MNC’s technology correlation effect and industry agglomeration

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Multinational Corporation (MNC)’s FDI and technology transfer are related to technology correlation, and they interact with industry agglomeration. In this study, conceptions of “correlated technology” and “spin-off technology” are defined in a new way. Then based on relationship between technical innovation and industry agglomeration, interactive mechanism of MNC’s technology correlation and industry agglomeration is analyzed, and interactive effect of correlated technology, spin-off technology and industry agglomeration is further studied.

Keywords: Correlated technology, FDI, Industry agglomeration, Multinational Corporation, Spin-off technology, Technology transfer

Introduction

Relationship between technology innovation and industry agglomeration is: 1) Innovation requires enterprises’ cooperation and competition, and is achieved by enterprise agglomeration; 2) Industry agglomeration is conducive to innovation, which gives an impulse to industry agglomeration; and 3) Innovation tends to cluster or focus on some sections and the near ones. Growth pole theory concluded that in a country’s economic growth, some leading sections or enterprises, which have innovative ability centralize in a specific area, and an economic development mechanism come into being, in which capital and technology is highly centralized, economy grows speedily, and benefit is noticeable. Based on multinational corporations (MNCs) interest, Mansfield put forward the choice theory about foreign direct investment (FDI) and technology transfer. Unifying organically the FDI, international trade and technology transfer, an international production choice model was built up to analyze multinational technology transfer mechanism and named as OIL paradigm (ownership-specific, internalization-specific and location-specific advantages). Paper studies interaction mechanism of multinational technology correlation and industry agglomeration (IA), and discusses interaction effect of IA and the correlated technology or spin-off technology (SOT).

Correlated Technology, MNC and Industry Agglomeration

Correlated technology can be classified into complementary technology (CT) and mutually exclusive technology (MET). CT means that developing one technology can lead to the development of other technologies. It can be subdivided into vertical CT (VCT) and horizontal CT (HCT). MET means that the development of a kind of technology restricts or weakens the others. Vertical MNCs conduct the production activities with dissimilar stages in different countries (or areas). Horizontal MNC produce the same goods in home factories as in overseas factories.

Vertical Complementary Technology and MNCs

In view of market conjunction, if industries are vertically related to each other by input-output structure, the products of upstream industry are the inputs of the downstream industry, which becomes the market of the upstream industry. Considering easy-to-enter of market, the upstream industry will be attracted to the area where many downstream firms are located. If the downstream firms locate in where quite many upstream firms have gathered, their costs will be reduced for easy-to-acquire of middle inputs. Demands and costs are the centripetal force, which decides where the firms will be located. If only transportation costs exist, externality of market will lead the downstream industry and the upstream industry to close up each other. But this only concerns market correlation and has overlooked the influence of technology correlation on IA. From the respective of market correlation effect, there is a close...
correlation between manufacture agglomeration and vertical MNCs\(^5\). In terms of technology correlation, vertical MNCs arrange different production stages of their diversified products in different countries. The agglomeration effect formed in those countries is based on CT of the upstream (or the downstream) industry of the host country, which depends more on the interdependent degree of CTs than the difference of factor costs.

According to technology diffusion theory, present paper divides VCT into three categories: 1) VCT based on growth pole; 2) Jumping VCT; and 3) Bidirectional VCT.

**VCT Based on Growth Pole and IA**

VCT based on growth pole is a bidirectional technology diffusion process, in which technology radiates all round from pole nucleus. Technology of pole nucleus drives the technology development of the upstream and the downstream of industry chain, meanwhile surrounding technology replenishes and advances the technology of pole nucleus. Toyota had benefited from early intervention of suppliers in R&D. When the assembly plant just finished their design of whole vehicle, suppliers had shaped the related mold. As a result, product development cycle\(^6\) was shortened by 1/3. The development of CT strengthens diversion and coordination of industry chain, which not only makes activities of industry chain more cooperative and effective but also promotes transfer values system of the whole industry chain. CT functions as a row of magnets whose negative poles are connected in which the growth pole is the strongest one, which centralizes related industry. This kind of IA is stable owing to the growth pole. In other words, scale and stability of IA lies on the interdependent degree of CT. In unbalanced growth theory, Hirschman\(^7\) assumed that correlation effect is an objective existence of interaction and interdependence in various industry sections, which can be measured by demand price elasticity and income elasticity of products, and it was concluded that the preferentially investing and developing industry must possess the maximum correlation effect. So it can be easily inferred that the industry coming into agglomeration first have a close correlation between CTs.

**Jumping VCT and IA**

Jumping VCT refers to the technology diffused from one area to the far area because technologies of the other links of industry chain (upstream or downstream) can complement each other rather than the low potential of specific areas’ technology (Fig. 1). In two-country models, enterprises would locate close to their suppliers or their buyers because of relationship of demand and supply and transaction cost of middle products\(^8\). The location predominance that the upstream firm closes the downstream firm will attract the other firms of this industry to gather in one place or several places. Besides transaction cost and market correlation, FDI and technology transfer of vertical MNCs is related to the complementarity of its technology and the upstream (or downstream) firm’s technology of this industry. All technology correlation, whether forward correlation (with customers) or backward correlation (with suppliers), can achieve industry’s expansion and preferential growth by technology complementation and technology spillover to the other links of industry chain, which promote the development of backward linkage sections, forward linkage sections and the whole industry so that agglomeration economy grows on the whole. For example, Basf, Bayer, etc. transferred their production of Polyurethane MDI to the region round about Shanghai and Zhejiang, and came into agglomeration with the local PUR industry mainly because of the well developed technology of local backward PUR industry. In observation to sources of product parts of Japanese investment enterprises, Xiao-Juan\(^9\) found the product localization ratio of Japanese MNCs is from 21.8\% of 1991 up to 47.3\% of 1999. The reason\(^10\) of MNCs enlarging direct investment and technology transfer in Chinese TV industry was the reduction in static technical difference between Chinese enterprises and foreign enterprises. In fact, this is the result of Chinese TV industry adoption to jumping VCT.

**Bidirectional VCT and IA**

Bidirectional VCT is the technology diffusion process that transfers technology I from area A to area B and complements technology II, then technology II is transferred to area A again and complements technology I (Fig. 2). It’s an advanced Jumping VCT. Technologies of German MDI and TDI were first transferred to Japan and complemented Japanese original synthetic leather technology, then Japanese advanced relevant technologies were transferred back to Germany and agglomerated with German industry. In Jumping VCT or Bidirectional VCT, CT links upstream industry and downstream industry, therefore
upgrades local industry’s technology. Most of these linkages exist in technology spillover and thus could bring agglomeration effects between industries.

**Horizontal Complementary Technology and MNCs**

HCT is the CT in the same link of industry chain. It is divided into four types: 1) Competitive developing; 2) Confederals; 3) Jumping; and 4) Bidirectional.

**Competitive Developing HCT and IA**

Competitive developing HCT means that enterprises have to increase inputs of R&D and accelerate the upgrade of production technology and equipment. Schumpeter\(^3\) has expounded about the interaction of IA and technology innovation. MNCs’ direct investment increases competition in the host country, which makes local firms use new technologies to enhance efficiency and quality of production\(^{11}\). It brings technology spillover to local firms, which benefit the host country greatly. The higher degree of technology spillover to the host country is the more speedy technology transfer from local subsidiary company by MNC. As a result, technology spillover steps up\(^{12}\), and the related industry is upgraded continually, therefore agglomeration is further strengthened. It is a circulation. Moreover, another form of technology spillover in MNCs’ direct investment is that MNCs may supply the related technology to the upstream firms and the downstream firms of the host country, which forms agglomeration of industry chain, according to VCT theory.

**Confederal HCT and IA**

Confederal HCT is that all alliance members form the different distance and complicated CT, which is based on certain knowledge innovation according to their technology predominance and different links and different functions in R&D. Thus, the recipients of CT constitute entity or virtual dynamic enterprise alliance. Technical innovations are diffused to the alliance members based on their relation. This kind of CT mostly forms the alliance between MNCs and past federal chain is becoming multilateral federal net. For example, Thomson of France, IRI of Italy and SANYO of Japan formed an alliance to develop data compression chip of high definition TV. So did POWER CPU alliance, formed by Motorola, IBM and Apple Computer Corp., to develop computer chips to challenge Intel. Alliance of CT needs frequent communication and contact between every level of alliance members including managers, technologists, salesmen and even workers. Sometimes, it may be necessary to set up trusting-coordinate private relationship, but it is hardly to do due to long distance. On the other hand, according to transaction cost theory and the centripetal force of CT, it is easy to infer that alliance members could agglomerate (Fig. 3).
Jumping HCT and IA

Jumping HCT refers to same kinds of technology diffusing from one area to the far area. Its appearance benefits from the progress of traffic and communication technology, which is mostly under the influence of the difference in regional technology potential, political and economic relations, condition of application and development, especially the guide idea of developing new market. For horizontal MNCs, Jumping HCT is the outcome of FDI investment and technology transfer. Its principle of agglomeration to the host country is same to that of competitive HCT. It also goes with technology spillover made by direct investment and technology transfer. One example of this kind of technology is technology transfer from North America and Europe to Korea and Taiwan inside MNCs. If this is the technology supporting pole nucleus of IA of one region, under the normal conditions (especially transferring from higher technology potential region to lower potential region), it will become the technology supporting pole nucleus of local IA.

Bidirectional HCT and IA

Bidirectional HCT is the same kind of technology that is transferred from one area to another one and then is transferred back to primary area after reconstructed and developed. For example, the technology of American software MNCs (Microsoft Corp.) was transferred to India, then back to America after developed in India and forming IA. This phenomenon is very similar to Flying-Geese Pattern Industry Development Theory by Akamstutu \(^{13}\) (Fig. 4).

Mutually Exclusive Technology (MET) and IA

Firstly, many traditional technologies are mutually exclusive of new technologies. In analysis of the reason that the manufacturer of mature industry zone cannot take advantage of new technology effectively, Gertler \(^{14}\) thought that people could anticipate the appearance of difficult when the application of advanced machine is far from producers in the nature, organizations or the society. This is because process technology is produced in society and social environment of producing and applying machine will be different along with regional environment. METs sometimes form their IA area, which can be seen everywhere world over (Fig. 5). Traditional industry gathers together, and new technology industry gathers together too, so they are difficult to amalgamate. This is called MET effect. Secondly, MET has close correlation to technology diffusion. If a new technology is employed by certain accepter, it maybe influence on other users of this new technology. This phenomenon is called Network Externalities of Technology, which if negative, will lead to order competition between accepters of the technology. Thus, earlier accepter could obtain more economic utilities, and if technology diffusion accelerates, it must make the IA with MET decay, whether or not the industry with new technology agglomerate. On the other hand, if Network Externalities are positive, utilities of new technology accepter will augment with increase of the number of new technology user. In initial stages, diffusion of new technology is very slow, so the corresponding industry of new technology can’t come into agglomeration in such short time. Finally, according to technology diffusion theory, in the whole course of diffusion, change of colony accumulation number will take on S type or Logic growth curve with the time change. Gompertz \(^{15}\), Bass \(^{16}\) diffusion pattern, etc. are the main classical theory. Decline in technology diffusion necessitates the production and diffusion of new technology, which may be a brand-new technology or
upgrade of a certain technology and is mutually exclusive with original technology. For example, in imaging field, traditional silver salt technology and modern digital technology is mutually exclusive. Though in most of enterprises, new technology and old technology blend into each other, some MNCs still transfer new technology and old technology to their own IA areas in terms of their global resource collocation (Fig. 6).

**Spin-off Technology in MNC and IA**

SOT is the byproduct of MNCs’ technical innovation and the result of technology spillover in FDI and technology transfer.

**Combined-type SOT and IA**

In technical innovation field, there are a lot of new technologies, which are organic combination of traditional technologies. Firstly, SOT sometimes adheres to traditional technology, and agglomerates with original technology, distributing in the related industry. In the course of IA, technologies related to the industry gather spontaneously, and impulse IA process consequently by reconstituting and developing new technology. Secondly, nowadays IA is no longer just the accumulation in a certain area and the flowage between different areas of production factors (such as capital, labor force, etc.). Sometimes one lays more stress on the reset and innovation of the knowledge and technology in flexible agglomeration. So the areas developed rapidly by flexible agglomeration of industry (flexible agglomeration body) often have the more strong innovation function and competitive forces. Finally, technology combinations usually need information communications and face-to-face contacts, which are called open secrets. It leads enterprises with combined technology to close to the related ones.

Herein, FDI and technology transfer of MNCs play an important impulsive role. Suppose MNCs establish a car assembly factory, thus the technology spillover is shown as: 1) Improving technology efficiency and production quality of local component firms; 2) Supplying the correlative technology to the local upstream firms to improve quality of the automotive whole body; and 3) Prompting local parts and accessories firms to employ new technology. As a result, localization ratio of auto-parts and technology

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**Fig. 4** — Flying-geese structure of bidirectional horizontal complementary technology

**Fig. 5** — Industry agglomeration and mutually exclusive technology

**Fig. 6** — Transfer path of traditional technologies and new technologies
is continuously improved, and up to a certain level, host country will be able to establish native car assembly plants with combination of these technologies.

Production-type SOT and IA

Kokko\textsuperscript{12} clarified that the fourth form of technology spillover effect of FDI is that the skilled workers and managers trained by MNCs may enter the local enterprises, who take away the technique and crafts, and enter other enterprises or establish new corporations, which supply similar products or services. In general, SOT is confined to some outdated technique or traditional technology without intellectual property and has a marked demonstration effect i.e., local firms can enhance their own technology levels by imitating and studying multinational technology, production flow and crafts. In labor-intensive industry, spillovers in IA are primarily this kind of technology; meanwhile, it also is the chief cause of IA. If a MNC is located near its costumers, new plants naturally centralize around the original corporation. Otherwise, production SOT is related to employees’ tacit knowledge. What they have taken away is not only technique and crafts but also the related tacit knowledge and the ability of developing the related higher technique. In the course of imitating, a certain aspect of tacit knowledge is often the key factor, but generally it is ignored and leads to invalidation of imitation. This is so-called causal ambiguity.\textsuperscript{18} Production type SOT not only diminishes causal ambiguity of imitation but also bring human resource reallocation, which makes technology innovation diffusion (including human and knowledge capital) accelerate and its self-enhancement further strengthens agglomeration effect.

Conclusions and Recommendations

Technology correlation is the important impetus of multinational FDI and technology transfer. The technology correlation effect between MNCs and the host country is one of the primary factors. VCT consolidates the interdependence between MNCs and the upstream industry or the downstream industry of the host country. Scale and stability of agglomeration lies on the interdependent degree of CTs. Agglomeration effect caused by HCT is multinational technology spillover and the centripetal force produced by CT body. Agglomeration effect caused by SOT is based on multinational technology spillover. The more advanced CTs are, the more beneficial is to attract multinational FDI and technology transfer. Therefore, foreign investment attraction policies and industry development policies of developing countries should have new emphasis.

From depending on preferential policies and the open degree, attracting FDI enters a new phase. Industrial technology correlation should play a more important role. Developing countries should adjust their industrial structure and develop preferentially the industries closely correlated to MNC’s CT. By means of technology complementarity, industrial expansion and preferential growth can be achieved. With the technology spillover to the other nodes of industry chain, the whole Industry can develop quickly and enhance the sustainable competitive advantage. Technology progress of upstream or downstream industries correlated to MNC’s technology should also be strengthened, which is beneficial to attract FDI as well as forming local IA. The investment tendencies of MNC traditional technology and MET should be paid attention to and upstream technology should be developed quickly in order to attract MNC traditional industry transfer. In some fields, it is beneficial to attracting FDI to develop HCT, which conflicts with the MNCs. Moreover, industrial technology correlation effect could enhance industry diversification development (forward and backward diversification), which is helpful to attract FDI. Finally, training effect can increase the local human resource by foreign enterprises’ training local managerial and R&D personnel, linkage effect can upgrade local enterprises’ technology by the technology linkage of FDI and native upstream or downstream enterprises, and demonstration effect may accelerate the absorption of MNC’s SOT. Therefore, technology spillover effect of MNC should be made full use of in developing countries.

References