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Studies on Spillover of Scientific and Technological Knowledge in High-tech Industry Clusters

---Taking Jinan High-tech Development Zone for Example

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Abstract

To achieve the "second pioneering" in high-tech development zone, it should vigorously develop high-tech industrial clusters to make a breakthrough. Only on the basis of industry clusters, by the establishment of an effective platform for science and technology innovation, through the vigorous support of technology with general character in industrial clusters, can improve the technological innovation capability of industrial clusters. Taking the industrial clusters in high-tech development zone in Jinan for example, the thesis has analyzed the inevitability of the spillover of scientific and technological knowledge. The results of analysis have supported the point of view that the strategy of scientific and technological innovation in the high-tech development zones should be based on the industrial clusters.

Keywords: Spillover of Scientific and Technological knowledge, High-tech Cluster, Studies

In the process of implementing the independent innovation and promoting high-tech industrialization, China's high-tech development zones have become the "habitats" of high-tech enterprises. But overall, China's high-tech zones lack of the ability of independent innovation. Although the industry has developed in a quick speed (Note 1) the value-added ratio is low for which the root is the few contributions of the independent intellectual property rights to the industries. It is reference significance for policy-making in the correct and objective understanding of the feasibility of inevitability of the spillover of scientific and technological knowledge. This thesis is composed of four parts. Part Ⅰ is the preface. Part Ⅱ analyzes the inevitability of the spillover of scientific and technological knowledge in the cluster brought forth even without the technological transfer. Taking the high-tech development zones in Jinan for example, Part Ⅲ analyzes the gradualness of the spillover of scientific and technological knowledge. Part Ⅳ is the conclusion.

1. Introduction

1.1 Studies on Literature of Technological Innovation

In the early 20th century, Joseph Schumpeter—-the economist of Austrian descendant in America, had proposed in the works "Theory of Economic Development" which made him famous that the so-called "technological innovation" was that the first commercial application of the new technologies and new inventions was to establish a new production function or supply function and to introduce a new combination of production factors and production conditions in the production system. Unfortunately, Schumpeter's argument for a long time did not attract people's attention. It is until the 1970s in 20th century, in the sum-up of the cyclical development and the law of the recession in the economic development that the theory of technological innovation of Schumpeter has aroused the concern of the mainstream economists and has been developed to a forefront of scientific study – study of economic and technical innovation, being called "the new Schumpeter principle."

Compared with the classic Schumpeterian theory, the new Schumpeter principle has paid more attention to technological innovation, and emphasized that "technological innovation" mainly included activities of three aspects: firstly, product innovation, referring to the commercialization of the technical changeable products. It can be entirely new products, and can also be improvements to the existing products. Secondly, process innovation, also known as technology innovation, referring to the major changes of the production technology of products, including new techniques, new equipments, new managements and new organizational methods. Thirdly, technology transfer.

1.2 Studies on Literature of Technology Spillover

The study methods of technology spillover in the clusters has been first advocated by Marshal in 1920, and been further studied by David and Rosenbloom (1990), Krugman (1991), Kelly and Hageman (1999), and others. It has been proposed that there has been three advantages in the clusters, that is, cluster exterior nature. First, the strength of the reservoir of the labor forces having been formed intensively in the location by the intra-industry enterprises because of the same industry or closely related industries. Second, relevant raw materials and other input elements which can be obtained in low cost. Third, the spillover of scientific and technological knowledge engendered among the neighboring enterprises and institutions as a result of the strengthening of the exchange of knowledge. Dobkins (1996), Paci, Usai (1999) and Hansen (2002) have also studied on the exterior nature and innovation space of the cluster. Their studies have discovered that the first two advantages in the above three have the indirect impact on the innovation capacity in the culture. At the same time, the third advantage has a direct impact not only on the labor force and enterprises in the cloture, but also on the process of innovation.

The above studies have provided us with the idea being used as reference. Through the establishment of models, the thesis has further verified the feasibility and inevitability of technology transfer and spillover of scientific and technological knowledge in the cluster.

2. Model Analysis of the Spillover of Scientific and Technological Knowledge within the Industry Cluster

2.1 Model Assumptions

Among the numerous industry clusters within the country, the vast majority of them take the big enterprises as their centers, the numerous small and medium-sized enterprises being the periphery to form the cluster of "vertebral shape". Under the assumptions of premises of clusters of "vertebral shape", through the establishment of the production function model including the variable of technological spillover, the following analyzes to explain how the cluster innovation and learning mechanism plays a role and how to enhance the competitiveness of the entire cluster through the large enterprises driving the progress of small enterprises.

The industry cluster function: Q=F(R, T, μ ,N, M).

Q is the output of the industry cluster; R is the resource essentials; T is the technology; μ is the ratio of technology spillover; N and M represents the number of overseas-funded enterprises and that of domestic-funded ones respectively.

2.2 The Technology Spillover Engendered by the Technological Innovations in Large Enterprises

We assume that the large enterprises have made the independent innovations whereas the small ones have not. The production function of enterprises in the industry cluster is determined by the essentials represented by R and the productivity of essentials represented by E. The essentials can be divided into two parts, one part being the essentials R_p used in the production, the other part being the essential inputs R_R used in the research and development. The production function of each enterprise of the large and small enterprises is

$$Q = E * R_p \qquad (1)$$

Here, we assume that there is no technological innovation in the large and small enterprise. The amount of technological knowledge in the cluster is $T_c = T_0$.

There is a close relationship between the essential productivity and the amount of technological knowledge in the whole cluster. Therefore,

$$E = a \cdot T_C^{\gamma} \qquad (2)$$

At this time, there is an enterprise which begins to make the first independent technological innovation. On the one hand, the technologies T obtained in the innovation are related to the amount of technological knowledge T_c in the cluster; on the other hand, they are related to its own essential inputs of research and development R_R.

$$T = T_C^{\delta} \cdot R_R = T_0^{\delta} \cdot R_R \qquad (3)$$

Whereas the technologies T obtained by the large enterprises through the technology innovations can be divided into two parts, one part being their own technological knowledge of the large enterprises T_1, the other part being the public technological knowledge T_2 in the industry cluster having been spillover.

$$T = T_1 + T_2 \qquad (4)$$

We mark the spillover ratio of scientific and technological knowledge as

$$\mu = T_2 / T \qquad (5)$$

The spillover ratio of scientific and technological knowledge μ is the variable representing the innovations and characteristics of learning mechanism in the cluster.

If the number of large enterprises which have made one time of technological innovation is N, then the knowledge amount of the whole enterprise cluster will become:

$$T_C = T_0 + \int_0^N T_2 dx = T_0 + N \cdot T_2 \qquad (6)$$

2.3 The Function Analysis of the Acceptation of Technology Spillover by Small Enterprises

Because we put the research emphasis on the industry clusters of numerous small and medium-sized enterprises and make the studies on the outputs of the small enterprises, we turn our view to the small enterprises now.

The production function of the small enterprises is also:

$Q = E * R_p$， $E = a \cdot T_C^{\gamma}$

Because at this time $T_C = T_0 + \int_0^N T_2 dx = T_0 + N \cdot T_2$， $E = \alpha (T_0 + N \cdot T_2)^{\gamma}$.

According to (5), $T_2 = \mu$ T and (3) $T = T_C^{\delta} \cdot R_R = T_0^{\delta} \cdot R_R$, now we can obtain the concrete form of the production function of small enterprises,

$Q = \alpha (T_0 + N \cdot T_2)^{\gamma} R_p$

It can obtain through the use of T_2 and T into the above equation:

$Q = \alpha (T_0 + N \cdot \mu \cdot T_0^{\delta} R_R)^{\gamma} R_p$

Because $R_R + R_p = R$, finally, we can educe the production function in the largest outputs of the small enterprises:

$$Q = \frac{\alpha \left[(T_0^{\delta} \cdot \mu \cdot N \cdot R)^2 - T_0^2 \right]}{4 T_0^{\delta} \cdot \mu \cdot N}$$

The production function in the largest outputs of the small enterprises the number of which being M

$$Q = M \cdot \frac{\alpha \left[(T_0^{\delta} \cdot \mu \cdot N \cdot R)^2 - T_0^2 \right]}{4 T_0^{\delta} \cdot \mu \cdot N}$$

The essential inputs R are constant variables. We can write the above equation in short:

$Q = M \cdot \varphi(\mu) \cdot \omega(\mu)$Q

Therefore, we can draw the conclusion that in the industry clusters of "vertebral shape", the outputs Q in the largest outputs of the small enterprises is the function of the spillover ration of scientific and technological knowledge μ and the scale of the cluster M+N.

3. Case Analysis of Jinan High-tech Development Zone

Being established in 1991, Jinan high-tech development zone is one of the first national-level high-tech zones approved by the State Council. In the development of industry clusters, Jinan high-tech zone has focused on building eight national professional industrial zones. There are more than 3,000 enterprises of all types, and more than 200 high-tech enterprises within the zone. By strengthening the construction of industrial clusters, the scale of the enterprises in the zone continues to expand. There are 15 world's top 500 enterprises having settled such as Korea's LG, Japan's Matsushita, Suzuki, NEC, Texas Instruments, Pepsi, American Standard, Volvo, and Sanyo. Through the enhanced international cooperation, the spillover effect of scientific and technological knowledge has been strengthened. The high-tech zone has built Chinese-Ukrainian High-tech Cooperation Park, being one of the national government cooperation projects. Qilu Software Park has established the relationship of friendly sister park with Bangalore Software Park in India. It has also cooperated with the oversea well-known software companies in the construction of "Microsoft Solution Lab", IBM solution Laboratory, Nortel Networks Laboratory and DSP Joint Laboratory. Through the cooperation with IBM Company in America, Qilu Software Institute has established the international computer training centre. Environmental Science and Technology Park has cooperated with Nordic SEM Company to establish the industrial base of environmental science and technology.

About the high-tech talent scale, there are 60,000 people who are directly engaged in the high-tech industry in Jinan high-tech zone, including more than 1,500 masters and doctors. In 2006, the product sale income realized annually by the above-scale enterprises is 56.7 billion yuan, with 15 billion yuan as the industry added value, 22.1 billion yuan as output value of high-tech industry, 814.11 million dollars as export income. About the commitment to high-tech projects, more than 100 projects of the national torch plan have been undertaken, with more than 300 projects of provincial and departmental torch plan being undertaken.

The spillover effects of scientific and technological knowledge in Jinan Hi-tech development zone have been embodied in: First, it has promoted the human capital to flow among the enterprises. Second, it has promoted cooperation interaction among enterprises. Third, the flow of the human capital and knowledge has accelerated the birth of new enterprises through the derivation of localization of enterprises. The enterprises having obtained the spillover effect can reduced the innovation costs and improve the capability of technological development, thus accelerating the spread of knowledge.

4. Conclusion

In order to achieve the "second pioneering" in China's high-tech development zones, we should vigorously develop hi-tech industry clusters to make a breakthrough. Only on the basis of industry clusters, by the establishment of an effective platform for science and technology innovation, through the vigorous support of technology with general character in industrial clusters, can improve the technological innovation capability of industrial clusters.

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Notes

Note 1. In 2007, the total income and total production value in 54 high-tech development zones in our country has reached 4300 billion yuan and 3600 billion yuan respectively. The industry added value was 852 billion yuan, accounting for about 9.4% in the industry added value of the country.