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Peer-reviewed author version

Zhao, Yan; Zhou, Wen; Hüsig, Stefan & VANHAVERBEKE, Wim (2010)
Environment, network interactions and innovation performance of industrial clusters: Evidences from Germany, The Netherlands and China. In: Journal of Science and Technology Policy in China, 1(3). p. 210-233.

DOI: 10.1108/17585521011083111
Handle: http://hdl.handle.net/1942/11268

Environment, Network Interactions and Innovation Performance of Industrial Clusters: Evidences from Germany, Netherlands and China

Yan Zhao

School of Management, Shanghai University, Shanghai, People's Republic of China

Wen Zhou*

School of Computer Engineering and Science, Shanghai University, Shanghai, People's Republic of China

Stefan Huesig

Faculty of Business, Economics and Management Information Systems, University of Regensburg, Regensburg, Germany and

Wim Vanhaverbeke

Department of Business Studies, Hasselt University, Belgium

Abstract

Purpose – The purpose of this paper is to categorize industrial clusters, and then compares three industrial clusters of three countries from the perspectives of hard environment, soft environment, factors from supply and demand sides, and the network mechanism.

Design/methodology/approach – Data were collected through interview with cluster coordinators. Qualitative case studies are conducted.

Findings – The center of excellence behaves well in nearly all aspects, while the spatially narrowly distributed specific center of innovation mainly exploits benefits from its concentrated sector. For the Chinese comprehensive technology incubator, relatively limited geographical space and broad sectorial distribution endow it with unclear strengths, implying the inadequacy of interconnectedness and industry relatedness mentioned by Porter (1990).

Research limitations/implications – Data were collected mainly from cluster coordinators, implying further data collecting and more comprehensive analysis.

Practical implications – It only makes sense to compare industrial clusters that are comparable with each other. And elements must be matched to facilitate the network interactions, and hence the innovation performance of clusters.

Originality/value – This paper contributes to the theoretical basis through it analyzing and clarifying the scales to measure industrial clusters, and answers the

* The authors thank the support of the project *the Complexity of Cluster Innovation System of Knowledge Intensive Business Services: Empirical Study based on China*, subsidized by Innovation Program of Shanghai Municipal Education Commission, The authors also thank the valuable advices and deep insights by the editors.

question: what is the situation of industrial clusters behaving in several aspects including hard environment, soft environment, supply, demand, network interactions and innovation performance?

Key words industrial cluster, interaction, innovation performance, network mechanism

Paper type Research paper

1. Introduction

Nowadays industrial clusters have been considered as one of the most important channels towards open innovation and economic excellence. There are signs that suggest industrial clusters might improve economic conditions of a region by means of gathering firms together and facilitating business transactions. Also, industrial clusters are often linked with innovation, in developed countries like France, Germany and US, where many clusters are about high-technology such as information and communication technology (ICT), bio-technology and nano-technology, or, about the booming knowledge intensive business services (KIBS), such as software systems, business consulting, and R&D services. In these particular sector-based clusters, innovation is inherent. Still another importance of the industrial cluster comes from its role of employment in a region. Thus, policy makers have been aware of this phenomenon, and are now trying to find out more evidences, and formulating corresponding policies and institutions to accommodate the development of clusters.

In reality, plenty of actions are being taken under way. From the perspective of practices, cluster improving measures are being continually implemented, such as the traditional Industrial Zones in Italy, Technopoles in France, Bio-clusters in Germany, as well as the already famous clusters like Silicon Valley and Route 128 in Boston in US. In emerging economies, great efforts are being made to propel the policy-driven clusters, especially in countries like China and Korea, where a good deal of industrial cluster initiatives at the national, regional or local level, are emerging.

From the theoretic or academic perspective, researchers are trying all the way to understand the cluster mechanisms in terms of operating, factor requirement, environment, and the impact of the industrial cluster on the local, regional or national economy. Nevertheless, there still remain vital questions before going further ahead: do those firms in the industrial cluster behave significantly better than their counterparts in the outside of the cluster? To what degree does this advantage come from their reciprocal dynamics? And to what degree does this advantage come from

other factors like environmental issues or cultural issues or infrastructure issues?

Indeed, these are vital, yet considerably difficult questions. Environment and network interactions both play vital roles in cluster's innovation performance. On the one hand, a good infrastructure system, including water, power and gas supply will benefit the cluster to a significant degree, while good systems of communication and transportation can also enforce the confidence of cluster managers and employees. Furthermore, firms in industrial clusters are able to enjoy a sound culture where creation and "radical ideas" are encouraged and rewarded. On the other hand, there are several types of interactions and co-opetition among firms, in a formal or informal way. Managers and employees are provided opportunities to meet in conferences, seminars and forums, where they can discuss various issues, while cafes and restaurants and even pubs are also available where they can have a casual chat before imaginative ideas jump out. The influence of these network interactions upon the well-beingness of the cluster, such as economic performance and innovativeness, requires step-by-step studies. What is also worth noticing is that the different natures, as well as distinguished cultural and social contexts of industrial clusters, probably play important roles in the pattern and style of the network interactions of the cluster.

This paper, therefore, is trying to explore this question: what is the context of some industrial clusters behaving in several aspects including hard environment, soft environment, supply, demand, network interactions and innovation performance? We mainly focus on the environmental effects, and interactions among the member firms of the clusters, trying to clarify the related issues from several aspects such as environment and factors that clusters need, and we will try to compare these aspects among several specific types of industrial clusters, taking account of different cultural and social backgrounds. This will provide researchers of industrial clusters and innovation system with better knowledge of the environmental situation of clusters and the interactions-based relationship, help to build meaningful mathematical models to integrate environmental issues and networking issues in details from micro- and meso- perspectives, and then to quantitatively compute the impacts of these factors upon the companies' and clusters' economic and innovative performances.

2. Environmental issues, factorial issues, networking of the industrial cluster members, and innovation

2.1 Environment and innovation

Research about the innovation of a cluster, or of a firm which is geographically embedded into a network, has received much attention recently. When discussing this phenomenon, much emphasis has been placed on environmental issues, such as the infrastructure, the management system, the cultural and social context, and so on.

One important research theme is about the connotation of the cluster innovation. For those clusters which emphasize on innovation, a major function is to enhance the knowledge creation, storage, flow and application within the clusters.

There are some features of industrial cluster which should not be ignored. Industrial clusters vary from other organizational forms in the sense that they embody the situation where multi- enterprises are located in one single district. Clusters depend neither on solely formal relationships, nor on financial or contractual links, but more on socialized relationships based on personal interactions, collective learning, and tacit knowledge flow. This tacit knowledge flow is based on informal networks embedded in the local clusters. Therefore, R&D activities of the member firms within the industrial cluster induce knowledge spillover, which in turn helps to increase the innovation level of the firms and the clusters.

However, besides the network benefits, the members of a cluster are also confronted with certain problems such as information redundancy (Zaheer and George, 2004; Casper and Murray, 2005), competitive blind spots (Zaheer and George, 2004), isomorphism (Rocha, 2004; Desrochers, 2001). Researchers use Porter’s model (Porter, 1990), which is a very often used model, to analyze industrial clusters in innovation capacity across the Taiwan Strait (Lai and Shyu, 2005), in which context for firm strategy and rivalry is discussed. Overall, the research summarized above has provided a valuable basis on which to understand the dynamics of the clustering process and demonstrated the implicit tradeoffs facing firms deciding to locate within

clusters. Furthermore, the geographical space within which a network is embedded has a significant influence on not only the current members and information stock of any network, but also its potential members and information stock (Owen-Smith and Powell, 2004, Kenney and Patton, 2005).

Therefore, environments, both the hard and soft environment, are important for providing the backgrounds of the clusters in which they come into being and evolve. Regional and local environment often provide many factors like “nutritions” for cluster members to absorb and grow. Here in this research we divide environment into hard ones and soft ones, considering that some of them are explicit, whether in reality or can be demonstrate by political or regulatory documents, while other are implicit but still manifested one way or another The hard environment, comprising local infrastructure, the local management system, and regulation systems such as tax regulations and laws, demonstrate the convenience of the facilities, provides institutional and regulatory elements, which are overt, for clusters’ growth. The soft environment, made up of human resource availability, social and cultural contexts, technological potentials, and research funding, on the other hand, supports the clusters more from the societal and non-systematic aspect, which are invisible. This especially deserves more elaboration between different countries.

2.2 Factors and innovation

For the factors which are conducive to cluster innovation, the importance of milieu has received much elaboration, including formal and informal relationships among cluster members. Collective efficiency, collective learning, localized network, interactive process, complementarities as well as resource interdependency have been used to explain the raised innovative capacity of the cluster companies.

The study of economic geography and spatial agglomeration has provided valuable insights into the dynamics of industrial organization (Swann et al., 1998; Scott, 2000, 2004). The primary contribution of this field has been the identification of the centripetal and centrifugal forces driving behavior within industrial clusters and the effects of these forces on individuals, firms, industries, regions and nations

(Marshall, 1920; Perroux, 1983; Krugman, 1991; Saxenian, 1990; Markusen, 1996; Martin and Sunley, 2003; Pouder and St John, 1996). Using Porter's model (Porter, 1990), researchers also analyze factor conditions and demand conditions (Lai and Shyu, 2005).

Rich inter-firm relationships are primarily driven by geographic vicinity to competitors, supply chain members and firms in related industries. Proximity facilitates an increasing number of interactions between related firms, largely as a function of high spatial concentration (McEvily and Zaheer, 1999; Bresnahan et al., 2001).

Thus, relevant factors are those directly affecting companies' decision to locate in the cluster, including demand and supply ones. Factors from the supply side are those ingredients that assist the enterprises in generating innovative products or services, by means of providing materials, information, technology or human resources. They include a good image, good suppliers, access to business information, access to knowledge outside, approach to research and education institutes, and training systems. Factors from the demand side, on the other side, refer to the ultimate motivation sources for the firms to innovate, comprising low cost of searching clients and convenience of contacts to clients.

2.3 Network interactions and innovation

There have been a number of studies on the interactions among firms and their impacts on innovation of the companies. Although not all are based on the cluster perspective, they provide valuable references for the study of the relationship between cluster innovativeness and member firm interactions. And they're mainly from micro-perspective.

Industrial cluster theory provides one stream of literature background for this study. Porter (1990) argue that national competitive advantage is constituted by "home base" conditions that are embedded in localized intrafirm and interfirm linkages, interorganizational collaboration, and networks. Attention should therefore be paid to spatially bound "clusters" (Porter, 2000). Malmberg and Power (2005)

claim that there are actually few evidences that firms interact or collaborate more with other local firms and conclude that “collaborative interaction with similar and related firms in the localized cluster does not come out as a major knowledge creating mechanism.” However, this does not necessarily lead to a rejection of locally bounded theories of innovation (e.g., clusters and regional innovation systems); rather, it leads to the conclusion that the insights of both approaches need to be integrated more explicitly in future research.

The industrial cluster approach promotes the idea of studying the interactions between firms and other organizations, but it largely restricts such analyses to a particular scale or type of proximity. In contrast, this paper argues that it is important to explore the concentration and dispersal of innovation processes across multiple scales (Malmberg, 2003; Malmberg and Power, 2005; Malmberg and Maskell, 2006) because local external economies from concentration produce both advantages and disadvantages for firms (Parr, 2002).

Meanwhile, although the industrial cluster approach addresses the specificity of location issues clearly, it has a tendency toward technological determinism in that technology is presented as a given to which regions respond. For instance, the comparison of innovation capacity at science parks across the Taiwan Strait was largely based on this assumption (Lai and Shyu, 2005). This is not taken for granted in this paper, as innovativeness, geography wideness and public policies interact with each other.

Another stream of literature, open innovation, by theory, is almost related to establishment of ties of innovating firms with other organizations. Since gaining accesses to local knowledge is of crucial importance in the current knowledge economy, industrial cluster and regional innovation systems are important for open innovation because the knowledge flows between cluster companies are crucial (Vanhaverbeke, 2006). This theory itself includes dyad level and inter-organizational networks. It is vital for the firms to consider the issues like how to select partners, how to assess the return and risks of an alliance, how to evaluate the fit between potential partners and how to structure the cooperative agreement and manage it over

time. As Chesbrough and Rosenbloom (2002) consider the value network as a function of business model, the value network increases the supply of complementary goods on the supply side, and can increase the network effects among customers on the demand side. Furthermore, as the knowledge flows more readily to closer entities (Jaffe, Trajtenberg and Henderson, 1993), the organizational and institutional embeddedness of geographically networks might be crucial in explaining the differences of open innovation in different regions or nations.

Firm theories clarify that the establishment of the boundaries of the firm reflects the entrepreneur's preferred but subjectively perceived way of coordinating external factor markets, internal resources and final customers. Where speed and flexibility are critical in the pursuit of new business opportunities, the entrepreneur will generally avoid building resources that are available through market transactions. And it is likely that new products that are introduced and exploited within the firm will have comparatively close connections to the existing genetic code, while ideas and products that have looser connections can be expected to be exploited outside the firm's boundaries. Motives for partnership are minimizing the sum of internal and external transaction costs, rising efficiency. Main factors within a relationship are: frequency, asset specificity, uncertainty, and complexity (Williamson, 1979). The geographical proximity can thus provide tremendous convenience for higher frequency of communication, lowering the uncertainty of transaction because the adjacency facilitates knowledge flow between organizations, and helps companies to better control their business.

Also, networks of actors benefit from enhanced information diffusion and their relatively loose structure facilitates the cross-fertilization of ideas and collaboration, relative to non-networked actors. This process aids in enhancing the innovative performance of firms, and provides an alternative to formal collaborative and control structures. (e.g. research consortia or equity joint ventures). (Feldman, 2003; Desrochers, 2001; Breschi and Lissoni, 2001; Martin and Sunley, 2003; Stuart and Sorenson, 2003)

Overall, under many circumstances, cluster provides a good background for

interactions and collaborations among member companies based on interdependence. Studies are under way to clarify the positive influences of these interactions. But there are also indications of negative effects. Nonetheless, the patterns of the interaction remain unclear for most management observers.

In this study, the concept of network mechanisms is used to describe, from several angles, the phenomenon and trend of the relationship among member firms within the clusters. These different angles embrace specialization, complementarities, collaboration, convenience to information, and homogenization.

2.4 Innovation performance

Finally, although there are empirical evidences showing that enterprises in the cluster might have more tendency of innovation (Baptista and Swann, 1998), the innovativeness of a cluster as a whole still remains questionable. Apart from the difficulty of measuring the innovativeness of a cluster, another possible reason is that most research in this stream tends to adopt the traditional way of observing innovation from the micro- perspective.

In this study, the concept of innovation performances of the cluster are used to display how industrial clusters are identified in terms of innovation related activities, such as patents (applied/authorized) or software copyrights, new products or services, as well as revenue/profits. All are observed from the perspective of comparison between cluster member companies and their competitors in the market in general.

3. Features of clusters and the categorization

Clusters at the present days have been promoted extensively, as an important method of sound innovation and economic performance. Due to different developing paths, cultural and social contexts and other factors, clusters vary tremendously.

One issue is the spatial scale of the industrial cluster. Interestingly, although it’s obvious that cluster, by definition, is closely connected with spatial meaning, this issue of geographical boundary hasn’t received much academic attention as other aspects. The term “geographical concentration” is vague in that it doesn’t specify in

details to what extent do the firms concentrate. In another word, it doesn't shed light on the situations whether firms cluster in one single multi-floor mansion or even a skyscraper, in their own independent tenements scattered in a land of one square kilometer, or in a large area where dozens of sizable cities can be counted in. Initially, Porter (1990) applied his cluster principles to national and international clusters within industrialized countries, such as Norwegian maritime cluster, but later realized the relevance for local, regional and state-based clusters (Porter, 2000). Geographic span of a cluster is affected by the ability of sharing information, resources and knowledge. Underlying social perceptions, cultural barriers and partiality may also influence or even limit the size of a cluster (Gibbs and Bernat, 1997). Indeed, companies tend to rationalize their decisions of locality from economic measurement, and most factors they consider include the convenience to contact the customers and suppliers, good infrastructure, availability of human resources, etc. On the other hand, geography is determined by the distance and time that people are willing to travel for employment and that employees and owners of companies consider reasonable for meeting and networking (Rosenfeld, 2002). Just-in time processes, the need for face-to-face interactions and visibility of regional economies are also highlights (Anderson, 1994). If one single building, or a small piece of land, whether it's called an incubator or science/technology park, located in a metropolis where there are plenty of resources mentioned before, meets these criteria, it has good potential of being an attracting cluster. In a larger scale, at the same time, more emphasis might be put on the availability of the industrial chain, the availability of fund and human resources of the whole region. Therefore, significant differences should be taken into account when considering the cluster categorization.

Another topic is about innovativeness of the cluster as a whole. First of all, industries vary in terms of innovativeness. Those clusters in the so called emerging sectors with strong innovativeness like ICT, life science, material, and so forth, develop fairly quickly and have more innovative fruits like patents, new products and services. The fast growing Knowledge Intensive Business Services (KIBS) are also behaving considerably outstanding. On the contrary, the traditional manufacturing

sectors are often less dynamic or active in these aspects. Nevertheless, more integration is being seen between these two types of sectors. The emerging technologies and new ways of serving clients are mobilizing and improving the efficiency and effectiveness of the traditional sectors. For instance, nanotechnology has been applied into classical materials chemistry industry. In particular, the great advancement and wide application of ICT are utilized as a powerful catalyst in numerous sectors and enterprises. In some cases, more collaboration about product and process information sharing, strategic alliance forming and cooperative R&D projects developing can be found in the emerging high-tech sectors.

A look at the industrial clusters in different economic contexts will discover vastly different characteristics of industry broadness, namely the industrial boundary of the cluster. In Europe and North America, the limits of an industrial cluster are often found to be complying with the standard industrial classification system. There, clusters are considerably specialized, meaning the relatedness of the members in the same cluster is high. For them, the relationships within a cluster, including buyer-seller links, competition, collaboration, and shared-resource relationships, are vital for innovation breeding and sound economic performance as well (Anderson, 1994). However, their counterparts in China are not like so. Often, the so called “high tech parks” there are found to comprise more than one specific business line, let alone some incubators in which ICT manufacturing firms and biotechnology R&D companies are on the same floor. Under this circumstance, the target market, business modes and market behavior of these cluster members vary so much that any meaningful cluster activities like coordination, collective meeting and presentation, training and membership interactions are less effective, which poses challenges to the economic performances and innovativeness of these companies.

This paper addresses the comparison between different types of industrial clusters, taking into account the differences regarding cultural and social contexts. Thus, these three dimensions are chosen for the mapping of clusters, namely geography wideness, industry broadness, and innovativeness or added value. The logic for choosing them is simple. There has been much study on industrial clusters

from the perspective of government's role and key firm's status. Clusters are either classified into spontaneous ones and policy induced ones, on the basis of government's dominating style, or into satellite ones and net-like ones, on the basis of the existence of a key firm. Nonetheless, the study of geographical wideness, industry broadness and added value has been scarce. Part of the reasons might be most industrial cluster research is focused on developed economies, where disputes over these issues are not common because consensus have been reached. Clusters in developing countries, however, vary greatly from their counterparts in developed economies regarding these three aspects. There are geographically big clusters such as Yangtze Delta of China, which extends hundreds of kilometers, while small incubators are also regarded as a form of cluster at the same time. The innovation connotations of the clusters are diversified, from the most modern high-tech ICT or biotechnology to the outdated manufacturing methods. What is more confusing is that the situations of industrial broadness are quite different from each other. While some clusters are focusing on one specific sector such as ties, cigarette lighter or shoes, as seen in many regions in southwest China, many policy induced industrial clusters such as science/technology parks lack the internal links among member firms. Sometimes totally different business lines can be found in the same cluster, with each occupies a sizable portion of the cluster's output.

There are a good number of types of industrial clusters. To illustrate some of them, some examples are given as below in Table 1 and Figure 1.

Table 1: categorization of industrial clusters and examples

Type	Examples
Manufacturing pole, Manufacturing cities	Ruhr Area of Germany, Northeast Industrial District of China, Yangtze Delta of China, Detroit of US
Classical Industrial Cluster	Italian Industrial District, Clothing Clusters in Yangtze Delta of China
Industrial Zone, Development Zone	Economic Development Zones in China
Specialized Park/Area	logistic parks, Shanghai International Automobile City, International Iron and Steel Service Area of Shanghai, Shanghai Shibei (North) Industrial Park
Traditional Business	Business Incubators, Entrepreneurship Service Centers

Incubator	
Science/Technology City	Eindhoven-Leuven-Aachen triangle in Europe
High-Technology Cluster	Silicon Valley, Boston Route 128, Bio Region of Germany, Business consulting cluster in CBD, Financial service clusters in London and New York
High-tech Development Zone	Science/Tech Parks (City/Country level) in China such as Zhongguancun Science Park, Zhangjiang Hi-Tech Park, and Hsinchu Science Park in Taiwan, and Tsukuba Science City of Japan
Center of Excellence	Technopoles in France, High Tech Campus Eindhoven, Chemelot in Netherlands, Software Technology Park of India in Bangalore, Zhongguancun Software Park in China
Comprehensive Technology Incubator	High-Tech Entrepreneurship Service Centers, Science/ Tech Parks (District/University level) in China
Specific Center of Innovation	IT-Speicher, BioPark, Sensorik in Germany

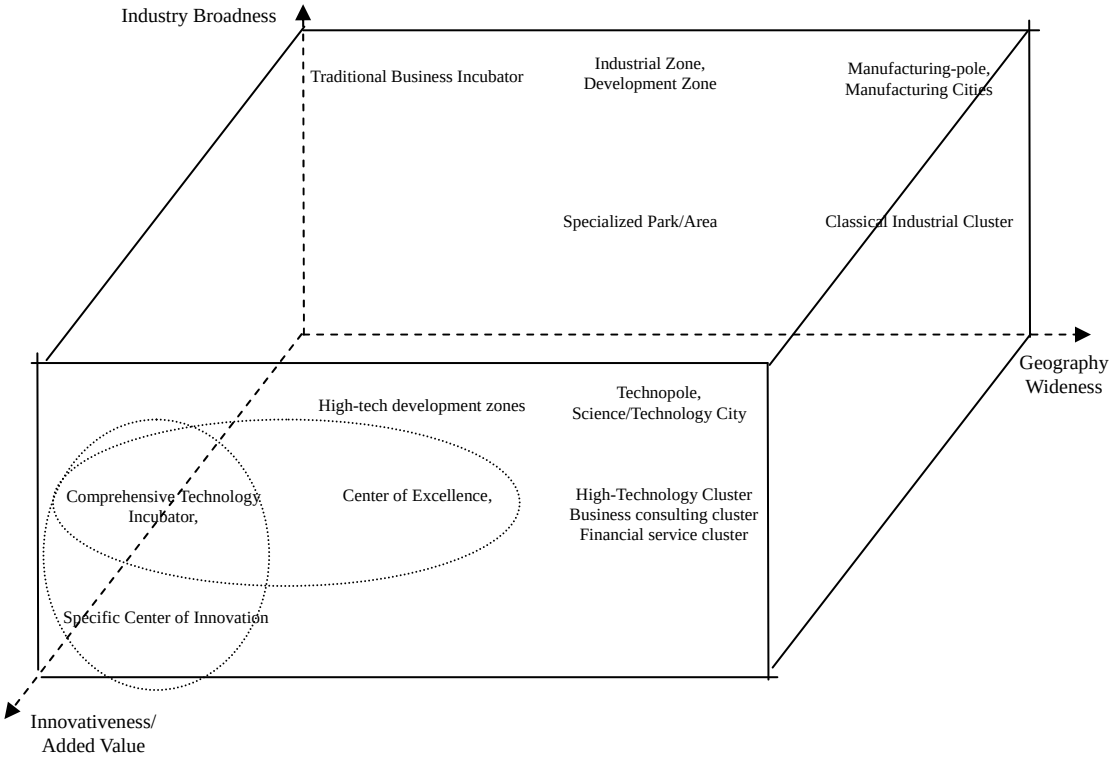

Figure 1: mapping of clusters

Among these industrial clusters, three types are of particular interest in this study. They are Center of Excellence, Comprehensive Technology Incubator, and Specific Center of Innovation. There are several reasons as follows.

First, there has been plenty of research about high-tech clusters such as Silicon Valley and Route 128 (Saxenian, 1994; Bresnahan, Gambardella, 2004; Fallick, Fleischman, Rebitzer, 2006), and high-tech development zones such as Zhongguancun, Zhangjiang and Hsinchu (Lai and Shyu, 2005; Tan, 2006), whereas one vacancy still remains for others which are studied in this paper.

Second, there are several features of these types of clusters. All of them are small scales geographically. This means these relatively small-scale clusters require fewer hardware resources such as land and basic utilities, compared with large ones. Therefore, they are suitable for those high tech R&D SMEs who don't demand a lot of those hard resources. This trait bestows them tremendous growth potential in developed areas where land is rare, or undeveloped areas where infrastructure building is not that handy. The requirement for soft environment buildings is often quite the reverse, though, because the innovativeness of these clusters is usually high.

Third, these clusters, though small scale geographically, still present good examples for observing and comparing the features of network mechanism. Since the limited space makes it possible to meet with the potential business partners, whether across the corridor or in the cafeteria, the interactions among member companies, especially informal ones, and perhaps formal ones as well, might increase. For innovative companies this makes big sense because they depend greatly upon knowledge flows to come up with innovative ideas. In this sense, the network interaction mechanism might have an impact upon the innovation of the cluster.

Furthermore, all three types are likely to follow the pattern of policy-led establishment and growth. As can be seen later in the cases, all of them are often "formal" ones in the sense member firms are subjective to the selection of the dominating organizations, whether it's a management commission appointed by the regional government or a key firm. This is quite different from the larger ones such as high-tech clusters in Silicon Valley and business services clusters in CBD of metropolis.

On the one hand, for these three industrial clusters, the similarity lies in innovativeness or added value, because all of them are either about high-technology

such as ICT software, material technology, and mechanical & electrical integration, or about high value added services such as business consulting, R&D services and financial services. On the other hand, the differences of industry broadness and geography wideness provide good perspectives to observe aspects such as environment and conditions of either supply or demand. Particularly, the extent to which spatial and industry characteristics are demonstrated might have an impact on the interaction mechanism within the clusters, and therefore influence the innovation performances as well. In this sense, the light shed on several dimensions within these clusters will help to clarify the relationship among them, and the influence on the innovativeness and economic performances of the cluster later on.

4. Empirical studies: Clusters in the Netherlands, Germany, and China

4.1 Backgrounds of three industrial clusters

Previous industrial cluster research mainly focuses on high-tech clusters and high-tech development zones, which are relatively large in either spatial scale or industrial wideness. The relatively smaller ones -- Center of Excellence, Comprehensive Technology Incubator, and Specific Center of Innovation, are somehow neglected. Trying to fill this gap, case studies of three clusters are conducted in this paper. The main objective is to clarify and compare several dimensions of these clusters, taking into account the social and cultural contexts, and probe into the connections among them and the network interaction mechanisms as well as the innovativeness of the clusters.

(1) IT-Speicher in Germany

Situated 100 km north of Munich, the Regensburg economic region in Germany is a fast growing location for ICT businesses. Over recent years some 30 percent of company start-ups there have been in the ICT sector. The Regensburg IT Incubator Center, IT-Speicher, is a center for promoting young ICT start-ups and new business settlements at very high standards. The ICT sector is supported in the Upper

Palatinate by the platform www.regensburg.it.

IT-Speicher is operated by IT Inkubator Ostbayern GmbH, which was established in 2001. This IT incubator has a total building area of 3,000 m². Forty companies, thirty of which are high-tech start-ups with their own ground-breaking products, are currently situated in this start-up center.

Considering the industry broadness and geography wideness, as well as its innovativeness, IT-Speicher is a good example of specific center of innovation.

(2) Chemelot in the Netherlands

Located in Limburg Province of the Netherlands, less than 20 km away from the city of Maastricht, Chemelot is in the middle of the so called knowledge triangle Eindhoven-Leuven-Aachen. It's not just an industrial park of chemical and materials, but also a unique community that ensures accelerated business growth through the open exchange of ideas.

With an area of over 800 hectares, Chemelot is one of the largest chemical industry clusters in Europe. There are over 60 companies on site, many of whom are global leaders in their product market combination. There are about 7,500 employees and more than 30 plants and chemical installations producing together approximately 7.5 million tons of products annually. At the same time, it is also a research & development campus, with approximately 250 patents produced per year.

Chemelot provides a good example of center of excellence.

(3) Shanghai University Science and Technology Park in China

Based in the campus of Shanghai University, the SUSTP is derived from an old technology park built in 1991, and is one part of the "One Zone, Six Parks" in Shanghai High-Tech Development Zone. The SUSTP administrative commission is fully responsible for operating and managing the technology cluster.

There are over 10,000 m² of a total building area in SUSTP in year 2009, and over 80 companies are located inside, which ranges from ICT, Mechanical & Electrical Integration, new materials, environment protection, life sciences, and so on. It also has a specialized incubator for multimedia, integrated circuit, nanotechnology, and glass art. Overall, about 700 staff is working in it for entrepreneurship.

SUSTP is a good example of comprehensive technology incubator.

4.2 Discussions

This paper tries to clarify and compare several dimensions of these industrial clusters, taking into account the social and cultural contexts, and to expatiate similarities and differences of environment, factors and interactions among different types of clusters. On the basis of that, attempts will be paid to probe into the connections between them and the innovation performance of the clusters.

To study these three industrial clusters, interviews with cluster coordinators and related regional and local officials were conducted from May 2008 to April 2009. They are chosen for this interview because, first, they are the ones who have the best knowledge of the overall situation of the industrial clusters we examine; second, it provides another perspective to observe the industrial clusters other than the traditional perspectives of company managers, which will complement the old knowledge and therefore offer a complete picture of industrial clusters. During these interviews some closed and open questions were asked and answered and records were taken. For most situations, interviewees were asked to give a mark ranging from 0 to 6, which show their opinions from “strongly disagree” to “strongly agree”. The questions are about the aspects of hard and soft environment, factors from the supply side and the demand side, network mechanisms, and innovation performance. Also those factors which were involved during the interviews are activities the clusters offer to the member companies. But they show no close link with the other aspects above, and are therefore not analyzed. All the above questions are related with industrial clusters and networks, especially from the geographical and cooperative perspective. Same procedures and patterns of interview were adopted respectively in Regensburg of Germany, Limburg Province of the Netherlands, and Shanghai of China, to ensure the comparability of the three clusters.

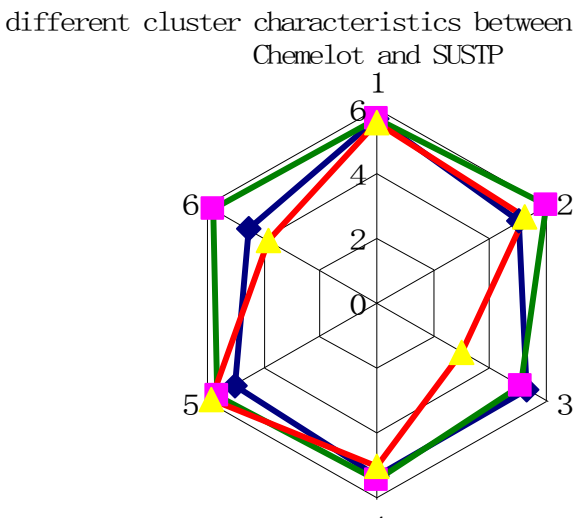

Figure 2: different cluster characteristics between IT-Speicher, Chemelot and SUSTP

(1) Dimension 1: Hard Environment

There are three items in dimension 1, including local infrastructure, local management system, and regulation systems such as tax regulations and laws.

The scores of this dimension are the same (5.7) for the German cluster IT-Speicher and Dutch cluster Chemelot, and is a little lower for the Chinese cluster SUSTP (5.5). For the center of excellence and specific center of innovation, the geographical wideness expands along with industrial broadness. This phenomenon takes place only if the local management systems, whether legislative, governmental or juristical, evolve into a higher level so that there are proportionate basic infrastructures and hardware facilities for the governance of the cluster. For a cluster, a relatively wide geographic area generally corresponds to a broad industrial spectrum, because good complementarities need to be achieved for a relatively large number of firms so as to help them realize low cost of searching for clients and convenience of finding suppliers. This doesn't apply to comprehensive technology incubators, though. Most technology incubators in China are rather broad-banded in terms of sectors. And the physical infrastructure, including network connections, water and electricity supply, and presenting and exhibition rooms, has to keep up with the expansion of the industry latitude, which brings difficulty because of the confined geographical space. The management systems, as well as tax regulations are also confronted with difficulties when trying to accommodate the same policies to different firms in

different industrial contexts.

(2) Dimension 2: Soft Environment

There are four items in dimension 2, namely human resource availability, social and cultural context, technological potential, and research funding.

For this dimension, IT-Speicher scores 5.0, while Chemelot scores 5.9, nearly 20% higher than the former. SUSTP gets a score of 5.2. A deeper look shows that the main discrepancy comes from technological potential and research funding. On one hand, Chemelot, as a center of excellence, was initially created and is still led (to some degree) by the large company DSM, which results in cutting-edge and ever-improving technologies in the chemical domain, and also endows the member firms better capacity in getting local or state fundings for further research. On the other hand, in IT-speicher, as a specific center of innovation, there is no leading, or core, corporations which can be a true kernel of technological inventions or marketing initiatives, or can provide the whole industrial cluster with technological infrastructures such as public laboratory, testing center, quality center, etc. Meanwhile, the ability of the cluster as one single entity to attract funding is limited largely due to the lack of flagship corporations and hence the cluster image. Similar situations are found in SUSTP, since the broadness of industrial area of the member companies and lack of core firms lead to even more disadvantages. On the other side, human resources and social/cultural contexts are all favorable for these three clusters. All are enjoying the benefits of being located in, or not far away from, the major regional central city where they can have good access to abundant human resources like university graduates or engineers, and which can provide them with rather loosened and free interaction environment. In all three clusters there are favorable atmospheres for entrepreneurship and innovation. What is slightly different is that in the two European clusters more casual working and life style can be found, while in China the emphasis is always put on hard working and achieving a successful career.

(3) Dimension 3: Network Mechanism

There are five items in dimension 3, which are specialization, complementarities, collaboration, convenience to information, and homogenization.

Slight differentiation is shown between IT-Speicher and Chemelot, since the former demonstrates a higher score of 5.3 compared to 5.1 of the latter. The main difference comes from collaboration and convenience to information. Indeed, the advantage brought by proximity of locating in the same building or land area is benefit by those firms in IT-Speicher, which has a smaller geographical wideness and narrower industrial broadness. Employees and managers of the firms have more opportunities of meetings or just bumping into each other, having a casual chat or formal talk, and arranging a business event together. Because there are clear specifications among companies, complementarities based on task dividing and project group can be achieved, and thus collaborations can be realized. For Chemelot as a center of excellence, which has a larger land area, collaborations may not be gained that easily, because contacts among people are usually restricted in their own buildings/organizations, and lesser interactions will be likely to occur between different organizations without exceptional reason such as meetings or parties. Also, information exchange will take place most likely in official occasions like conferences, seminars and presentations, but less so unofficially. For SUSTP which gets a score of only 3.0, however, the situation is considerably different. Although it has a land area of identical order of magnitude to IT-Speicher, very low network interactions are detected. Complementarities among member firms are not easily realized probably due to the different sectoral backgrounds, let alone project based collaborations. There are recreational facilities like tea houses, cafes and bars at arm's length, but the mental orientation of chasing success as well as heavy work load itself prevents the staff from benefiting from them. Several interviewees even mentioned that they "never went there because it makes no sense". Overall, the advantages of being tightly located are offset by the differed business lines.

(4) Dimension 4: Factors from Supply Side

Supply side factors mainly address the services or resources that the cluster is able to straightly provide its member companies with. They include a good image, a good supplier, access to business information, access to knowledge outside, approach to research and education institutes, and training systems.

There is not much difference between IT-Speicher and Chemelot regarding this aspect (5.3 vs. 5.4). Considering the industrial cluster as a whole, both have good images in their industries, and there are abundant suppliers and research institutes nearby. As far as business information and knowledge are concerned, it makes not much difference from the size of the clusters since they both represent high level brands within the industry across the whole region after all, and the flow and exchange of the information and knowledge are free and plenitudinous, and therefore those resources can be readily accessed. Yet it is moderately differed for SUSTP (scoring 5.0). As one part of the so called “One Zone, Six Parks”, it has a good reputation not only among university science and technology parks, but also in integrating the resources of the University and Zhabei district. But the situation of supplier, business information and knowledge are not optimistic, because more industrial colleagues or competitors along the supply chain are distributed in other districts of Shanghai, and in most cases the conferences, forums and seminars are organized within the district. Thus the cluster isn’t able to provide these conveniences unless it helps its members to attend more local or international seminars/conferences, and take part in more exhibitions together.

(5) Dimension 5: Factors from Demand Side

When companies have to make decisions whether to locate in a cluster, variables they consider most frequently are connected with customer, such as the cost of searching clients, and convenience of contacting clients. They are referred as the demand side factors.

For IT-Speicher, this condition is not as good as those of Chemelot and SUSTP (5 vs. 5.7 and 5.8). There are three possibilities to this situation. First, relatively small size limits its ability of getting in touch with clients. Second, member firms in IT-Speicher are specified in the very sector of the software industry, which also restricts its potential number of customers, although it has a good reputation in the industry. In comparison, the broadness of the industry covering for the other two clusters brings them relatively ease of searching and locating potential clients. Last but not least, the lack of a core company in the cluster makes it difficult to combine as

a whole group and enter the market to find the clients, and to circulate any valuable information regarding this matter. Interestingly, SUSTP behaves well in this aspect, surprisingly comparable with Chemelot, despite the fact it has no core company. One possible reason is that Shanghai University, Non-Profit Organization though it belongs to, is playing a crucial role in assisting the cluster to get in touch, and build new bridges with potential clients. The University as a high prestigious entity in the society offers a one-and-only advantage for the technology cluster, and thus forms a unique business relation advantage for it.

(6) Dimension 6: Cluster Innovation Performance

Innovation performance looks at three aspects: patents (applied/authorized) or software copyrights, new products or services, revenue/profits. All these factors are observed from the perspective of comparison with competitors in the market.

Chemelot demonstrates better in this dimension again than IT-Speicher (5.8 vs. 4.5). It has an excellent track record in patents, and sound record in revenues. The existence of DSM as a core player within the cluster presents a major advantage: it facilitates the process of inventing and applying for patents, not only providing infrastructure such as labs, testing center or quality center, but also corresponding trainings, professional advices and improvement suggestions, which are truly value added activities for the other smaller cluster members. This might as well be a source of comparatively higher revenue/profits for the cluster. For SUSTP, the score of 3.8 really demonstrates the problem of insufficient capability of innovation. The numbers of patents applied and authorized from its members are small, not competitive against other firms in the market, and there are not many new products or services released each year. The revenue/profits situation is reasonably better, largely owing to the tax/fiscal preferential policies provided by the cluster administration office and the local government, which is de facto the key attractiveness for most entrepreneurial companies.

5. Implications and Conclusions

5.1 Implications

Although economic geographers and management researchers began studying industrial cluster nearly 20 years ago, it still leaves a lot of blank issues. One of the main concerns is that how cluster members interact with each other, and how this network mechanism, combined with other factors such as supply and demand as well as environmental contextual elements, influences the innovation performance of the whole cluster.

The first implication of this paper is that it only makes sense to compare industrial clusters that are comparable with each other. That is to say, when talking about different industrial clusters, there are at least three dimensions to be considered: geography wideness, industry broadness, and added value characteristics. This selection criterion should be considered when discussing clusters because elements and resources might vary too much to make the comparison meaningful.

Second, elements must be matched to facilitate the network interactions, and hence the innovation performance of industrial clusters. Land area should be matched to industry broadness. This is specifically meaningful for those small-scale clusters. This means, while the big high-tech clusters like Silicon Valley represent a way of integrating a tremendous number of companies in relatively narrow business lines in a large wide-spread land area, the comprehensive technology incubators, which are prevalent in developing countries like China, on the other hand, are not good at encouraging member firms to get integrated into the local network, nor is it easy for them to improve the innovativeness. This might be because of shortage of corresponding resources to accommodate so many sectors at the same time. Synergistic effect can be achieved best perhaps under the circumstances of moderate similarities between actors, not too much at least. Therefore it is not optimizing to draw firms of as many sectors as possible into the cluster. It has been common in OECD countries to build specialized clusters instead of “all in one” clusters. The importance of having more meetings, seminars, presentations and other formal

occasions of interactions as well as those informal ones such as parties, coffee bar talks and occasional corridor chats, have been clearly perceived by the cluster organizers and business. However, for less developed economies this situation has not been fully comprehended. Many clusters such as science and technology parks and incubators, even though in the general “high technology” field, still lack the interconnectedness and industry relatedness mentioned by Porter (1990), due to the contradictions between a large geographic area and yet a severe shortage of business connections.

5.2 Conclusions

First, this paper deals with the issue about what are the right scales to measure the industrial cluster? Consistent with instinct, different land area of clusters will lead to different types and extents of interaction among member firms, and it is also important to consider the relativity of the business that the companies are running, i.e. the closeness of their business along the value chain or supply chain. Meanwhile, it is sensible to divide clusters into a traditional level and a higher-end level according to the added-value or innovativeness characteristics, so that to demonstrate their differentiated position in the economic system.

This paper, next, tries to answer the question: (1) what is the situation of a particular set of industrial clusters, i.e. center of excellence, specific center of innovation, and comprehensive technology incubator, behaving in several aspects including hard environment, soft environment, supply, demand, network interactions and innovation performance? (2) What are the similarities and differences? This means we are mainly focusing on the interactions among the member firms of the clusters, trying to clarify the related issues from several dimensions such as environment and factors that clusters need, and we will try to compare these aspects among several specific types of clusters, taking into account different cultural and social backgrounds.

According to the above analysis, it is apparent that the example of center of excellence, Chemelot, demonstrates fairly good quality in hard environment, soft

environment, demand side factors, and innovation performance. Compared with IT-Speicher and SUSTP, it shows a kind of “comprehensive boost”, which means it has no real “short slab” in all the discussed aspects. It enjoys an ample spatial advantage, and a relatively broad but still well matched industrial span.

On the other hand, IT-Speicher exhibits strongly in hard environment, network mechanism, and supply side factors. Although spatially narrowly distributed, the specific center of innovation exploits the benefits from its concentrated sector, thus facilitating the interactions among its member firms, and encouraging companies to enter it based on good business essentials like suppliers, information and knowledge flow.

For SUSTP, a typical Chinese comprehensive technology incubator, relatively limited geographical space and broad sectoral distribution endow it with somewhat ambivalent conditions. Although it behaves not bad, almost comparative to the other two clusters in fact, in aspects of hard and soft environment, as well as supply and demand factors, seldom do its member companies benefit from interactions with their cluster colleagues like the other two. Collaboration for a project is difficult to realize because the complementarities are not there in the first place. Due to onerous daily work and business, the entertainment facilities of arm’s length which are suitable for unofficial social network activities, are not utilized as much as expected. Entrepreneurs, managers and employees of different business lines congested in one single building can hardly produce idealized network interactions.

In summary, the findings of this paper are that the examples of center of excellence and specific center of innovation in Europe demonstrate relatively better in network mechanisms and innovation performance than the Chinese comprehensive technology incubator. Given that the other aspects are slightly different, it might well be that the network interactions within the cluster has positive connections with the innovation performance of the cluster. This, therefore, leaves further space for research in the future.

5.3 Contributions

This paper tries to evaluate some industrial clusters according to a set of criteria. In order to fulfill this purpose, analyses and categorization of clusters are conducted. The contribution of this paper includes:

First, this paper contributes to the theoretical basis through analyzing and clarifying the scales to measure industrial clusters. Situations vary greatly between mature economies and emerging/undeveloped economies regarding the degree of government motivation of pushing the industrial cluster, and the degree of perfection of infrastructure. Spatial scale, relativity of the business as well as the added-value or innovativeness features are chosen for mapping industrial clusters. This taxonomy corresponds to the reality that the differences exist in cultural and social contexts, which might have a significant impact on the cluster's innovativeness and economic behavior.

Second, combining theoretical and practical perspectives, this paper answers the question: what is the situation of industrial clusters behaving in several aspects including hard environment, soft environment, supply, demand, network interactions and innovation performance? Three specific types of industrial clusters are chosen for comparing according to these dimensions. Mainly focusing on the interactions among the member firms of the clusters, trying to clarify the related issues from several dimensions such as environment and factors, this paper takes into account different cultural and social backgrounds. This will provide researchers of industrial cluster and innovation system with better knowledge of the relationship based on interactions within clusters. In particular, these three clusters analyzed are from three different countries, two from mature economies and one from emerging economy, thus representing different context. This might shed light on the potential impact of economic and cultural background upon the mechanism of interaction within cluster.

Third, this paper provides a potential pathway for researchers of industrial cluster and innovation system to build meaningful mathematical models to measure the interactions within clusters in details from micro- and meso- perspectives, and then to quantitatively compute the impacts of these interactions upon the companies' and clusters' economic and innovative performances. Network theories, graph theories as

well as complex system theories are all possible in quantitatively assessing the development of industrial clusters, whether statically or dynamically.

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Appendix: Case Study Questions

The questions below include closed ones and open ones. For closed ones please give a mark from 1 to 7. (1: strongly disagree; 2: moderately disagree; 3: slightly disagree; 4: neutral; 5: slightly agree; 6: moderately agree; 7: strongly agree). For open ones please give your brief remarks and ideas about them.

Cluster is defined as a geographically proximate network of interconnected companies and associated institutions in a particular field, including product manufacturers, service providers, suppliers, universities, and trade associations.

Advices for the filling of the questionnaire

We apply here basically the business organization principle .please also answer the question, even when it doesn't deal with an independent firm.

Important indicators of this cluster

- Which economic sector is the main business field of this cluster?

- What products does this cluster produce and what service does this cluster provide?

- Can you tell us the special competences of the products, services or production method, which are characteristics of this cluster (e.g. special machine or special services).

1. Environment

（1） Hard environment

- Do you think the local infrastructure is good for the company's development?
- Do you think the local management system (from the government) is good for the company's development?
- Do you find a loose regulation (tax and law) in this area?
- Do you think the local assessment system (for the company managers and entrepreneurs) is good for the company's development?

（2） Soft environment

- Do you think there is abundant availability of local qualified human resources for the company's staff? If so, where are they mainly from? (open)
- Do you think the local social and culture environment is good for the company's development? Describe them briefly. (open)
- Do you think the local technological potential and R&D level is good for the company's development?
- Do you find it easy to get state or local research funding?

2. Network mechanism

- Do you think there is a clear specialization in local companies?
- Is it possible for the companies to complement each other's ability and have a good cooperation?
- Is it easy for companies to collaborate with each other for a project?
- Are local cafes, bars or parties important and convenient to access useful business information, idea, people or other resources?
- Are the companies more and more similar to each other in the cluster? (Products or services, strategy, R&D, etc) If so, what do you think the reasons are? (open)

3. Influencing factors for companies to locate in the cluster

Organizing and managing the local cluster here, to what degree will you agree that the following factors are good in the cluster?

（1） Supply side:

- A good image
- Enough good suppliers
- Can easily access the up-to-date information in this industry
- Get more knowledge from other companies such as fellow traders, suppliers and clients
- Can easily approach the research institutes such as universities, colleges, and research institutes
- Good training system

（2） Demand side:

- Low cost of searching clients
- Convenient contacts to clients

4. Is innovation performance of the local cluster very good?

- Patents (applied/authorized) or software copyrights
- New products or services
- Revenues/ profits
- Is it long to market the products or service?

5. What activities does your cluster offer, and how often? (Open)

- Cluster internal working group
- Cooperation with other members in cluster
- Information event of the cluster
- Qualification offers of the cluster
- International measure
- Presence in exhibition together
- Others

6. Further questions about cluster

a) Is there any elements of which according to your belief the cluster lack. (Multiple choices possible)

Research Institution	Education and Training Workshop
Important Suppliers	Important Service Providers
Financing/Venture Capital	Network coordinators
Others	

b) What are the advantages as a member of a cluster from your perspective?

New contact to R&D cooperation partners
New contact to Suppliers
New contact to Customers
Better access to qualified professionals of the region
Better access to the financial subvention
Better access to credit capital
An image improvement for the own economic field in the space of Maastricht
Better access to information
Others

c) What obstacles and problems do you see in the cluster relevancy?

Too little knowledge about the potential partners in space of Maastricht
No appropriate Partner located in the space of Maastricht
High additional time and coordination’s effort for cluster activities

Too high dependency to partners
Disadvantages through the publication of know-how to the cluster partners/competitors
Too little own utility from cluster activities
Others

d) What characters in your opinion does a successful cluster own?

e) On which field of regional economic politics in your opinion should be emphasized?

Thank you very much for your work!