

# The Impact of Enterprise Heterogeneity on the Diffusion of Technological Innovation

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## Abstract

*In order to explore the impact of enterprise heterogeneity on technology diffusion, this paper puts forward the hypothesis that the impact factors of enterprise heterogeneity on technology diffusion, using structural equation methods to build the structural equation model of the influence factors to technology diffusion. The results show that the enterprise's own nature, the access to the enterprise technological innovation, the enterprise technology exchange activities and the cooperation degree of the enterprises have a significant effect on the diffusion of technological innovation, which proves that the enterprise heterogeneity has a significant effect on the diffusion of technological innovation.*

**Keywords:** *technological innovation diffusion, enterprise heterogeneity, structural equation.*

## 1. Introduction

Schumpeter, the granddaddy of technological innovation, thinks that technical progress and innovation process consists of three stages: invention, innovation and diffusion. It shows that only the achievement of technological innovation diffusion could really reflect the value of technological innovation. According to United States scholar Rogers's "diffusion of innovation theory", technology innovation diffusion is the process of spreading and being accepted by the members of the technology innovation in a certain time, technology innovation diffusion should have three elements: the technology innovation source, the diffusion media, and the adoption. [2] As the source of technological innovation and diffusion, the role of enterprises cannot be ignored. Under the framework of new classical analysis, the individual is considered to be completely homogeneous, regardless of whether the product or the product service provided by the production factors is not there any difference. But the reality is that, because of the geographical environment, the accumulation of elements, cultural heritage and the production technology and other aspects of the difference between different companies tend to have strong heterogeneity. [5]

On the theoretical research of the relationship between the heterogeneity and the technological innovation behavior, the scholars have carried out from the knowledge store, the basic diffusion process, the enterprise ability, the innovation strategy and the market competition. Nelson (1982) pointed out that the knowledge reserve is the direct source of technological innovation, the heterogeneity of the knowledge reserve of enterprises, which is conducive to the development of new investment and innovation, which will promote technological progress and economic development.[6] Silverberg (1989) based on the innovation diffusion model, a new technology is able to complete its diffusion process, because of the differences in production scale, technology level and so on. So the new technology can be absorbed by a new technology.[7] Foray (1993) pointed out that the enterprise internal regulations, the innovation history, the staff's imitation and learning ability are the reasons for the formation of the enterprise's sustainable heterogeneity, the

heterogeneity of the employee's quality and the behavior after the imitation can improve the innovation efficiency.[8] Saviotti (1996) analyzed the heterogeneity from different perspectives, which was closely related to the heterogeneity, technological progress and economic development.[9] Llerena and Oltra (2002) will rely on internal knowledge accumulation of growth type enterprise and rely on the external knowledge and learning the growth type enterprise distinguish, pointed out that the difference of innovation strategy is the source of high tech, innovation strategy differences in the degree of higher conducive to technological innovation.[10] On the basis of the concept of Saviotti (2014) , Nguyen proposed it is believed that the rapid development of the market can promote the formation of niche market, which is conducive to the development of new products or the improvement of existing products.[11]

Based on the theoretical research, scholars use different empirical methods and statistical data to empirically test the impact of enterprise heterogeneity on technological innovation. Jacobs (1969)'s empirical results show that diversification of the market environment is conducive to reduce barriers to entry, and promote new enterprises to enter the market, thus bringing the competition effect will encourage enterprises to invest in R & D, and promote technological progress of the industry.[12] Glaeser (1998) confirmed the results of the Jacobs, found that the market structure of diversification and enterprise scale is indeed able to promote R & D activities. Feldman and Audretsch (2009) combined the heterogeneity of the innovation behavior and the innovation output; also get the conclusion that the heterogeneity and the technical innovation behavior are positively related. [13-14] Greunz (2014) confirmed that there is a significant impact on the innovation behavior of enterprises in the 153 regions of Europe through the investigation of 16 manufacturing industries.[15] Woerter Martin (2009) using the data from 4945 industries of 30 Swiss enterprises on the enterprise characteristics, market environment and the relationship between the R & D behavior empirical test, panel data model results show that the difference of the market environment is more conducive to enterprise innovation performance than homogeneous market.[16]

From the point of view of theory development, the research on the heterogeneity of enterprises mostly stays on the impact of technological innovation, which has little effect on the technology diffusion. This study tries to make a contribution to fill this gap.

This study combined with the experience of enterprises, and the reference of the innovation diffusion theory, the paper puts forward the factors that affect the diffusion of technology innovation based on enterprise heterogeneity. And use structural equation method to construct the structural equation model of the factors influencing the technological diffusion, and then analysis the verification hypothesis. It is proved that the heterogeneity of enterprises has a significant impact on the diffusion of technological innovation, and it is hoped that these conclusions can provide some theoretical and practical guidance for the effective diffusion of technological innovation in Chinese enterprises.

## **2. Influence Factors of Enterprise Technology Diffusion**

Technology diffusion is a wide spread and application of new technology. As the core competitiveness of modern enterprises, the promotion and application of technological innovation is of great significance to the development of enterprises [1]. This paper puts forward the assumption of enterprise technology diffusion from four aspects: the nature of enterprise, the way of enterprise get technology innovation, the development of enterprise technical exchange activities and the degree of cooperation between enterprises.

The impact of enterprises' region: China is divided into East China, Southern China, central China, North China, northwest, southwest, South and northeast eight economic zones. Enterprises in the more developed eastern coastal areas are more

willing to adopt new technology to promote the development of enterprises, while the relatively backward enterprises such as the northwest region is prone to self-closed state, which will inhibit the proliferation of technology.

Effects of enterprises' kinds: as a legal person, an enterprise' kinds including: enterprises owned by the whole people (*i.e.*, state-owned enterprises), collective owned enterprises, joint enterprises, foreign-funded enterprises, private enterprises and other enterprises. Compared to the traditional single state-owned enterprises operating philosophy, corporate culture are more open to the foreign-funded enterprises and private enterprises will be more willing to explore new technology development are good for business, so as to accelerate the diffusion of technology.

Enterprise development stage: according to the enterprise life cycle and related follow-up study, the enterprise development process is divided into five stages: (1) start-up stage: the company has just set up soon, benefit is not stable; (2) stage of development: enterprise product structure is basically stable, enterprise benefit is relatively stable; (3) mature stage: fixed product structure, enterprise benefit is relatively stable; (4) the recession phase: product market is shrinking, the decline in business efficiency; (5) once again venture stage: original products is gradually shrinking, enterprise products into upgrading or switched to the new products. Enterprises will try to use new technology to bring more advantages to the product, and in the new stage, enterprises are forced to adopt new technologies and will be accompanied by a certain risk. Enterprises in the start-up phase and the decline phase to consider the benefits of fluctuations in the rejection of new technologies, thus inhibiting the proliferation of technology.

So we put forward the hypothesis H1: the nature of the enterprise has a significant impact on the technology diffusion.

Enterprises are usually obtained through two channels of technological innovation: (1) from universities and scientific research institutions to obtain personnel and technical assistance; (2) to obtain technical assistance from other enterprises. Enterprises can get the help of talents and technology through the cooperation of the project from the University and scientific research institutions, to achieve the unity of the University and research institutions are more willing to interact with the enterprise. Relatively speaking, the difficulty of obtaining technical assistance from other enterprises will be more difficult, because the technology can help enterprises and the enterprise must belong to a field, each other to compete, to help the premise in addition to the need to pay a certain fee will have other restrictions, which has a certain effect on technology diffusion [1].

In addition to innovative channels, the required production factors of enterprise innovation if more easily obtained, it is able to promote the role of innovation, and can accelerate the diffusion of innovation. But it is difficult to obtain the necessary production factors, such as the need to involve the relevant patents and other issues; it will slow down the pace of business innovation, thereby inhibiting the proliferation of new technologies.

So we put forward the hypothesis H2: the way of getting technology innovation has a significant impact on the technology diffusion.

Technical personnel flow: the core technology of the enterprise is usually in the hands of the relevant technical personnel, if the enterprise can often carry out professional and technical personnel, such as the exchange of technical personnel, will be very good to promote the diffusion of technology. But because of the patent protection and interests of the problem, it is difficult to exchange technical personnel in the enterprise. It is very difficult to carry out the high salary of the executive search company, which can inhibit the effective diffusion of technology.

The expansion of communication activities: the technical personnel with the core of the enterprise, if they can often communicate with other organizations on

experience and skills, will effectively promote the diffusion of technology. Compared to the exchange of technical personnel, the enterprise to carry out similar projects in the nature of the exchange of experience will be easier, so that neither the core technology of the enterprise, but also through the exchange of both sides benefit. But some companies take into account the leakage of core technology and the exchange will be refused to participate in the exchange will inhibit technology diffusion.

The development of innovative activities: in the enterprise internal often carried out on the exchange of innovative activities will greatly enhance the probability of enterprises to adopt new technologies. Building a communication platform in the enterprise could avoid exposed the core technology, effective protection of the patent, and encourage all employees to participate in brainstorming, through the technological innovation for enterprises to bring greater benefit. But in a single system, the management of the traditional enterprise, it is difficult to carry out similar activities, will inhibit the proliferation of technology.

Therefore, we put forward the hypothesis H3: the technology exchange activities of enterprises have a significant impact on the diffusion of technological innovation.

The degree of cooperating with other enterprises on project: if companies can often work with other business organizations on different levels of cooperation, and to obtain new technical information from the partners, and pass the knowledge and technology to other enterprises, not only can make new technology new ideas spread, but also build enough trust in the two companies, so as to promote the enterprise to continue to expand cooperation with each other. On the contrary, the enterprise can inhibit the diffusion that new technologies or new information aren't shared in the cooperation and the enterprise don't have the non - willing to cooperate.

The level of staff skills after the cooperation: the cooperation between enterprises needs to be completed by the different levels of different functions of the staff. If the level of the staff can actively learn advanced technology in the course of the project, their technical skills have been improved; it will promote the follow-up cooperation between enterprises, so that the new technology has been effectively spread. On the contrary, the staff through the project did not improve, or learn bad habits to work; it will make the enterprise difficult to carry out cooperation projects, so will inhibit the proliferation of innovation.

So we put forward the hypothesis H4: the degree of enterprise cooperation has a significant effect on the diffusion of technological innovation.

### **3. Structure Model Construction**

Structural equation modeling (SEM) is a verification and non-detection analysis model, is to measure and measurement techniques of integration, is mainly used for treating polygenic and fruitfulness, including measurement equation and structural equation [23].

The structural equation model has the advantage that multiple variables can be used at the same time, and it can be used not only to deal with numerical continuous variables, but also to deal with the classification variables, which are not available in many other ways. [3] Because of the influence of technological diffusion in the enterprise, the enterprise's own nature, access to enterprise technological innovation, enterprise technical exchange activities and enterprise cooperation, the relationship among them are numerous and complex. The other advantage of structural equation modeling is that there are errors in the allowable variable. Because the enterprise cooperation level and other variables are generally difficult to measure, and it is difficult to use a single index to measure, multiple indicators of the synthesis will produce errors; in order to understand the relationship between the variables, each

variable has to choose a number of measurement indicators, and the structural equation fits this particular point. So the structural equation model is suitable for the study of the influence of enterprise heterogeneity on the technology diffusion. The expression for the equation is shown as follows:

$$X = Ax\xi + \delta$$

$$Y = Ay\eta + \varepsilon$$

$$\eta = B\eta + \tau\xi + \zeta$$

This research is based on the questionnaire survey, questionnaire design, small scale research, questionnaire survey, and large-scale survey. A total of 250 questionnaires were distributed, 76 enterprises involved, 212 questionnaires were collected, 180 were valid questionnaires, and the other 32 questionnaires were considered as invalid questionnaires, the effective recovery rate was 72%.

In this paper, the structural equation model includes the following variables: enterprise's own nature, the way of getting technology innovation, enterprise technical exchange activities, enterprise cooperation, and enterprise technology innovation diffusion degree (as in table 1).

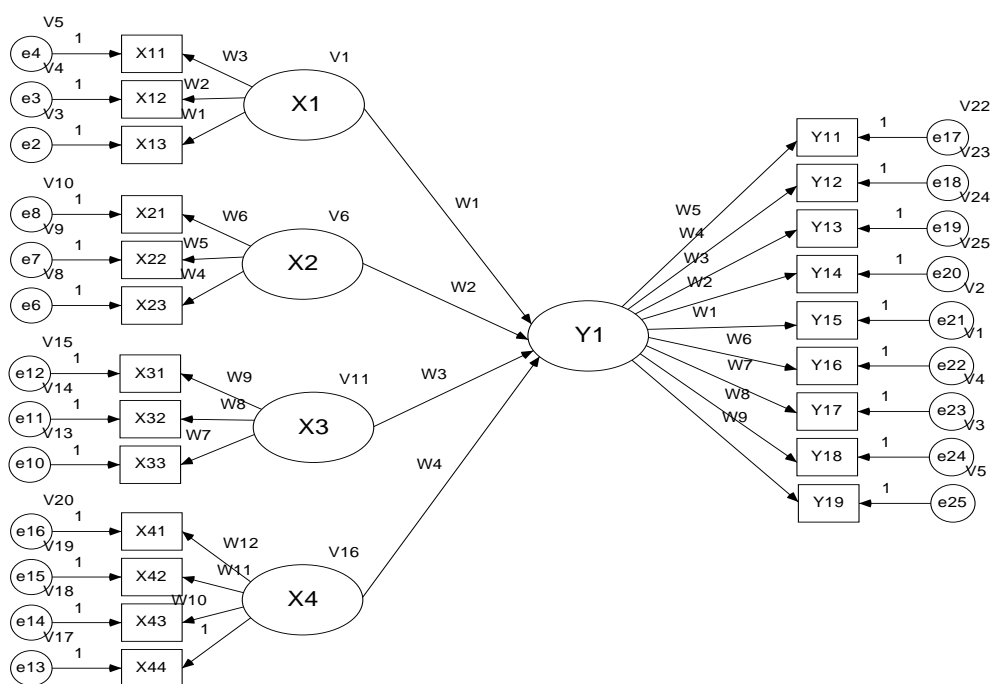
**Table 1. Latent Variable and Measurement Variable**

Latent variable	Measurement variable
enterprise's own nature	Enterprise location X11;
	Enterprise type X12;
	Enterprise development stage X13
The way of getting technology innovation	Companies often get talent and technology from universities and research institutions to help X21;
	Companies often get technology from other companies to help X22;
	Enterprise innovation required the production elements of the transaction to get X23
Enterprise technical exchange activities	Enterprises often carry out professional and technical personnel of the mutual flow (such as the exchange of technical personnel) X31;
	Enterprises often carry out the exchange of innovative activities X32;
	Business and other organizations to carry out the exchange of experience and skills X33
Enterprise cooperation	Companies often collaborate with other enterprise organizations X41;
	Companies often get new technical information from collaborators X42;
	Enterprises in cooperation with other agencies to pass the knowledge and technology X43;
	Enterprise to improve the skills of the staff through cooperation X44
The degree of enterprise technology innovation diffusion	Information on technical innovation and the cooperation between enterprises and agencies often Y11;
	Enterprise information to improve the enterprise's innovation speed Y12;

	Knowledge of the enterprise to improve the performance of the enterprise Y13;
	The degree of new insights gained from the knowledge of the enterprise is relatively high Y14
	Enterprises often develop new products Y15
	Enterprises can take the lead in the introduction of new products Y16
	Enterprises to launch new product technology content is very high Y17
	Enterprise's new product improvement and consummation has the very good market reaction Y18
	Compared with their peers, the success rate of new product development of enterprises Y19
	Compared with their peers, the input and output efficiency of new product development is very high Y20

On the basis of the path hypothesis, the influence of enterprise heterogeneity on the diffusion of technological innovation is drawn by AMOS17.0 software, as shown in Table 2.

**Table 2. Structural Equation Model of the Influence of Enterprise Heterogeneity on Technological Innovation Diffusion**



In order to obtain a stable analysis result, we need to test the reliability and validity of the questionnaire. This paper uses the internal consistency method to analyze the reliability of the questionnaire, and the internal consistency method to measure the reliability of Cronbach's ALPha, Cronbach's ALPha is more than 0, all of which show that the questionnaire has good reliability. The reliability analysis results are shown in Table 3. The validity of this questionnaire was tested by factor analysis. KMO statistics need to be more than 0.5; it is suitable for the analysis of factors. Factor analysis results are shown in table 3. The corresponding factors were all higher than 0.5, which indicated that the questionnaire had good construct validity.

**Table 3. Coefficient of Reliability and Validity**

Latent variable	Measurement variable	Cronbach' s ALPha	Factor load
Enterprise's own nature	X11;	0.8132	0.814
	X12;		0.763
	X13		0.779
The way of getting technology innovation	X21;	0.7103	0.801
	X22;		0.692
	X23		0.728
Enterprise technical exchange activities	X31;	0.7648	0.815
	X32;		0.781
	X33		0.794
Enterprise cooperation	X41;	0.8016	0.837
	X42;		0.791
	X43;		0.764
	X44		0.826

Through the above analysis, the questionnaire of the various problems of the Cronbach's ALPha coefficient and factor load are meet the requirements, so in the back analysis of all indicators.

#### 4. Data Calculation and Empirical Analysis

According to the factor analysis, the results showed that the relationship between the two variables was significant. In this paper, the path and hypothesis test results are shown in table 4. The path coefficient and the test result can be concluded from table 4. The above hypothesis has significant influence on the diffusion of technological innovation.

**Table 4. Path Coefficient**

Assumed path	Path coefficient r	The value of P	Test result
H1	0.492	<0.05	Significant
H2	0.315	<0.05	Significant
H3	0.446	<0.05	Significant
H4	0.470	<0.05	Significant

From the structural equation model analysis results: the nature of the enterprise itself has a significant impact on the technological diffusion hypothesis, the region of enterprise, the type of enterprise and enterprise development stage directly affects the enterprise technology innovation and diffusion. And the path coefficient is 0.492, which indicates that the nature of the enterprise, which is determined by the region, the type and the development stage, has the greatest influence on the diffusion of technological innovation. Enterprises in coastal areas like Beijing, Shanghai and Guangzhou are more likely to come into contact with new technologies, and are

willing to adopt new technologies to improve enterprise performance, thus promoting the diffusion of new technologies, and in the relatively remote and relatively remote areas; relative to state-owned enterprises, private enterprises and multinational enterprises in the market because of the pressure of survival, technology sector employees will continue to develop new technologies or new technologies to improve the quality of products to occupy more market, which makes the new technology has a good effect, and state-owned enterprises due to the greater degree of protection, the idea is more inclined to maintain the status quo, cautious innovation, which is not conducive to the proliferation of new technologies; if the enterprise is in a relatively stable development stage and mature stage, it will try to use new technology to bring more advantages to the product, so as to promote the technology diffusion, in the start-up phase and the decline phase of the enterprise to consider the benefits of fluctuations and reject new technology, thus inhibiting the proliferation of technology.

The technological innovation of enterprises has a significant impact on the technological diffusion. Enterprises are often obtained from the universities and scientific research institutions to help companies often get technology from other companies and the need for innovation in the production factors are easier to get a direct impact on the extent of technological innovation of enterprises. The path coefficient is 0.315, which shows that the help of talents and technology from universities and research institutions, enterprises often get the help from other enterprises, and the production factors of enterprise innovation are more easily obtained. In the channel, the enterprise can get help from the University, but it is difficult to get help from other enterprises, but once acquired can be used directly, which can affect the diffusion of new technology. In addition, the production factors of enterprise innovation can be promoted.

The assumption that the diffusion of technological innovation diffusion has a significant effect on the technological exchange activities of enterprises comes into existence. Enterprises often carry out professional and technical personnel exchanges (such as the exchange of technical personnel), often carried out in the business on the exchange of innovative activities and the exchange of experiences with other organizations often have a direct impact on the enterprise technology innovation and diffusion. The path coefficient is third, and the 0.446 place, which shows that the enterprises often carry out professional technical personnel in exchange for each other; enterprises often carry out the exchange of innovative activities and the exchange of experience with other organizations to create a greater impact on technology innovation. Often exchange technical personnel of enterprises due to the use of different techniques or ideas to improve the performance of enterprises, so as to promote the proliferation of technology, but taking into account the issue of patent protection, it is difficult for the exchange of technical personnel in the enterprise, which inhibits the effective diffusion of technology. Compared with the exchange of core technology, enterprises are more willing to carry out some experience exchange activities, so as to carry out technical exchanges, make the new technology get a two-way diffusion, but some companies consider technology leakage risk and refused to participate in the exchange of technology can quickly collect new ideas, improve the efficiency of the new technology, but because the system cannot carry out similar activities, so that technology can be effectively spread.

The degree of cooperation of enterprises has a significant impact on the technological innovation diffusion. Enterprises often cooperate with other business organizations and companies often get new technical information from the partners. The company has passed the knowledge and technology to other organizations. Its path coefficient is 0.470, after the enterprise's own nature, which means that



companies often cooperate with other enterprise organizations; companies often get new technical information, enterprises in cooperation with other agencies to pass the knowledge and technology and enterprises through cooperation to improve the level of technology innovation and technology innovation. Often with other enterprises to cooperate and exchange knowledge and technology, it can promote new technology and new ideas, and to protect their own technology and not to cooperate with other companies or in cooperation in the exchange of information, the new technology will be suppressed, the new technology will be improved, and the ability to promote cooperation between enterprises.

## 5. Conclusion

This paper is to explore the impact of enterprise heterogeneity on technology diffusion, based on the existing research, the paper puts forward that: enterprise heterogeneity has four aspects: the nature of enterprise, the acquisition of technological innovation, the cooperation between enterprises. Which businesses technology and research institutions have access to technical assistance from other companies and technical assistance from other companies often carry out technical exchanges often work with other companies. On this basis, the paper puts forward the hypothesis that the structural equation model of the factors affecting the diffusion of technological innovation by using the structural equation method, and the results of the questionnaire survey of 76 enterprises. The results show that the enterprise's own nature, the access to the enterprise technological innovation, the enterprise technology exchange activities and the cooperation degree of the enterprises have a significant effect on the diffusion of technological innovation, which proves that the enterprise heterogeneity has a significant effect on the diffusion of technological innovation.

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