2= relatively disagree; 3= uncertain; 4= relatively agree; 5= strongly agree

27. We are consistent with the cooperative enterprise in the concept of risk and interest.

1= strongly disagree; 2= relatively disagree; 3= uncertain; 4= relatively agree; 5= strongly agree

Part IV Knowledge Sharing

28. We are willing to provide innovation partners with general views on issues, share some basic information, data and general technical methods.

1= strongly disagree; 2= relatively disagree; 3= uncertain; 4= relatively agree; 5= strongly agree

29. The latest research reports and trends are often provided in the industry.

1= strongly disagree; 2= relatively disagree; 3= uncertain; 4= relatively agree; 5= strongly agree

30. We have strong knowledge understanding ability and comprehension ability.

1= strongly disagree; 2= relatively disagree; 3= uncertain; 4= relatively agree; 5= strongly agree

31. We can obtain information, knowledge and experience from innovation partners.

1= strongly disagree; 2= relatively disagree; 3= uncertain; 4= relatively agree; 5= strongly agree

32. We can obtain knowledge information and technical information from the alliance.

1= strongly disagree; 2= relatively disagree; 3= uncertain; 4= relatively agree; 5= strongly agree

Part V Digital Construction

33. The enterprise adopts digital technology to transform and upgrade its existing products, services and processes.

1= strongly disagree; 2= relatively disagree; 3= uncertain; 4= relatively agree; 5= strongly agree

34. The enterprise comprehensively promotes digital design, manufacturing and management.

1= strongly disagree; 2= relatively disagree; 3= uncertain; 4= relatively agree; 5= strongly agree

35. The enterprise develops digital products and services.

1= strongly disagree; 2= relatively disagree; 3= uncertain; 4= relatively agree; 5= strongly agree

36. The enterprise is willing to spend energy to vigorously promote and publicize digital skills and management knowledge.

1= strongly disagree; 2= relatively disagree; 3= uncertain; 4= relatively agree; 5= strongly agree

37. The enterprise agrees that the adoption of digital technology and digital management is conducive to the development of the enterprise.

1= strongly disagree; 2= relatively disagree; 3= uncertain; 4= relatively agree; 5= strongly agree

ACKNOWLEDGMENT

The authors would like to thank the staffs who have participated in this survey for their help in obtaining the research data and completing the relevant research.

REFERENCES

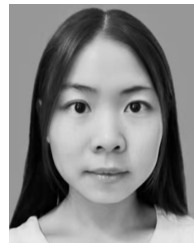
- [1] N. Satish, L. Kalle, M. Ann, and S. Michael, "Digital innovation management: Reinventing innovation management research in a digital world," *MIS Quart.*, vol. 41, no. 1, pp. 223–238, Jan. 2017.
- [2] J. He, H. Chen, and F.-S. Tsai, "Strategy orientation, innovation capacity endowment, and international R&D intensity of listed companies in China," *Sustainability*, vol. 12, no. 1, p. 344, Jan. 2020.
- [3] Z. Wu, Y. Shao, and L. Feng, "Dynamic evolution model of a collaborative innovation network from the resource perspective and an application considering different government behaviors," *Information*, vol. 10, no. 4, p. 138, Apr. 2019.
- [4] L. Klerkx and J. Guimón, "Attracting foreign R&D through international centres of excellence: Early experiences from Chile," *Sci. Public Policy*, vol. 44, no. 6, pp. 763–774, Dec. 2017.
- [5] J. Wang, Y. Xue, and J. Yang, "Boundary-spanning search and firms' green innovation: The moderating role of resource orchestration capability," *Bus. Strategy Environ.*, vol. 29, no. 2, pp. 361–374, Jul. 2019.
- [6] V. Naidoo, "Firm survival through a crisis: The influence of market orientation, marketing innovation and business strategy," *Ind. Marketing Manage.*, vol. 39, no. 8, pp. 1311–1320, Nov. 2010.
- [7] S.-T. Chen, K. Y. A. Haga, and C. M. Fong, "The effects of institutional legitimacy, social capital, and government relationship on clustered firms' performance in emerging economies," *J. Organizational Change Manage.*, vol. 29, no. 4, pp. 529–550, Jul. 2016.
- [8] W. Shan, C. Zhang, and J. Wang, "Internal social network, absorptive capacity and innovation: Evidence from new ventures in China," *Sustainability*, vol. 10, no. 4, p. 1094, Apr. 2018.
- [9] H. Jiao, Y. Wang, and M. Liu, "The effect of the social network of the top management team on innovation in cultural and creative industries: A study based on knowledge network embedding," *J. Chin. Hum. Resource Manage.*, vol. 10, no. 1/2, pp. 4–18, Oct. 2019.
- [10] W. Chen, X. Wei, and R. Liu, "Influence of interfirm social networks on technological innovation and its time lag effect: A meta-analysis," *IEEE Access*, vol. 7, pp. 167019–167031, 2019.
- [11] Y. Jiang, W. Chun, and Y. Yang, "The effects of external relations network on low-carbon technology innovation: Based on the study of knowledge absorptive capacity," *Sustainability*, vol. 10, no. 2, p. 155, Jan. 2018.
- [12] A. Thomas and V. Gupta, "Social capital theory, social exchange theory, social cognitive theory, financial literacy, and the role of knowledge sharing as a moderator in enhancing financial well-being: From bibliometric analysis to a conceptual framework model," *Frontiers Psychol.*, vol. 12, May 2021, Art. no. 664638.
- [13] Y. Li, Y. Song, J. Wang, and C. Li, "Intellectual capital, knowledge sharing, and innovation performance: Evidence from the Chinese construction industry," *Sustainability*, vol. 11, no. 9, p. 2713, May 2019.
- [14] R. Lubit, "Tacit knowledge and knowledge management: The keys to sustainable competitive advantage," *Organizational Dyn.*, vol. 29, pp. 164–178, Jan. 2001.
- [15] J. H. Choi and J. E. Scott, "Electronic word of mouth and knowledge sharing on social network sites: A social capital perspective," *J. Theor. Appl. Electron. Commerce Res.*, vol. 8, no. 1, pp. 69–82, Apr. 2013.
- [16] B. Mehdi, M. Stefan, C. Jim, and V. Wim, "How does outside-in open innovation influence innovation performance? Analyzing the mediating roles of knowledge sharing and innovation strategy," *IEEE Trans. Eng. Manage.*, vol. 67, no. 3, pp. 1–14, Jan. 2019.
- [17] L. Wu, B. Lou, and L. Hitt, "Data analytics supports decentralized innovation," *Manage. Sci.*, vol. 65, no. 10, pp. 4863–4877, Oct. 2019.

- [18] M. Iansiti, K. R. Lakhani, *Competing in the Age of AI*. Harvard Business Review Press, Jan. 2020, pp. 60–67.
- [19] W. Dai, Z. Mao, X. Zhao, and A. S. Mattila, “How does social capital influence the hospitality firm’s financial performance? The moderating role of entrepreneurial activities,” *Int. J. Hospitality Manage.*, vol. 51, pp. 42–55, Oct. 2015.
- [20] S. D. Berkowitz and D. Knoke, “Political networks: The structural perspective,” *Contemp. Sociol.*, vol. 21, no. 1, p. 27, Jan. 1992.
- [21] Z. Lin, H. Yang, and B. Arya, “Alliance partners and firm performance: Resource complementarity and status association,” *Strategic Manage. J.*, vol. 30, no. 9, pp. 921–940, Sep. 2009.
- [22] M. Baer, K. Evans, G. R. Oldham, and A. Boasso, “The social network side of individual innovation: A meta-analysis and path-analytic integration,” *Org. Psychol. Rev.*, vol. 5, no. 3, pp. 191–223, Aug. 2015.
- [23] M. G. A. Rojas, E. R. R. Solis, and J. J. Zhu, “Innovation and network multiplexity: R&D and the concurrent effects of two collaboration networks in an emerging economy,” *Res. Policy*, vol. 47, no. 6, pp. 1111–1124, Jul. 2018.
- [24] C. J. Collins and K. D. Clark, “Strategic human resource practices, top management team social networks, and firm performance: The role of human resource practices in creating organizational competitive advantage,” *Acad. Manage. J.*, vol. 46, no. 6, pp. 740–751, Dec. 2003.
- [25] X. Zhu and Y. Fei, “An empirical study on the relationship between relationship characteristics, resource acquisition and start-up performance,” *Nankai Bus. Rev.*, vol. 13, no. 3, pp. 125–135, Jun. 2010.
- [26] C. K. Prahalad and G. Hamel, “The core competence of the corporation,” *Harvard Bus. Rev.*, vol. 68, pp. 275–292, May 1990.
- [27] R. Lee, J.-H. Lee, and T. C. Garrett, “Synergy effects of innovation on firm performance,” *J. Bus. Res.*, vol. 99, pp. 507–515, Jun. 2019.
- [28] J. Xu, Q. Hou, C. Niu, Y. Wang, and Y. Xie, “Process optimization of the university-industry-research collaborative innovation from the perspective of knowledge management,” *Cognit. Syst. Res.*, vol. 52, pp. 995–1003, Dec. 2018.
- [29] I. Qureshi, Y. Fang, N. Haggerty, D. R. Compeau, and X. Zhang, “IT-mediated social interactions and knowledge sharing: Role of competence-based trust and background heterogeneity,” *Inf. Syst. J.*, vol. 28, no. 5, pp. 929–955, Jan. 2018.
- [30] S. Qiao, Q. Wang, Z. Guo, and J. Guo, “Collaborative innovation activities and BIM application on innovation capability in construction supply chain: Mediating role of explicit and tacit knowledge sharing,” *J. Construct. Eng. Manage.*, vol. 147, no. 12, pp. 166–172, Dec. 2021.
- [31] R. Rialti, L. Zollo, A. Ferraris, and I. Alon, “Big data analytics capabilities and performance: Evidence from a moderate multi-mediation model,” *Technol Forecast Soc Change*, vol. 149, no. 12, pp. 1–10, Dec. 2019.
- [32] R. G. McGrath, “Exploratory learning, innovative capacity, and managerial oversight,” *Acad. Manage. J.*, vol. 44, no. 1, pp. 118–131, Feb. 2001.
- [33] J. Yang and F.-K. Wang, “Impact of social network heterogeneity and knowledge heterogeneity on the innovation performance of new ventures,” *Inf. Discovery Del.*, vol. 45, no. 1, pp. 36–44, Feb. 2017.
- [34] M. Ruiz-Arroyo, I. Sanz-Espinosa, and M. D. M. Fuentes-Fuentes, “Alerta emprendedora y conocimiento previo para la identificación de oportunidades emprendedoras: El papel moderador de las redes sociales,” *Investigaciones Europeas de Dirección y Economía de la Empresa*, vol. 21, no. 1, pp. 47–54, Jan. 2015.
- [35] K. Koschatzky and R. Sternberg, “R&D cooperation in innovation systems—Some lessons from the European regional innovation survey (ERIS),” *Eur. Planning Stud.*, vol. 8, no. 4, pp. 487–501, Aug. 2000.
- [36] C. M. Porter and S. E. Woo, “Untangling the networking phenomenon,” *J. Manage.*, vol. 41, no. 5, pp. 1477–1500, Jul. 2015.
- [37] M. Schutte, “Building the knowledge society on the internet: Sharing and exchanging knowledge in the networked environments,” *Online Inf. Rev.*, vol. 33, no. 1, pp. 207–208, Feb. 2009.
- [38] H. Sullivan, “Building a knowledge-sharing system: Innovation, replication, co-production and Trust—a response,” *Austral. J. Public Adm.*, vol. 78, no. 2, pp. 319–321, Feb. 2019.
- [39] J. Alcácer, J. Cantwell, and L. Piscitello, “Internationalization in the information age: A new era for places, firms, and international business networks?” *J. Int. Bus. Stud.*, vol. 47, no. 5, pp. 499–512, Jun. 2016.
- [40] L. B. Si, “Construction of operation mechanism of technological collaborative innovation in equipment manufacturing industry,” *STPP*, vol. 34, no. 2, pp. 72–79, Jan. 2017.
- [41] Y. B. He, “Theoretical model of industry university research collaborative innovation,” *Stud. Sci. Sci.*, vol. 30, no. 2, pp. 165–174, Jan. 2012.
- [42] P. Akhtar, Y. K. Tse, Z. Khan, and R. Rao-Nicholson, “Data-driven and adaptive leadership contributing to sustainability: Global agri-food supply chains connected with emerging markets,” *Int. J. Prod. Econ.*, vol. 181, pp. 392–401, Nov. 2016.
- [43] B. van den Hooff and J. A. de Ridder, “Knowledge sharing in context: The influence of organizational commitment, communication climate and CMC use on knowledge sharing,” *J. Knowl. Manage.*, vol. 8, no. 6, pp. 117–130, Dec. 2004.
- [44] Q. Hu, “Mechanism and performance of enterprise digital transformation,” *Zhejiang Acad. J.*, vol. 241, no. 2, pp. 146–154, Mar. 2020.



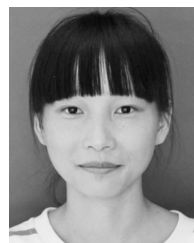
BIN MIAO is currently the Vice President of the School of Management and Economics, North China University of Water Resources and Electric Power, the Deputy Director of the MBA Center, a Professor, and a Master Supervisor, China. He has won the third prize of scientific and technological progress in Henan Province, the first prize of educational achievements in Henan Province, and the second prize of scientific and technological information achievements in Henan Province.

He has published many SCI and EI articles, published many academic works, and presided over key projects in Henan Province of China many times. His research interests include human resource management, enterprise economy, accounting, finance, and taxation.



YINGJIE LIANG is currently pursuing the master’s degree with the School of Management and Economics, North China University of Water Resources and Electric Power, China. She once participated in the science and technology public relations project of Henan Province, China “Research on the transformation path of social industry medical institutions based on the virtual pension of Internet of Things,” and presided over the graduate innovation project of North China

University of Water Resources and Hydropower “Research on the impact of organizing social networks on Enterprise collaborative innovation under the background of the digital economy.” Her research interests include enterprise innovation, digital economy, and knowledge management.



YUEYUE SUO is currently pursuing the master’s degree with the School of Management and Economics, North China University of Water Resources and Electric Power, China. She once participated in the science and technology public relations project of Henan Province, China, “Research on the transformation path of social industry medical institutions based on the virtual pension of the Internet of Things,” and presided over the graduate innovation project of North

China University of Water Resources and hydropower, “Research on the impact of destructive leadership on employee performance in the post epidemic era.” Her research interests include leadership and employee creativity.

...