Network Structure and Innovation Performance-The Mediating Role of Tacit Knowledge Sharing Behavior

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Abstract

With the introduction of tacit knowledge sharing behavior of employees, this paper explores the mechanism of the network structure on innovation performance. Research shows that: the network connection strength, the network centricity and network scale significantly affect tacit knowledge sharing behavior, and tacit knowledge sharing behavior significantly affects innovation performance; Network connection strength, the network centricity, network scale significant direct impact on the innovation performance; Tacit knowledge sharing behavior is the intermediary variable. The results of the research further the relationship between the network structure and the innovation performance. The network structure can promote innovation performance through the intermediary role of tacit knowledge sharing behavior.

Key words: INNOVATION PERFORMANCE, NETWORK STRUCTURE, TACIT KNOWLEDGE SHARING BEHAVIOR.

1. Introduction

The enterprise facing unpredictable internal and external environment at intellectual economic times, innovation becomes the eternal theme. Innovation performance is becoming enterprises' focuses. Network structure being the important feature in group network has a prominent influence on enhancing enterprise core ability and improving enterprise innovation performance. However, the influence is not occurred directly [1]. There are many factors to limit the enterprises' innovation performance. The occurrence of innovation is a process of interaction in network. It relies on not only network of enterprise, production policy, laws and regulation, etc., but also the internal factor of tacit knowledge sharing behavior. High level of tacit knowledge sharing behavior could help to obtain the technology, resource and information, etc., and to improve the enterprises' innovation performance. Network structure, tacit knowledge sharing behavior can help the innovation's occurrence, and improve the innovation performance of enterprise.

Recently, there are abundant researches on the relationship between network structure and innovation performance. Some scholars focus on the direct

influence of network structure on innovation performance. Sccot showed that network structure could tighten employee communication, which could share knowledge adequately [2]. The interaction between the supplier and the customer can make the enterprise more successful in product improvement. College and research institution play an important role in new production development [3]. Shan, Walker and Kogut (1994) indicated a positive correlation between the interaction in enterprise network and the innovation output [4]. From analyzing the formation process of learning network, the network centricity of bio emerging enterprises had the positive impact on the prospering co-operated technology innovation among enterprises [5]. Structure features embedded in the enterprise network, such as network density, association strength, reciprocity, stability, intermediateness and the level of resource, have a positive effect on innovation performance. Some scholars analyzed network structure's influencing mechanism on the innovation performance, and generally proves the positive correlation between network structure and innovation performance. Some scholars further studied the mechanism between these two variables.

From the research literature, academic group has deeply research the relationship between network structure and innovation performance. However, the perspective from mediating role of knowledge sharing behavior is ignored. Thus, this paper treats the knowledge sharing behavior as the mediating variable, network structure as independent variable, and innovative performance as the dependent variable. This paper collected the data from investigation, applied SEM to analyze the relation among variables. This study tries to explain the influencing path of the knowledge sharing behavior as mediator, to unfold the black-box of 'network structure-innovation performance' relationship, and to further reveal the mechanism of network structures' effect on innovation performance to explore the new path to improve the innovation performance.

2. Theoretical basis and research hypothesis
2.1 Theoretical basis
2.1.1 Network structure

Some classical literatures related to network structures believe the resource type of network players depends on network structure. Network structures are features in the relationship among network nodes. Granovetter [6] defines two dimensions of network structure: relation embeddedness and structure embeddedness. Gilsing [7] divides network structure to network connection density, connection scope and network centricity. Siu [8] believes network structure

consists of network structure scope and network centricity. In conclusion, this paper divide network structure into network intensity, network stability, network centricity and network scale. Network intensity is the connection frequency in enterprise network. It performs connection times, the degree of intimacy, the degree of reciprocity, etc. Network centricity is the number of enterprise connection through the focus enterprises, inspects the importance and position advantages in network environment, the extent to which acts as a network hub, and degree of control over the resources. Centricity is the position enterprise stands in the network. Network scale is the number that enterprise connects with others. The more innovation partners, the more innovation resource enterprise will get which will bring the power to innovation.

2.1.2 Tacit knowledge sharing behavior

Polanyi firstly introduces explicit knowledge and tacit knowledge. Goldblatt points that explicit knowledge only represents a tip of the iceberg while tacit knowledge is the base. Compared with explicit knowledge, tacit knowledge is implicit, not coding and high level of personal perception. It is not easy to imitate by competitors and is the cornerstone of enterprise core competitiveness. The exploration and explicitness of tacit knowledge are the source power of knowledge innovation and the premise of new products and new services. IBM, McKinsey research shows that many of enterprise knowledge are hidden in tacit knowledge, which is important resource to cultivate core ability, improve competitiveness and develop technology innovation ability.

Behavior is common action in reality and is the focus in this research [9]. Tacit knowledge sharing behavior is a process that swapping from individual ration consciousness and creation new knowledge. This process is realizing from personal to organization [10]. In the past, tacit knowledge sharing researching focuses on cause and application, but less on influence of personal or organizational performance and behavior.

2.1.3 Innovation performance

In 1912, Schumpeter proposed the concept of "innovation". From line mode, market coupling mode, chain mode, system integration and network mode to recognize the innovation mode.

Innovation performance is sum of enterprise internal innovation changes, which performs the profit increasing, new production or new developing service, core competitiveness enhancing, etc. It is sum of ability, process and result, performing enterprise direct economic performance and potential development ability.

2.1.4 Structural equation model and mediator

Structural equation model is a comprehensive statistical method, which uses variable covariance matrix to analyze the relationship among a number of reasons and results and deals with such variables which can't be directly observed. This method makes up for the shortcomings of traditional statistical method and has become an important tool for multivariate data analysis. （Judd & Kenny，1981；Baron & Kenny，1986）

If the variable X affects Y by M, M is mediator [17]. Mediating effect means that when the regression has a mediator X only. X and M exists a causal relationship. Variable M and Y exists a causal relationship. When the M is put into the regression, the causal relationship between X and M is not continued. So M is complete mediating effect. Otherwise, X is partial mediating effect [18]. At this time, the causal relationship between X and Y remains exist, but it is weakened.

The regression equation is:

$$Y = cX + e_1 \qquad (1)$$

Among them, Y is the independent variable, Y is the dependent variable，c is an error, and coefficient c represents the total effect (Indirect effect and direct effect).

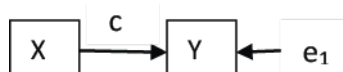It can be expressed by structural equation model as:

Figure 1. Causal relationship

Doing the regression of Y to X and M, the regression coefficients are c' and b. Doing the regression of M to X, it can get the regression coefficients of a. Mediating effect is $a*b$. Test the coefficient a and b. If both of them are significant,$sig < 0.05$, the mediating effect is significant. If the mediating effect is significant and at the same time c' is not significant, it is completely intermediary. The role of independent variable on the dependent variable is completely created by mediator M. If c' is signifi-i cant, the role is partial mediating effect.

$$M = aX + e_2 \qquad (2)$$

$$Y = c'X + bM + e_3 \qquad (3)$$

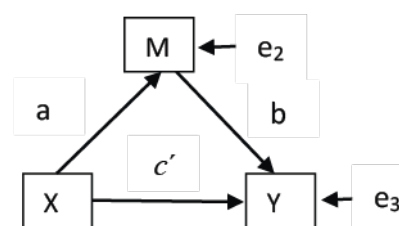The relationship between the effect：

$$c = c' + ab \qquad (4)$$

Figure 2. The mediating effect of M

2.2 Research hypothesis

2.2.1 Network structure and innovation performance

Network Growth Pattern, which gets rid of traditional logic of Value Exchange Theory, is the rational choice for enterprise to grow rapidly in network environment. It transfers the way of competition from individual enterprise to inter organizational Networks [13]. So, network relationships between enterprises have become important intermediary. Network members use Value Network to complement the supply of resources for each other [14]. Network structure makes the member enterprises can have deeper and wider communications by providing a communicate platform for them. Network structure directly influence the potential of network and the generation of knowledge, for dense structure will have better ability in information transmission, then promoting the communication and cooperation between nodes of network.

It is believed by Simsek that inter-firm networks and entrepreneurial behavior accelerates the knowledge share between enterprises, strong link relationships will shape the attitude and faith of sharing [15]. This will make enterprises recognize the change of market quickly by promote deep communication of knowledge and information in network. Strong link of network helps the enterprises interact deeply, believe in each other firmly, save selling expenses, reduce the cost of acquiring information and knowledge as this paper as accelerate the spread speeding. All these will avail companies' better performance. Network position, which is usually expressed in network centrality, has great effects on business unit innovation and performance [16-17]. By analyzing the network centrality, enterprise can know whether they have become the hub of network, whether they can obtain or control a resource. Enterprises have higher centrality make it easier to get and control the latest news relevant to innovation, own various information channels and information sources, converge complementary skills from different companies, and often can win the opportunity of cooperating with excellent enterprise. Shan W, Walker G, and Kogut B [18] think the

number of Inter firm cooperation (network scale) and innovation has positive correlation, because network scale can reflect the abundance of acquiring innovation resources: The larger, the more abundant, the more likely to realize the scale effect of innovation.

In conclusion, this paper assumes:

H1.1: There is positive relationship between degree of inter-firm networks linking and innovation performance.

H1.2: There is positive relationship between network centrality and innovation performance.

H1.3: There is positive relationship between network scale and innovation performance.

2.2.2 The relationship between network structure and tacit knowledge sharing behavior

Social network has remarkable effect on tacit knowledge. It is the main channel of spreading tacit knowledge [19]. From its process, sharing tacit knowledge is the connected relationship between groups in network. Strong link can promote enterprises to develop the convention of sharing knowledge and to form cognitive model. It will create the sharing attitude, proposal and faith, which will improve organizations' learning degree. As an important social capital, the network position in enterprise is a key factor that influences learning effect. Enterprise, who is in the network center, acts as the role of the hub of the network, have better ability to access to the network information and resources, and through the comparison evaluation of information, to ensure the authenticity of the information. Network size can not only expand the amount of information acquisition, but also increase the diversity of network relations, which is conducive to obtain the heterogeneity of information, and thus improve the behavior of tacit knowledge sharing.

In conclusion, this paper assumes:

H2.1: There is positive relationship between degree of inter-firm networks linking and Tacit knowledge sharing behavior.

H2.2: There is positive relationship between network centrality and Tacit knowledge sharing behavior.

H2.3: There is positive relationship between network scale and Tacit knowledge sharing behavior.

2.2.3 The relationship between tacit knowledge sharing behavior and innovation performance

In the process of cooperation and communication between enterprises, through the channels of exchanging knowledge, information, skills, new ideas, the spread of time and space, so that different nodes in the network can achieve sharing knowledge and information, and strengthen the enterprises' knowl-edge bases, generate new creations or ideas, further improve the performance of enterprise innovation. Knowledge sharing between organizations can effetely promote organization of knowledge capital appreciation, so as to improve the organization's performance.

Hence, this paper assumes:

H3: Tacit knowledge sharing behavior has a significant positive effect on employee innovation performance.

2.2.4 The mediating effect of tacit knowledge sharing behavior

According to the principle of the selection of the intermediate output of Baron and Kenny, the intermediate variable must have a strong correlation with the independent variable and dependent variable. The new synthesis of network organization members' tacit knowledge and information rooted in the action of network actors and organizations, and help enterprises to share the benefits of network embedding and access to knowledge. Through these shared knowledge and technology to improve the overall innovation capability of the network enterprise. Enterprises in the network can absorb more knowledge, and have a higher growth rate and innovative performance.

Therefore, this paper considers that tacit knowledge sharing behavior is the intermediary variable between network structure and innovation performance. So, it put forward the following hypothesis:

H4: Tacit knowledge sharing behavior plays an intermediary role in the relationship of network structure (network connection strength, network centrality, network size) and innovation performance.

According to the above discussion, the research model is presented as shown in figure 3:
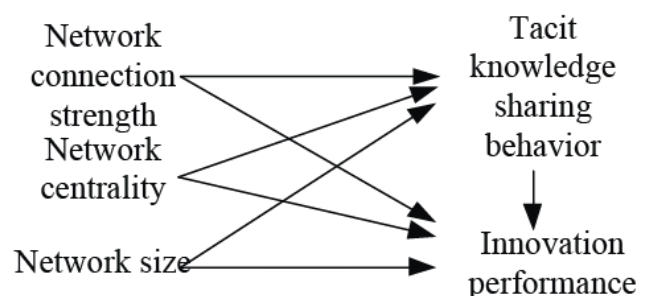

Figure 3. Research model

3. Research design
3.1 Data collection

The data collected in this paper is carried out by the way of questionnaire survey. The objects are high-end service enterprises. The reasons for selecting high service enterprises as the object of investigation are: the high-end service enterprises are general-

ly based on service innovation, knowledge intensive enterprises, and enterprises attach great importance to innovation performance. In order to improve the universality of the research conclusion, the sample involves more than 30 enterprises in Xi'an, Zhengzhou, Tianjin, Wuhan, Shenzhen and other cities. Through email, phone calls or visits with enterprise sales information center and the human resources department related personnel communicate, which mainly introduces the research background, show that the survey of intention, distribution and collection of questionnaires, a total of 306 questionnaires this paper issued, 163 copies of questionnaires, effective 132 questionnaires, recovery rate was 53.27%, and the recovery of effective rate was 80.98%. The basic features of the sample are as follows.

Table 1. Subjects distribution table

Feature	Sample Distribution	Number of samples (person)	Percent (%)
Age	20-30 Years Old	47	35.61
	31—40 Years Old	85	64.39
	41 years old (or more)	33	25.00
Gender	Male	132	66.00
	Female	68	34.00
Educational Background	College (Inclusive)	86	65.15
	Undergraduate	40	30.30
	Postgraduate	6	4.55
Seniority	5 Years (Inclusive)	58	43.94
	6--15 Years	32	24.24
	16 (or More) Years	42	31.82

3.2 Mesurement of variable and testing of validity and reliability

This research sheet absorbs related filelds of research results. From researching view, this paper adjust part of measurement clauses in order to make the subject suit for rsearching content. This measurement subjet according to the Likert five level measurment sheets designed. Number 1 shows the least suitable degree. The number is larger, the suitable degree is higher. Number 5 shows very suitable.

The measurement of enterprise network structure is according to the questionnaire of Pothis paperll, Gnyawai, Madhavan, Gilsing, Nooteboome and Caner [20-22]. It has three dimensions mesurement structure, which are network communication strength, network centrality and network scale. Network communication strength sheet refers to Granovetter [23]. There are seven communication frenquencies to inspect the communication strength between enterprise and enterprise group, which are objective enterprise and customer, supplier, competetior, college and scientific research insitution, intermediary, financing institution and government department, etc. The de-sign of network position sheet refers to Freemadan's mesurement research [24]. It has two demensions and four subjects. The network scale sheet refers to Powerll's researching, which has six questions [5].

The measurement of tacit knowledge sharing behavior refers to Lin CP's researching result to determine three subjects [25].

The measurement of innovation performance refers to OECD's Proposed Guidelines for Collecting and Integrating Technological Innovation Data and to Haiyang Li, Kwaku Atuahene Gima's point [26]. It divides enterprise innovation performance into two parts, which are innovation effect and innovation efficiency. They have four indexs to measure enterprise innovation performance that are new product number in past three years, innovative product revenue, successful application to the patent number of innovative and innovative product sales revenue accounted for proportion of total sales revenue.

The specific questionnaire of measurement sheet and the result of validity and realiability is shown in table 2.

Table 2. Measuring item and the analysis of reliability and validity

Measured Variables	Measured Question	Literature sources	Factor loading	CR	AVE	α Coefficient

Degree of Inter-firm networks linking	Our company has closer connection with customers than others who do the same business with us	Granovetter (1973)	0.823	0.83	0.71	0.81
	Our company has closer connection with suppliers than others who do the same business with us		0.845			
	Our company has closer connection with competitors than others who do the same business with us.		0.797			
	Our company has closer connection with University and scientific research institution than others who do the same business with us		0.785			
	Our company has closer connection with intermediary than others who do the same business with us		0.790			
	Our company has closer connection with banking institution than others who do the same business with us		0.835			
Network centrality	When the co-operative enterprise are building its internet connection□they often use your company	Freeman (1979)	0.792	0.81	0.69	0.82
	The enterprise can offer other cooperation relationship and partner		0.783			
	The enterprise mainly builds the cooperation partner by other cooperation relationship		0.734			
	The enterprise uses several intermediaries to find and build new cooperation relationships and partners		0.796			
Network scale	The enterprise has lots of customers	Powell (1996)	0.848	0.84	0.58	0.81
	The enterprise has lots of suppliers		0.825			
	The enterprise has lots of competitors		0.817			
	The enterprise has lots of partners who are Universities and scientific research institutions		0.758			
	The enterprise has lots of partners who are government agencies		0.745			
	The enterprise has lots of partners who are banking institutions		0.784			
Tacit knowledge sharing behavior	I would like to share my working experience with my colleagues	Lin CP (2007)	0.867	0.86	0.71	0.83
	I would like to share my technique skills with colleagues		0.854			
	I would like to share my knowledge if my colleagues need me to do that		0.835			

Innovation performance	The number of innovation product of the enterprise in the past three years	Haiyang Li, Kwaku Atuahene Gima (2001)	0.792	0.82	0.78	0.79
	The sales revenue of the enterprise in the innovation		0.806			
	The number of innovation product of the enterprise with patent in the past three years		0.763			
	The percentage of the innovation product in past three years		0.795			

3.3 Statistical Analysis

From table 1, all of the Cronbach α of Variables are higher than 0.7, which implicates that the table is reliable. The normalized factors of variable in table 2 are located between 0.734-0.867. Both of the Composite Reliability and the Average Variance Extracted are higher than the acceptable value o.7 and 0.5. This implicates that the convergent validity of the table is reliable.

In addition, there may be Common Method Variance, CMV because the questionnaires use the self-report. According to the single factor experiment that proposed by Harman, this paper do the exploration factor analysis to the 23 questions. This paper gets the result that the SPSS of the first main factor which is not rotate is 25.3%, and it is obviously smaller than 40%. This indicates that the first factor is not a leading role to the explanation of the variable. So the obvious difference of common ways does not exist.

4. Results

4.1 The examination of the adaptability model

The structural equation modeling adopted by this paper examines the direct and in direct effects. The software adopted AMOS 22. Before the examination of the assumption, it needs to examine the situation of the whole adaptability model. The result of the examination: χ^2 / df = 2. 37(less than 3), RMSEA = 0. 07 (less than 0. 08), GFI =0. 94(more than 0. 9), AGFI = 0. 92 (more than 0. 9), CFI = 0. 91(more than 0. 9), NFI = 0. 92(more than 0.9), IFI = 0. 93(more than 0. 9). Every index meets the standards of the surveying and this shows that the model suits this paper.

4.2 hypothetical testing

4.2.1 The examination of the direct ways

Sheet 3 illustrates the research model of the path analyses results. The network connection strength, the network centricity, and the network scale have various and positive effects on the innovation performance, assuming that H1.1, H1.2, and H1.3 get examined.The network connection strength, the network centricity, and the network scale have various and positive effects on the tacit knowledge sharing behavior, assuming that H1.1, H1.2, and H1.3 get support. The path coefficient for the tacit knowledge sharing behavior and innovation performance of employees is 0.33, which reaches the magnificent level of 0.001, assuming that H3 gets support.

Table 3. The result of the path analyses

Assumption	Path	Path Coefficient	T Value	Result
H1.1	The network connection strength to the innovation performance	0.27**	3.25	Support
H1.2	The network centricity to the innovation performance	0.22**	2.83	Support
H1.3	The network scale to the innovation performance	0.24**	2.92	Support
H2.1	The network connection strength to the tacit knowledge sharing behavior	0.26**	3.12	Support
H2.2	The network centricity to the tacit knowledge sharing behavior	0.25**	2.98	Support
H2.3	The network scale to the tacit knowledge sharing behavior	0.19*	2.37	Support
H3	The tacit knowledge sharing behavior to the innovation performance	0.33***	4.34	Support

Reference:*,**, and*** respectively show that the magnificent level are 0.05, 0.01 and 0.001.

4.2.2 The examination of the indirect effect

Adopt the measure of the assumption without normal distribution for the bootstrap to examine the intermediary effect of the tacit knowledge sharing behavior. AMOS offers the relevant functions. The number of the samples for bootstrap is 1000. The confidence interval is 95% and the results are shown in the sheet4.

Table 4. The examination result of the indirect effect

Path	The value of the intermediary effect	P value	The minimum of 95%Confidence interval	The maximum of 95%Confidence interval
The network connection strength→The tacit knowledge sharing behavior→The innovation performance	0.096*	0.028	0.042	0.463
The network centricity→The tacit knowledge sharing behavior→The innovation performance	0.079*	0.031	0.094	0.532
The network scale→The tacit knowledge sharing behavior→The innovation performance	0.106*	0.019	0.138	0.613

From sheet4, this paper can learn the apparent level of the extreme values of three paths; P values are all less than 0.05 and the confidence intervals of three all exclude 0. All of these prove that the intermediary effect makes great sense and they also prove the tacit knowledge sharing behavior plays a role of the intermediary variable among the relationships of the network connection strength, the network centricity, the network scale and the innovation performance, assuming that H4 gets partially examined.

5. Discussion

Tacit knowledge sharing behavior is introduced to this paper for the first time as the intermediary variable to discuss the mechanism of the network structure on innovation performance. Real evidence shows that network structure plays the intermediary role for the tacit knowledge sharing behavior between the network structure and the innovation performance, which also proves that network structure has positive effects on the tacit knowledge sharing behavior and the innovation performance and so does the tacit knowledge sharing behavior to the innovation performance. The network structure affects through the tacit knowledge sharing behavior. To some extent, it connects the network structure and the innovation performance. But there are still other ways to affect and the intermediary variables need to be further analyzed in the later research. In addition, this paper is only involved in the enterprises which locate in the high level. Whether the result of the research can apply to other areas still needs deep confirmation.

6. Conclusions

Although the research of the relationship between the network structure and the innovation performance is prosperous, there is little research regarding the tacit knowledge sharing behavior as the intermediary medium. The concept of the tacit knowledge sharing behavior gets the network connection strength, the network centricity, network scale, the tacit knowledge sharing behavior, the innovation performance together and it systematically analyzes the ways of affecting and mechanism of action so that it offers the basics of the theory for the innovation performance and the followings are the main conclusions of the research:

(1) The effect of the network structure on the tacit knowledge sharing behavior. The network connection strength, the network centricity, network scale have the variously positive effects on the tacit knowledge sharing behavior. And this conclusion is consistent with the majority of former researches. Strong connections can contribute to the formation of the habit of sharing knowledge between enterprises and it also promotes the firm in the central of the network strengthen its confidence to share with its advantages of resources. It brings that the network scale is helpful with the appearance communication of the different information and the tacit knowledge sharing behavior. So, the terrific network connection strength, the network centricity, and the network scale are helpful for the promotion of the tacit knowledge sharing behavior.

(2) The effects of the tacit knowledge sharing behavior on the innovation performance. The tacit knowledge sharing behavior among enterprises can internalize the knowledge, the information, the skills and new ideas. It also inspires new concepts, cultivates the environment of the innovation and is good for the improvement of the innovation performance.

(3) The relationships among the network structure, the tacit knowledge sharing behavior, and the innovation performance. It can be found that the net-

work connection strength, the network centricity, and the network scale variously and directly influence the innovation performance of employees and create the apparent intermediary effects through the tacit knowledge sharing behavior on the ground of the assumptions H1.1, H1.2, H1.3, H1.4. In this process, the tacit knowledge sharing behavior plays an important role which passes on the positive effects of the network connection strength, the network centricity, and the network scale to the innovation performance. In other words, good network structure not only promotion of the innovation performance but also has the indirect effect on the latter one through the tacit knowledge sharing behavior. In this way, it can offer ways and bases to the enterprises as network members through the tacit knowledge sharing behavior improving the innovation performance.

This paper about network structure, the tacit knowledge sharing behavior and the innovation performance proves the mechanism of action among them and has an effect of the guidance on the practical management.

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Analysis of Business Competitive Cooperation Relationship Based on Game Theory

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Abstract
Based on the electronic businesses on the E-commerce platform as the research subject, this paper establishes the incomplete information static game model, to carry out the game analysis on the behavior between the businesses involved in the transaction, so as to make suggestion to establish and perfect the trust mechanism of E-commerce. The game behavior between the businesses is fundamental the game in