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AStudy on the Mechanism of Open Innovation on Enterprise InnovationAbility

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Abstract: The implement of enterprises open innovation has great significance on improving its innovation ability. The main purpose of the enterprises implement of open innovation is to obtain the ten key resources, and the measurement of enterprise innovation ability mainly focused on the enterprise inject, production, management, marketing, output five aspects. The thesis constructed the relationship model between open innovation and enterprise innovation ability, and used structural equation model to verify the rationality of the conceptual model of relationship, the result of which shows that both the horizontal and vertical cooperation between enterprises, the government-industry-university-research cooperation as well as the public innovation platform construction is conducive to the improvement of enterprise innovation ability.

Keywords: Open Innovation; Enterprise Innovation Ability; Structural Equation Model

1. INTROUCTION

In knowledge economy era, innovation has become a trend, however, the demand of the market and the complexity of the enterprise survival environment has made the enterprise's survival pressure getting more and more stronger, and the original innovation power becoming more and more intense, as a result, enterprises spend a lot of effort, human, financial and material resources on technical innovation. The most typical representatives are multinational enterprises such as IBM and Procter & Gamble. Before the 1990s, the multinational company is relying on its abundant scientific research strength and advanced equipment instrument to develop lots of revolutionary innovations, while contributing to the science improvement of human society. But at the end of the 20th century, the profits of these old innovation giant tended to stagnant or even backward slightly. The study result shows that although the enterprise still has a lot of innovation every year, these innovations has not been used for commercial production. As time goes by, these innovations will gradually lose to the outside of the enterprise, while leaving the achievements made up with a great deal of manpower, material resources, financial resources to bring no profit to the shareholders of an enterprise at all. However, some emerging enterprises established a stark contrast to the existed enterprises performance in the meanwhile, such as Cisco and Intel. Although these emerging enterprises lack of strong scientific research ability, they are good at using external innovation resources, and grasping every opportunity, as a result, these enterprises accomplished the rapid expansion in a short time and give the established enterprises with a certain degree of threat. This strange phenomenon of enterprise has aroused the attention of many scholars, in 2003, the American scholar Chesbrough formally put forward the term" open innovation " in his book < Open innovation: technical innovation and profit from the new rules>, and quickly got the academia widely recognized[1]. Under the new situation, studying the effect of open innovation on the enterprise innovation ability, and exploring its mechanism to promote our country enterprise innovation ability, and the construction of an innovative country is of great significance.

2. LITERATURE REVIEW

The core idea of the resource-based theory which is born in the 20th century is that enterprise consists of sorts of tangible or intangible resources which can turn into a unique ability, and these resources can support the

implementation of enterprise strategy, mainly including enterprise assets, comprehensive ability, enterprise owned information and knowledge, enterprise attributes and so on[2][3]. Teece (1986) [4] found out that resources is the foundation of enterprise innovation, especially complementary resources the enterprises need. Other scholars believe that the implementation of cooperative innovation between enterprises is based on the introduction of technology and market knowledge. Cohen and Levinthal (1990) [5] argued that enterprise can obtained technology from the partners through the way of imitating and turned it into their own ability. In 1998, Hippel proposed the four external source of enterprise knowledge in his research: (1) the foreign technology and competitors; (2) the government and private research institutions; (3) users and suppliers; (4) the university [6]. Allen and Nishiguchi affirmed the importance of enterprise external innovation source supplier, and they believed the important part of the information technology development projects came from the supplier. Hagedoorn (1993) [7] discussed the complementary assets strategic cooperation problem between enterprises, and found that complementary cooperation is an effective mechanism to maximize the enterprise value. Katz (1961) [8] agreed the development of enterprise cooperation would enable the enterprise to improve the development efficiency. Scholars such as Gemunden(1996) [9][10] found that there are eight external organizations contributed to the enterprise innovation success through the empirical study, namely: 1) the user; (2) the distributor; (3) cooperation supplier; (4) raw materials suppliers and manufacturers; (5) competitors; (6) the government; (7) research and training institutions; (8) the consultant.

Some scholars pointed out that one of the main purposes for enterprises implementing open innovation is to obtain the key resources innovation needed to enhance the competitiveness of the enterprises [11]. The innovation resources out of the enterprise which is also known as the enterprise external innovation resources, compared with the enterprise internal innovation resources, it is also one of the important sources of innovation resources. To reach the company internal and external resources optimal configuration, it is the key to obtain and maintain enterprise competitive advantage [12], as a result, one of the key point of the modern enterprises to improve their innovation ability is to use the external innovation resources effectively. The external innovation resources, on the one hand, can bring new business models and fundamental change to enterprises, on the other hand, can realize enterprise internal and external innovation resources' collaborative configuration, and improve enterprise internal ability including learning, absorption, research and development, which is helpful to improve the core competitiveness of enterprises. On the lateral level, enterprises can cooperate with competitors to enhance the enterprise discursive right, and affect the business environment, more importantly, it can improve enterprises' discursive right in industry standards making process, while contribute to the more objective and specific policies, promoting the development of the industry. On the longitudinal level, enterprises can realize resources integration either with upstream or downstream enterprises (such as users and suppliers), on the one hand, it can help enterprises understand the specific innovation needs of upstream and downstream enterprises, on the other hand, it can improve the overall efficiency of enterprises to achieve the optimal allocation of resources.

Zhao Xiaoqing (2004) [13] divided the source of knowledge lead to enterprise technical ability growth into two categories: internal knowledge and external knowledge. The three ways for enterprises to acquire external knowledge are imported technology, form strategic alliances with other enterprises and build the innovation network system, through external knowledge acquisition, enterprise technical ability will be greatly increased. Ye Fei (2007) [14] found that if let suppliers to participate in the early days of new product development phase, the value of the product will be greatly improved. While some scholars divided enterprise external innovation resources into two levels: external innovation main body and the used tangible or intangible resources. Among them, the former refers to the entities which can improve innovation resources for the enterprise, including longitudinal users and suppliers and transverse competitive enterprises and research institutions; the latter mainly includes the technology, knowledge and capital the enterprise innovation needed. Professor Chen

Jing(2007) [15] studied the related problems for mobile phone enterprise external innovation source, and found out that the main innovation source of the mobile phone is manufacturers and customers, additionally, customers can improve the efficiency of enterprise's development greatly. What's more, he also classified the external innovation resources system into 7 classes, namely suppliers, competitors, customers, research institutions, universities, government, and consultancy. In subsequent studies, Chen Jing (2009) added intellectual property rights and risk investment institutions into the enterprise external source of innovation, on the basis of the leading users and mainstream users.

3. THERETICAL MODEL CONSTRUCTION

3.1 Longitudinal cooperation and technology intensive enterprise innovation ability

3.1.1 Suppliers

Both the theoretical research and specific practice show that the strategic partner relationship between enterprise and its suppliers can consolidate and improve enterprise's core competitive ability significantly. Propris (2000) [16] found that the cooperation between enterprises and suppliers can improve the innovation ability of enterprises after investigating part of the UK enterprises. After studying forklift and forklift related field, Hippel found parts suppliers is an important power of enterprise innovation. Participating in the innovation of the enterprise in the early design and development process, through technology combined, suppliers can assess different ideas more objective and fair from multiple angles, and points out the unreasonable place during design and development process, saving development time, reducing the waste of resources, shortening the innovation cycle and improving the efficiency. Some scholars believe that by sharing technology and market information, enterprises and suppliers can reduce the uncertainty in the process of research and development, while improving the success rate of innovation. After realizing the importance of supplier to enterprise innovation, Japan is the first to bring supplier into the enterprise innovation activities, and has made a huge success. Since then, many large multinational companies follow the lead, build strategic partnership with the enterprise supplier and jointly cope with the fierce market competition.

3.1.2 Users

With the development of economy and increasing strength of governments to crackdown corporate monopoly, products have been changed from a seller's market into a buyer's market, that is to say, users have more freedom to choose to buy or not buy and what to buy the product. In order to adapt to the demand of diversification of users, the enterprise needs to learn the user's actual demand, and it is also important to let users to participate in the product development stage. Rothwell (1992) [17] found that the key to the success of innovation should be guided by the user. Enterprises need to understand the needs of users listen to the voice of the user and actually reflect the needs in the R&D process to provide more superior and diversified products. Enterprises should keep close contact with customers, which can shorten the development cycle, reduce development costs, reduce market risk, and improve the efficiency of innovation. In the enterprise development process, users' importance reflects in the following four aspects: first, the user can provide enterprise product demand information, and make enterprise aware of the innovation direction; Second, to the users can help enterprise balance product performance and cost in the process of innovation; Third, since the innovation is based on the needs of users, reducing the resistance of the same type of user is conducive to product sales.

According to the above analysis, the thesis puts forward the following hypothesis:

H1: Cooperating with longitudinal enterprise is conducive to the improvement of enterprise innovation ability.

3.2 Horizontal cooperation and technology intensive enterprise innovation ability

3.2.1 Competitors

Nowadays, the enterprise strategic alliance, especially the strategic alliance between competitors has become the more and more popular. The appearance of this kind of situation is not an accidental phenomenon, professor Piao Shenghu (2008) [18] believes that this is the inevitable result of the new historical conditions: first, when the multinational companies enter into the product markets in other countries, the local market competition can provide better cooperation and is conducive to product promotion in foreign countries, and sino-foreign joint venture is the typical representative of this model; Second, with the diversity consumer demand, cooperating with the specialty competitors can help enterprise make the full of each other's advantages to develop products with new properties, and meet the demand of consumer diversity; Third, as the modern science and technology is more and more developed, the spread of the enterprise technology is becoming more and more fast, and the product life cycle is becoming more and more short, the cooperation with competitors can reduce the uncertainty in the process of new product development, and improve the success rate of innovation; Fourth, the cooperation with competitors can improve enterprise discourse power.

3.2.2 Complementary enterprises

Enterprises can not only build strategic alliance with competitors, but also cooperate with technology complementary enterprises. In the initial stage of product development, technology and development capability is the key to the success of enterprise innovation, the cooperation with competitors dominate in this stage; But in the late of product research and development process, as firms could not have all the elements needed to innovate, cooperating with technology complementary enterprises to get scarce resources of innovation is the key to success. The complementary relations of cooperation must based on the complementary of technology and need between each other, namely, the partner’s advantage can make up for the other party’s weakness. Through setting up cooperative relationships with complementary businesses, the success rate of innovation in product research and development can be improved, and the commercial application of products will becoming faster.

According to the above analysis, the thesis puts forward the following hypothesis:

H2: Cooperating with horizontal enterprise is conducive to the improvement of enterprise innovation ability.

3.3 Government-industry-university-research cooperation and technology intensive enterprise innovation ability

3.3.1 Universities/research institutions

The enterprise cooperation with universities and research institutions is also known as industry-university-institute cooperation, the innovation of which is essential for the cooperation innovation between the complementary institutions. Universities and research institutions are coped with advanced experimental equipment, high-quality scientific research personnel and rich experience in research, and it is easier to make fundamental innovation. Universities and research institutions take the technology development as the main purpose, rather than the technology; however, enterprises are on the contrary, so there rarely have problems like exclusive ownership of technology in the cooperation between enterprise and universities and research institutions, the same to the direct conflict of interest between each other. Through the industry-university-institute cooperation, universities and research institutions can get the funds required to research and development and experiment equipment, while the enterprise can gain huge profits from innovation.

3.3.2 Government

The government mainly influences the innovation by introducing various fiscal and tax policy support.

First, the government may formulate innovation support policy and matching with the perfect technology policy to ensure the enterprise innovation environment; Second, by making forward-looking innovation development strategy, increase the support of core technology to some important areas, and lead domestic enterprises carrying out basic research and development; Third, set up the public innovation platform, and provide enterprises with innovation experience exchange opportunities; Fourth, establish procurement policy for domestic enterprises technology products, and supporting selling their own technology products to ensure the development of domestic enterprises.

According to the above analysis, the thesis puts forward the following hypothesis:

H3: The closer the government-industry-university-research cooperation is, the stronger the enterprise's innovation ability will be.

3.4 Public platform and technology intensive enterprise innovation ability

3.4.1 Risk investment institutions

With the progress of technology, the innovation product contains is more and more complex, and the funding need also become more and more large, as a result, enterprises must have enough ability of financing. But due to the continuously shortening of the product innovation cycle, the high uncertainties still remain in the simultaneous innovation process, considering part of the enterprise top managers averse of risk, the innovation investment is always insufficient. Risk investment is the way to solve the contradiction between growing demand for investment and enterprise innovation investment insufficient. Risk investment can solve the problem of insufficient enterprise innovation input and with the participation of risk investment institutions, enterprises are able to have access to valuable market information and technology, the innovation efficiency of which have greatly improved.

3.4.2 Technology intermediary agencies

In the enterprise innovation process, technology intermediary enterprises function as bridges. Information is the object technology intermediary agencies processing, and technology intermediary agencies can screened, classification, storage all kinds of information in the complex market at relatively low cost, and then provide the information to the enterprises according to the requirements. Through technology intermediary agencies, Departments of enterprises can break the agency information blockade and monopoly, reduce the enterprise's own information search cost, reduce the information asymmetry problems in the process of R&D, cooperation, in order to improve success rate of the enterprise innovation.

3.4.3 Intellectual property agencies

If the enterprise subject to its own research and development ability or their research and development cost is too high, then it can consider buy the needed information through external approach, and intellectual property agency is a good choice. Through the intellectual property institutions, enterprises can satisfy the technology need economic and timely.

According to the above analysis, the thesis puts forward the following hypothesis:

H4: The construction and perfection of innovation public platform can improve enterprise innovation ability

4. THE EMPIRICAL RESEARCH

Since the open innovation model and the data related to innovation ability is difficult to directly obtain on the Internet, Issuing questionnaires is the only way to collect the required data. Author send 250 emails to alumni in different enterprises through the alumni directory, and received 131 replies, the recovery rate of which was 52.4%. In addition, author also distributed both the paper and electronic file to the MBA students who are studying in China University of Geosciences (Wuhan) at the total of 150 questionnaires, and received 117

replies, the recovery rate of which was 78%. Besides, author also sent 200 electronic file to some enterprises, and received 13 replies, the recovery rate of which was 6.5%. To sum up, 600 questionnaires have been distributed and received 261 replies, the recovery rate was 52.6%, and due to some missing data, there were 32 questionnaires are invalid questionnaires, while the rest 229 were valid questionnaires, the efficiency of which was 45.8% efficient.

4.1 Variable Declaration

4.1.1 Open Innovation

According to the above analysis, the following four aspects can be used to measure technology intensive enterprises open innovation, namely longitudinal enterprises cooperation, horizontal enterprises cooperation, government-industry- -university-research and public platform, which can be divided into nine secondary indexes. The author using the Likert five point scale method to measure the close degree enterprise cooperation with external innovation source, using "1", "2", "3", "4", "5" represent "strongly disagree", "not agree", "general", "agree" and "strongly agree". The bigger the number enterprises select, the closer the cooperation between enterprises and external innovation source is.

4.1.2 Enterprises innovation ability

Enterprise's innovation ability is kind of a comprehensive ability, mainly reflects the innovation investment ability, innovation production ability, innovation marketing ability and innovation output ability, and each of which can be calculated quantitatively or qualitatively by some specific indices.

4.2 Statistical method

This thesis uses the structural equation model. Structural equation model is used to measure the relationship between multiple dependent variables and multiple independent variables in the area of social science. Compared to the traditional multiple regression analysis, linear correlation analysis and linear regression analysis, structural equation model has the following advantages.

4.2.1 Handle multiple dependent variables simultaneously

When calculating an exogenous latent variable’s affection on the endogenous latent variables, structural equation model is calculating the potential impact the other latent variables have on the endogenous latent variables. But in the traditional regression analysis and path analysis, when considering the relationship between the dependent variables, the calculation is always based on the assumption that other dependent variable doesn't work, even if is the final results show that there are more than one dependent variables work at the same time.

4.2.2 Allow variable error exists

Structural equation model is used to measure the attitude of the main body, behavior, etc., however, this kind of subjective activity cannot be directly measured, and can't simply measured by single index, so when measuring the subjective activity, it can’t avoid being affected by man-made factors, and errors will always exist. Structural equation model allows using multiple qualitative or quantitative indicators to measure the potential variables, whole allows individual or exogenous latent variables and endogenous potential measurement errors exist at the same time.

4.2.3 Allow greater elasticity measurement models

When treating the variables, the traditional regression analysis method requires that a factor must corresponding to an indicator, which is difficult to deal with the complex model that a factor is corresponding to multiple index, while the structural equation model can face the model that a potential variable is corresponding to multiple index variables, which is better in handle complex model.

4.2.4 Estimate R-squared of the model

In the traditional linear regression model, the only data can be estimated is path coefficient, which is the effect of each independent variable on the dependent variable. Structural equation can use different models on

the same sample data explanatively, so as to pick out the highest level of the whole fitting model.

According to the above analysis, the open innovation and enterprise innovation ability concept model diagram is built, as shown in figure 1.

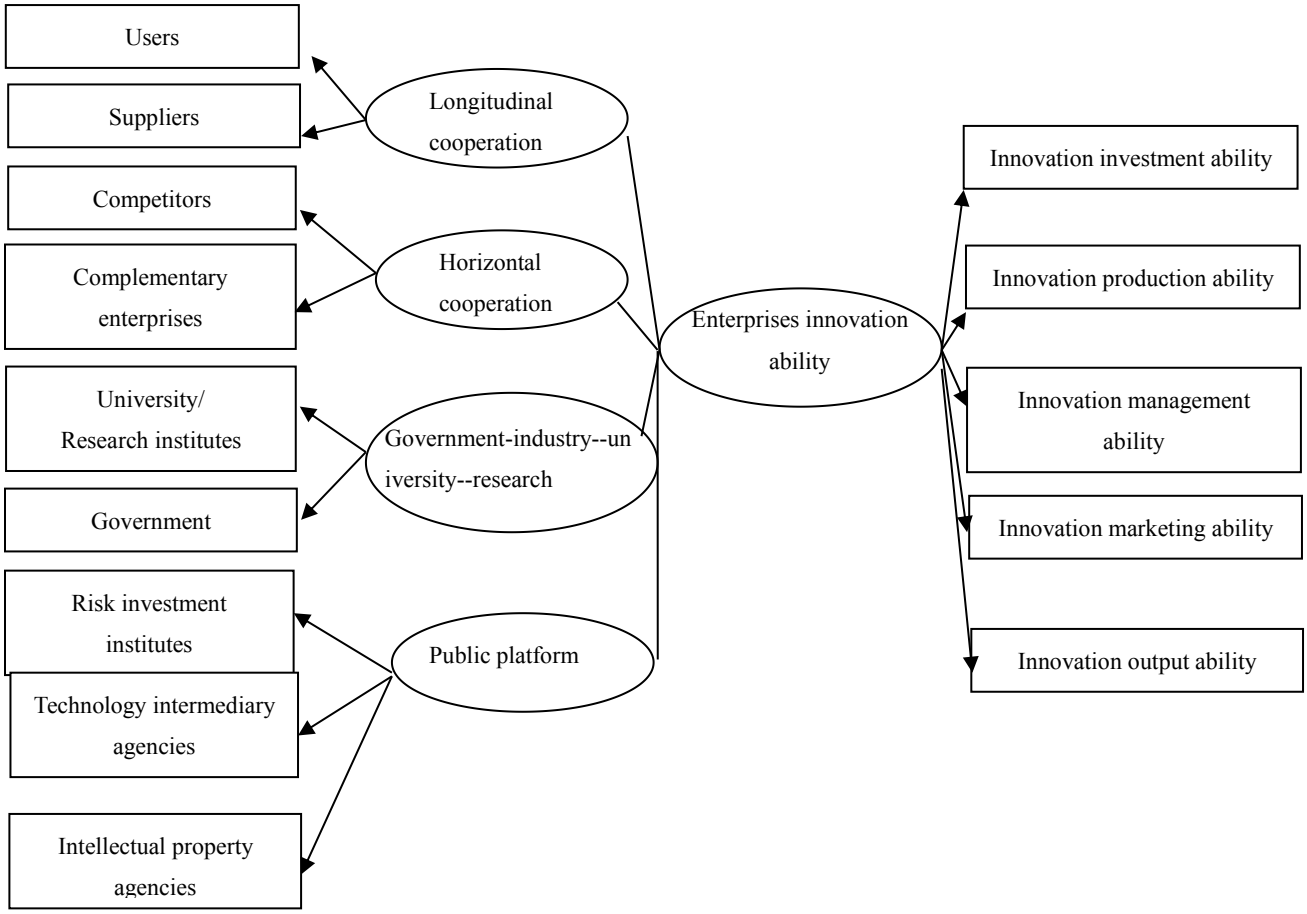

Figure1. Open innovation and enterprise innovation ability concept model diagram

4.3 Reliability and validity analysis

4.3.1 Reliability and validity analysis of enterprises open innovation

Reliability, just as its name implies, is credibility, and it reflects whether the questionnaire results' are equipped with stability and consistency when using a particular method for the same project in the process of the investigation, in other words, it represent whether the measuring tools such as questionnaires or scales can effectively measured things or variables. Validity, the validity of the things, it refers to the use of a certain measuring tool or means to shows the accuracy of the things.

The testing result shows that the internal consistency of the questionnaire is relatively high, and the reliability of the questionnaire can meet the requirements of the structural equation. As for the validity analysis, the KMO value is greater than 0.6, and Bartlett significant probability P value is less than 0.05, which means that validity has passed the test of significance.

4.3.2 Reliability and validity analysis of enterprises innovation ability

The testing result shows that the alpha value of the questionnaire was 0.194, namely the internal consistency of the questionnaire was relatively high. As for the validity analysis, the KMO value is greater than 0.6, besides, Bartlett significant probability P value is less than 0.05, namely validity has passed the inspection.

4.4 The research hypothesis testing

Based on the consistency and validity test of the questionnaire, according to the previous theoretical

analysis, put all the questionnaire data into AMOS17.0, the standardized coefficients of the model are all less than 1 when estimating path coefficient of structural equation model , which means the model itself does not exist a negative error variance and larger standard error, namely the model does not appear to violate the basic assumptions, and can undertake model adaptation degree of inspection. As for the absolute adaptation degree, the value of chi-square is 1.26, which is less than2, meaning that assumption model's covariance matrix adapted to observation data. Meanwhile, significant probability p value is 0.14, which is greater than 0.05, meaning the model didn't pass the significance test, which described the implied covariance matrix adapted to the sample data implicit matrix. As for the value-added adaptation degree, the RFI, IFI, TLI, CFI and other indicators are greater than 0.9, although the NFI failed the test, the model can be accepted as a whole. The result of structural equation model analysis is shown in table 1.

Table 1. Result of structural equation model analysis

Path	Standardized path coefficient	P-value	Supporting degree
H1：Cooperating with longitudinal enterprise is conducive to the improvement of enterprise innovation ability.	0.742	0.043	support
H2：Cooperating with horizontal enterprise is conducive to the improvement of enterprise innovation ability.	0.816	0.009	support
H3：The closer the government-industry-university- -research cooperation is, the stronger the enterprise's innovation ability will be	0.694	0.001	support
H4：The construction and perfection of innovation public platform can improve enterprise innovation ability	0.713	0.026	support

5. THE CONCLUSION

According to the results of structural equation model, as you can see, the path coefficient of longitudinal cooperation innovation ability of technology intensive enterprises improvement is 0.742, significant probability P value of which is 0.043, less than 0.05, which means, under the level of 0.05, the model failed to pass the significant test, therefore, assumption H1 is supportive under the significance level of 0.05, namely that the longitudinal cooperation was beneficial to the improvement of the technology intensive enterprise innovation ability. The path coefficient of horizontal cooperation in technology intensive enterprise innovation ability improvement is 0.816, significant probability P value of which is 0.009, less than 0.05, which means, under the significance level of 0.05, the model failed to pass the significant test, therefore, assumption H2 is supportive under the significance level of 0.05, namely that enterprise horizontal cooperation was beneficial to the improvement of the ability to innovate. The path coefficient of government-production-study- -research cooperation in technology intensive enterprise innovation ability is 0.694, significant probability P value of which is 0.001, less than 0.05, which means, under the significance level of 0.05, the model failed to pass the significant test, therefore, assumption H3 is supportive under the significance level of 0.05, namely that government-production-study-research cooperation is conducive to the improvement of enterprise innovation ability. The path coefficient of public platform construction of technology-intensive enterprise innovation ability is 0.713, significant probability P value of which is 0.026, less than 0.05, which means, under the significance level of 0.05, the model failed to pass the significant test, therefore, assumption H4 is supportive under the significance level of 0.05, namely that innovation public platform construction is conducive to the improvement of enterprise innovation ability.

To sum up, see from the perspective of resource-based theory, enterprises implement open innovation's main purpose is to obtain various external resources needed for its innovation, and the external resources is the

external market factors that affect innovation ability and macro policy. Specifically, technology intensive enterprise external innovation resources mainly include longitudinal suppliers and users, horizontal competition and complementary businesses, universities/research institutions and the combination of enterprises and government-production-university- -research, and intermediary agencies including technology, intellectual property institutions, risk investment institutions, innovation of public service platform. Based on this the thesis proposed four basic assumptions about the affection the external innovation resources have on the technology intensive enterprise innovation ability, and used structural equation model empirically analyzed the reliability of this four hypothesis. Finally get the following conclusion: longitudinal and horizontal cooperation between enterprises, cooperation between government-production- -university-research and innovation public service platform construction is beneficial to the improvement of the enterprise innovation ability.

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