Research on Interactive Learning, Knowledge Sharing and Collective Innovation in SMEs Cluster

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Abstract—In the knowledge-based economy, small and medium enterprises (SMEs) clusters have played a significant role in the development of local economy, especially in technology innovation. This paper's aim is to propose an analytical framework on technology innovation and knowledge transfer of enterprises cluster based on collective innovation. Firstly, this paper analyzes the interactive learning mechanism of SMEs clusters in perspective of vertical, horizontal and multifold dimensions. Secondly, it focuses on knowledge spillovers in clustering firms and discusses the SECI's process of the knowledge transformation of SMEs cluster. Thirdly, it analyzes the key influencing factors of knowledge spillovers and knowledge transfer. Finally, it pays more attention to the collective innovation mechanism and discusses the crucial role of focal firms in cluster innovation.

Index Terms—Interactive learning, knowledge sharing, collective innovation, small and medium enterprises cluster.

I. INTRODUCTION

Enterprises clusters are geographic concentrations of interconnected enterprises and institutions in a particular field [1]. There is a growing literature linking the dynamism of SMEs to their location within enterprises clusters. Firms located in clusters tend to perform better than isolated firms [2]. Firms based in local or regional agglomerations benefit from locating in clusters as they outperform those located outside these clusters in terms of innovation outcomes[3], [4]. Clusters might greatly foster innovation any time it involves a large share of tacit knowledge. Clustering Enterprises exchange and create knowledge through face-to-face interactions and with the creation of common languages and institutions. Inter-firms communication and interactive processes of interactive learning play decisive roles in processes of innovation and growth [5].

The notion, such as "Industrial Atmosphere" [6], "Buzz" [7], "Local broadcasting" [8], is used to emphasize the local network's significance for interactive learning and technology innovation. In recent years, more and more scholars have started to claim that knowledge system and innovation activities should be considered to be central in the process of sustainable development for small and medium enterprises clusters. Cluster could usefully be thought of as a

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reduced-NIS (national innovation system), in which the most essential and functional system elements help stimulate the emergence of specific kinds of innovation in various segments of a national economy [9].

The relevance of enterprises clusters for growth, competitiveness and innovation has received increasing attention over recent years among academics, consultants and policy makers. This paper attempts to contribute to this research gap by adding the interactive learning and collective innovation perspective to the cluster innovation literature. Collective learning outlines how local innovation network and spatial proximity between actors influence the sharing and creation of skills and knowledge in cluster innovation network. And, an analytical framework on technology innovation and knowledge transfer of SMEs cluster is proposed in this paper. Firstly, the interactive learning mechanism for SMEs located in local network is analyzed. Secondly, knowledge sharing process and influencing factors are discussed. Finally, this paper pays more attention to the collective innovation mechanism and the crucial role of focal firms in cluster innovation.

II. INTERACTIVE LEARNING MECHANISM OF SMEs CLUSTER

Innovation process is a learning process in nature. Although, the correlative researches have presented diverse explanations on cluster innovation process, theses explanations are all close related to learning mechanism.

In SMEs cluster, the interactive learning process consist of the learning process between clustering firms (such as: learning by doing, Learning by using, learning based on R&D, reverse engineering and so on), the learning process between clustering firms (especially for focal firms) and institutions(such as: university, public R&D institution, information center). The interactive learning involves in three dimensions: vertical learning, horizontal learning and multi-angle learning.

A. Horizontal Learning

Clustering firms located in the same link of value chain mostly belong to the same industry and provide purchaser with similar productions and services. In horizontal dimension, the relation of the firms is competitive. The competition mostly focuses on the common raw material, labor force and production market. And the cooperation focuses on the creation of common market, the establishment and maintenance of common brand and so on. The learning process is involved in the comparing and observing between firms. Similar production condition and "common language" benefit to the communication and knowledge transfer.

Geographical proximity offers the firms a chance to observe and evaluate the innovation activities of others expediently and freely, which reduce the cognitive distance and enhance the absorptive capability of clustering firms.

B. Vertical Learning

Vertical learning refers to the learning process of the firms located in different links of value chain. Forward interaction involved in the learning between the providers and the consumers. Backward interaction is involved in the learning between the producer and the supplier. The input-output relation is formed in their firms owing to complementary resources. The specialization division, exchange of materiel and cooperation boost the new knowledge.

The development process of new production is close related to the interaction with the users [10]. By contacting with users in forward interaction, clustering SMEs can acquire market information. Especially, the rigorous users ask for the higher quality and reliability of production, which contribute to the designing and improvement of production. The backward learning helps to acquire the complementary technology to upgrade the design and R&D capability. In SMEs cluster, owing to long-term cooperation and high trust, the clients and the suppliers are able to communicate each other widely and freely, which benefit to the exchange of open information and the solve of common problem.

C. Multi-angle Learning

Multi-angle learning refers to the interactive learning between firms with local government, university, public research institution and Intermediary organization. These institutions provide local firms with all kinds of services and infrastructure, which promote the innovation cooperation, knowledge-sharing, information feedback. Especially as for the knowledge and technology infrastructure, university and public research institution not only create new idea, knowledge and technology but also perform the role in education, training and technology achievement transfer. On one hand, clustering firms can acquire the knowledge and high skilled worker through the institutions. On the other hand, clustering firms, especially for focal firms, is better to focus on the cooperative innovation and technology development with the institutions.

The interactive learning outlines how local network and spatial proximity between clustering SMEs influence the sharing and creation of skills and knowledge. The interactive learning process is involved in knowledge spillovers and knowledge transform. In next part, this paper will focus on knowledge spillovers and knowledge transform in clusters.

III. DIFFERENT TYPES OF KNOWLEDGE AND KNOWLEDGE SPILLOVERS IN SMEs CLUSTER

A. Knowledge Spillovers of SMEs Cluster

Geographical proximity facilitates knowledge spillovers and, thus, interactive learning and innovation. The knowledge spillover of SMEs cluster, is refers that, when carrying out knowledge activities, one enterprise will voluntarily and involuntarily transfer knowledge and information (such as: production technology, production

process, business knowledge, research, market information and etc.) to the other enterprises to a great extent. The mentioned above is inner knowledge spillovers for a cluster. The knowledge spillover is also include the external knowledge spillovers, which refers to clustering firms' knowledge exchange and transfer with institutions (such as: enterprises, research institutions and university) located outside the cluster. The inner knowledge spillover is involved in knowledge interaction among firms located inside the cluster, which is the base of cluster knowledge system. While a large number of studies have emphasized the importance of local network, there is growing awareness that being connected to extra-local knowledge networks is a key to upgrade the innovation capability of clusters. The external knowledge spillover is involved in knowledge interaction between clustering firms with institutions outside the cluster, which is useful to update the cluster knowledge base.

As for SMEs cluster, the knowledge interaction inside and outside offer particular, albeit different, advantages for the innovation and knowledge creation. Inner knowledge interactions make it easy that the information and knowledge obtained from the outside is able to spread to other clustering enterprises. Clustering enterprises, particularly SMEs, are more dependent on tacit knowledge and less capable of searching for and using codified knowledge than large firms in general. This forces them to rely more on personal and localized ways of transferring tacit knowledge and on learning-by-doing and interacting. The more developed the linkages to external knowledge sources are, the more new and valuable knowledge information are transferred to local enterprises. Cluster might greatly foster innovation any time it involves a large share of knowledge and information.

B. Different Kinds of Mediums for Different Types of Knowledge

Polanyi (1958) classified knowledge into explicit knowledge and tacit knowledge based on the different expression modes of knowledge [11]. Explicit knowledge can be articulated into formal language, including grammatical statements (words and numbers), mathematical expressions, specifications, manuals, etc. it also can easily be processed by a computer, transmitted electronically, or stored in databases. So, it is easily to transmit and process. Whereas, tacit knowledge is highly personal and difficult to formulize, including experience, know-how, ideas, feelings, etc. Explicit knowledge cannot be articulated and be easily spread and transmit. Tacit knowledge is generally acquired through frequent face-to-face interactions. With the speedup of economic globalization and production internationalization, explicit knowledge gradually becomes the mutual resource, even a kind of general resource. However, the tacit knowledge becomes the crucial resource for an organization, which is usually difficult to obtain and transfer.

As for the different types of knowledge, the dissemination media and communication channel is very different. This paper divided the media into tangible media and intangible media. And communication channels can be divided into the formal channels and informal channels.

The formal communication in SMEs cluster, is referred that knowledge is transferred by the medium such as:

production, standards, advertising, contracts and etc. the situation include: Suppliers know the information about product through new product launch, acquire the information about standard by a contract with manufacturer, obtain the information about demand by advertisement. The knowledge transferred by formal channel is used to explicit knowledge.

The informal communication is referred that knowledge is transferred by forums, business party and interpersonal communication. The knowledge transferred by informal channel is used to tacit knowledge. The interpersonal interaction is more frequent and enhanced within a cluster. Geographical proximity facilitates knowledge sharing and, thus, interactive learning and innovation.

IV. KNOWLEDGE TRANSFORMATION IN SMEs CLUSTER

A. Relation between Knowledge Transformation and Knowledge Spillovers

The difference of knowledge system between firms is great. One reason is that an enterprise's knowledge endowments have a mare great difference than that of other's. Another reason is the results of long-term specialization division. Lombardi(2003) proposals the cognitive theory of cluster and insisted that the distribution of cognitive resource in a cluster is uneven [12]. Giuliani (2003) carried out empirical research on three wine clusters in Italy and Chile. His conclusions show that the research on cluster knowledge system should pay more attention to uneven and selective nature of cluster knowledge networks at the micro-level [13]. So it is necessary to know the relationship between knowledge spillovers and knowledge transform. This paper thinks that knowledge transformation is the latter process of knowledge spillovers. Knowledge transformation facilitates the absorption and transfer of knowledge through SECI's process [14]. The performance of knowledge spillovers and knowledge transformation has an important influence on the efficiency of cluster knowledge system.

B. SECI's Process of SMEs Cluster

Knowledge transformation is a dynamic process to absorb and utilize knowledge. He proposed a knowledge transformation framework with four phase three level, which is used to analyze the knowledge transformation inside an organization. As the figure 1, Nonaka (1995) proposed the SECI knowledge conversion model, which has been widely used in the knowledge creation and transformation [15]. Based on the above researches, this paper next will analyze the knowledge transformation of enterprises cluster.
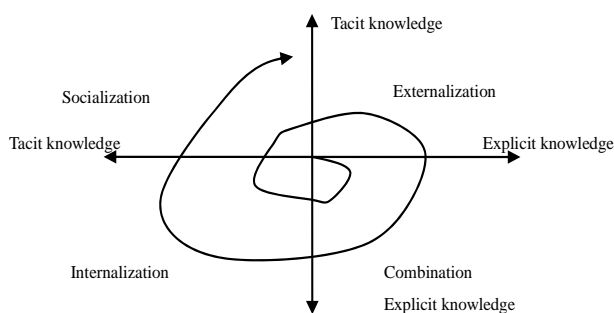

Fig. 1. SECI's process of knowledge in SMEs cluster.

1) Socialization: from tacit to tacit.

As for SMEs cluster, it is a process to centralize tacit knowledge by sharing the experience. As tacit knowledge is highly personal and difficult to formulize, it is helpful to acquire the tacit knowledge by sharing the experience and having face-to-face interaction. SMEs cluster is both a social phenomenon and an economic phenomenon. Cluster is a localized ecosystem; it is embedded in local people's experience and tradition. The embeddedness and values tradition of cluster is helpful to facilitate and boost the sharing of tacit knowledge. The socialization of tacit knowledge in SMEs cluster is more easy and spontaneous.

2) Externalization: from tacit to explicit.

It is a process to articulate the tacit knowledge into explicit knowledge, by which knowledge is easy and facilitated to transmit and share. In order to utilize tacit knowledge obtained from the other clustering member better, the knowledge should be articulate with formal language, including words, numbers, mathematical expressions, specifications, manuals, etc. the process of continuously interaction and recognization between the clustering members is necessary. The Geographical proximity of clustering enterprises, suppliers, clients and competitors reduce the exchange cost of interaction. The prior knowledge system of the firm integrates the tacit knowledge obtained from the other clustering member. And the tacit knowledge is transformed into the explicit knowledge by the process of externalization.

3) Combination: from explicit to explicit.

It is a process to systemize the isolated and disorder explicit knowledge into a knowledge system, which is more complex and functional than the summation of the components. The clustering members exchange and organize the knowledge and information through formal channels such as: contract, standards and meetings. By selecting, adding, combining and classifying, the knowledge is reconstructed and systemic.

4) Internalization: from explicit to tacit.

As for SMEs cluster, it is a process to absorb and embody explicit knowledge into tacit knowledge. Through the internalization of knowledge, the knowledge spillovers come from the other clustering members is merge into the knowledge system of enterprise. Internalization of knowledge is related to "learning by doing" and "learning by using", which extend, expand and reconstruct the knowledge. Through internalization of knowledge, the knowledge quantity and knowledge structure is perfected and upgrade.

The tacit knowledge of clustering firms is shared each other by the socialization process of knowledge. Next, the process will enter the new and higher level round of SECI. The knowledge is innovated and integrated through the development of knowledge and the inter-transformation between the tacit and the explicit. Socialization, externalization, combination and internalization alternate in turn and move in an ascending spiral.

V. INFLUENCING FACTORS OF KNOWLEDGE SHARING IN SMEs CLUSTER

The influencing factors of knowledge sharing are mostly

related to the motivation and dependability of knowledge holder and receiver [16]. The more openness of the two parties in alliance is, the more knowledge both of cooperators will acquire. So, in SMEs cluster, the trust to each other is essential of knowledge sharing in localized learning process. As for knowledge holder, the worry of unfair revenue will reduce the dynamics to transfer knowledge. As for knowledge receiver, the dependability of knowledge holder will lead to the positive activities. When knowledge headstream is undependable, the knowledge sharing becomes difficult.

A. *Degree of Inter-firms Trustiness*

The efficiency and performance of knowledge sharing depend on the absorptive capability of clustering enterprise. The primary influencing factors of absorptive capability is prior knowledge (basic skill and learning experience) and organizational management factors (such as: knowledge communion and sharing mechanism in organization) [17]. Except for prior knowledge, Jan, Rene and Theo (2003) claimed that the investment in R&D, internal and external network linkages also have an important influence on absorptive capability of firms. The decrease of cognitive distance is able to advance the efficiency and performance of knowledge sharing [18].

Compared to the firms outside the cluster, inter-firms relationship inside enterprises cluster is closer and their space distance is relatively smaller. The business culture based on regional culture and local context leads to more "common language" between the clustering firms, which reduce the culture distance. Moreover, the organizational distance is decreased owing to business communication based on subcontract or cooperation production relationships. So, the absorptive capability of clustering firms is enhanced with the decrease of space distance, culture distance and organizational distance.

B. *Role of Focal Firms*

Focal firms are also namely leader firms. In the knowledge spillovers and knowledge transformation, focal firms play an important role. Owing to their outstanding advantage of technical resources and capacity, they improve and create new knowledge and excellence technology. They play a lead role in the cluster innovation network, generating new knowledge and technologies, attracting researchers, investments and research facilities, enhancing others firms R&D activities, stimulating demand for new knowledge and creating and capturing externalities. Focal firms use external knowledge to a greater extent than other firms operating in the cluster, by leveraging on their intellectual and social capital, they can act as "technological gatekeepers" for the whole district, thus enhancing the absorption of new information into the cluster and facilitating its internal dissemination [19].

C. *Density of SMEs Cluster Network*

One the one hand, the increase of local network' density is positive for knowledge transfer in cluster. Firstly, higher density will strengthen the reputation mechanism, which helps to reduce the opportunistic behaviors. Secondly, higher density of network contributes to the trust to each other.

Thirdly, with the increase of local network' density, the formal and informal interaction will become more frequent, which benefit to the decrease of transaction cost and boost knowledge transfer.

On the other hand, exorbitant density might lead to the decrease of openness and flexibility of cluster network. Owing to the lack of communication with the outside, enterprises cluster will become "Knowledge Island" and run into "lock-in" risk [20]. Then, the capability of knowledge acquiring and dealing with change is gradually weaken. When clustering firms become too much inward looking, their learning ability may be weakened to such an extent that they lose their innovative capacity and are unable to respond to new developments.

VI. COLLECTIVE INNOVATION MECHANISM OF SEMs CLUSTER

A. *Self-dependent Innovation Based on Focal Firms*

Focal firms have great advantage on independent innovation owing to their better knowledge endowment and unique position in cluster network. The structure hole theory shows that focal firms have information advantage and control advantage in cluster network [21]. On one hand, the occupancy of structure hole helps focal firms to acquire more and more non-redundant information and become the distributing center of information. On the other hand, the occupancy of key path makes it possible that deciding the direction of knowledge flow and the collocation of knowledge resource. Focal firms search, filter and absorb the new knowledge from the external. Moreover, they integrate the knowledge from each link of cluster network. So, Focal firms upgrade their knowledge resource and structure. Their capability of self-dependent innovation is enhanced by embedding the new knowledge in organization routine and human resources. Facing to the internal and external competition, focal firm can maintain its head position by sustaining technology innovation.
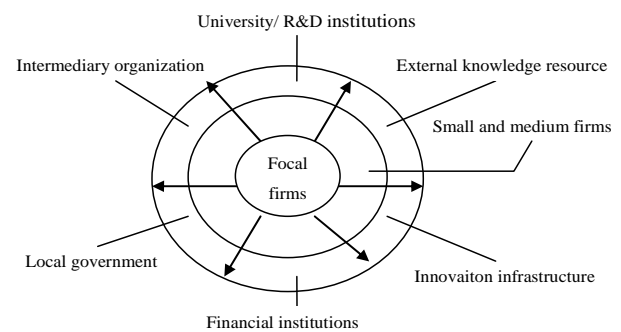
Fig. 2. The layers of SMEs cluster innovation system.

B. *Cooperative Innovation among Clustering Firms*

Clustering firms are able to acquire complemental knowledge from cooperation partners, which can enhance the firm's knowledge absorptive capability. Saka (1997) researched the cooperation innovation behavior of four hundred firms in Japan; his results show that acquiring complemental technical knowledge is the primary motivation of cooperation innovation [22]. In SMEs cluster, long-term

cooperation results in the higher degree trust and timely information feedback, this contributes to the speedup of the production innovation process and the increase of the innovation efficiency. The frequent knowledge interaction between the clients and the suppliers promote the tacit knowledge-sharing. Especially between focal firm and its suppliers, the close contact with each other and the maintenance of cooperation in quality, efficiency and R&D help to acquire new knowledge and accelerate the pace of technology innovation.

C. Cooperative Innovation between Clustering Firms and University/Research Institutions

Enterprises and university/research institutions have different advantage on technology innovation. Enterprises have a comparative advantage on technical achievements commercialization. University/research institutions have a comparative advantage on basic sciences. In knowledge-based economy, the alliance consisted of enterprises and university/research institutions gradually become an important type of knowledge creation and knowledge transfer. So, the innovation advantage of enterprises cluster is close related to the interaction and cooperation between enterprises and university/research institutions. As a headstream of knowledge and the supplier of professional personnel, university/research institutions promote the knowledge, information and technology transfer and diffusing by education, training and R&D cooperation. So, the industry-university-research institute collaboration play an indispensably role.

D. Coherent Innovation between Key Value Links and Special Value Links

SMEs cluster is based on specialization and division of labor. So, the systemic innovation and industry upgrade mostly depend on the collective action of clustering enterprises. There are some strategic and dominant links of industrial value chain, which are occupied by focal firms. Other small and medium enterprises occupy the special link of industrial value chain. So, the SMEs' innovation activities are close related to the special link. Focal firms might play an important role in leading and integrating the innovation activities of other links. In the coherent innovation process of cluster, local information center, local university/ research institutions and other members play respective different roles.

E. Focal Firms and Its Integration Role in Cluster Innovation

Focal firms are also namely leader firms. Lorenzoni and Badenfuller (1995) define focal firms as "strategic centres" with superior co-ordination skills and the ability to steer change [23]. They distinguish four ways in which a focal firm contributes to the competitiveness of their partners: through strategic outsourcing, the sharing of knowledge, by forming a bridge between different networks, and by focusing on competition on a value chain or network level rather than on firm level. Lazerson and Lorenzoni (1999) identify "focal firms", which are companies that occupy strategically central positions because of the greater number and intensity of relationships that they have with both customers and suppliers [24]. Focal firms are firms in a cluster that have -because of their Endowment, resources and entrepreneurial skills- the ability and incentive to make investments with positive externalities for other companies in the cluster.

Focal firms as innovation initiator. Owing to their outstanding advantage of technical resources and capacity, they improve and create new knowledge and excellence technology. They play a lead role in the cluster innovation network, generating new knowledge and technologies, attracting researchers, investments and research facilities, enhancing others firms R&D activities, stimulating demand for new knowledge and creating and capturing externalities.

Focal firms as supporters of startups. This is particularly true for the creation of startups as suppliers or subcontractors of focal firms. Initial support usually prevents startups from incurring risks related to new business venturing. Their learning process is enabled by a set of practices implemented by focal firms. Startups are guaranteed a certain quantity of orders for prototypes and new products; they are provided with instruments, facilities and services to start the production activities. Startups can get access to a focal firm's network of relationships with other firms and institutions.

In SMEs cluster, focal firms integrate the various innovation activities by several approaches. These approaches are as followed: (1) to encourage the innovation activities in accordance with the focal firms' innovation strategy by determining the purchasing quantity in cluster; (2) to lead the innovation activities by transforming market information into production knowledge, even technology standards; (3) to harmonize the innovation and produce process through "reputation" and "authority" mechanism; (4) to affect the choice of innovation direction by authorizing other firms to use itself brand and patent technology; (5) to integrate the innovation activities by establishing linkage between the different nodes and occupying the structure holes.

VII. CONCLUSION

This paper analyzes the interactive learning mechanism and knowledge sharing process of SMEs clusters. Moreover, it discusses the influencing factors of knowledge transfer and analyzes the collective innovation mechanism. This paper makes several conclusions as followed: (1) the interactive learning involves in three dimensions: vertical learning, horizontal learning and multi-angle learning; (2) the knowledge spillover is an important dynamics of clustering. Firms inside the cluster exchange and share knowledge through face-to-face interactions, which might greatly foster innovation; (3) knowledge transformation is the latter process of knowledge spillovers, which involved in four process: Socialization, externalization, combination and internalization; (4) some factor have an important influencing on knowledge sharing process in a cluster, which includes inter-firms trustiness, focal firms, local network density, cognitive distance and absorptive capability; (5) the innovation advantage of cluster is close related to the interaction and cooperation between enterprises and university/research institutions. Focal firms play an important role in knowledge creation and technology

innovation in SMEs cluster.

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