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The Strategy of Industrial Clusters to Deal with Disruptive Innovation

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Abstract

Disruptive innovation may be a fatal threat to industrial clusters, or it may be a major development opportunity. The key lies in how industrial clusters respond to disruptive innovation. The main obstacles to the development of disruptive innovation in industrial clusters are lock-in and cluster inertia, which originate from the negative effects of cluster system isomorphism. In order to break through the development barriers, industrial clusters need to adopt a targeted overall response strategy, including adopting bottom-up local subversive innovation policies, introducing external knowledge, encouraging spin-off entrepreneurial enterprises, and encouraging alliances and cooperation between incumbent enterprises and entrepreneurial enterprises, etc.

Keywords

Industrial Clusters, Disruptive Innovation, Strategies, Entrepreneurial Enterprises

1. Introduction

Unlike sustaining innovation, disruptive innovation produces important changes in products, markets or technologies, and even leads to obsolescence of existing technologies [1]. Disruptive innovation may lead to the decline of industrial clusters, which will lead to regional economic turmoil. For example, the Swiss watch industry cluster has experienced the "Quartz Revolution". In less than 30 years, a large number of cluster enterprises have closed down, laid off a large number of companies, and low-end mechanical watches have almost been wiped out in the quartz crisis. The threat of disruptive innovation to industrial clusters does not mean that industrial clusters have no resistance in front of disruptive innovations. Many cases show that if industrial clusters can cope with the impact

of disruptive technologies in a timely manner, they may even achieve significant development. For example, the Castellon industrial cluster in Spain has successfully developed digital printing technology, replaced the core position of the Italian machinery manufacturing cluster in the value chain of the world ceramic tile industry, and successfully transformed and upgraded. Small and medium-sized enterprises in the Yiwu industrial cluster have successfully used disruptive innovation to achieve internationalization [2]. Therefore, disruptive innovation may be a fatal threat to industrial clusters, or it may be a major development opportunity. The key lies in how industrial clusters respond. At present, there is still little research on disruptive innovation based on the meso-level. If Chinese industrial clusters want to use disruptive innovation to achieve overtaking on the curve, they need to learn from the experience of developing disruptive innovations in foreign industrial clusters, and take corresponding countermeasures based on China's actual situation. This paper first introduces the connotation of disruptive innovation, and discusses the impact of disruptive innovation on industrial clusters. On this basis, the obstacles to the development of disruptive innovation in industrial clusters are analyzed. Finally, it summarizes the strategies of industrial clusters to deal with disruptive innovation.

2. The Connotation of Disruptive Innovation

The concept of disruptive technology was first proposed by Bower and Christensen in 1995. Disruptive technologies introduce a completely different set of attributes than a mainstream customer's historical value, and often perform so much worse on one or two dimensions that mainstream customers value, that mainstream customers are reluctant to use disruptive products. Disruptive technologies are often only used and valued in new markets or applications and enable the emergence of new markets. Once a disruptive architecture has established itself in a new market, continuous innovation follows a steep trajectory to rapidly improve performance to meet the needs of customers in the established market, allowing incumbents to be replaced by latecomers [3]. Christensen [4] argues that disruptive technologies are generally simpler, cheaper, more reliable, and more convenient than existing technologies. In 2003, Christensen [5] began to replace "disruptive technology" with "disruptive innovation". Yu [6] argues that this practice is to broaden the application of the theory to include not only technological products, but also services and business model innovations, and that disruptive innovation is a more appropriate term that can be used to describe the entire phenomenon. Si *et al.* [7] argue that the theory of disruptive innovation faces a dilemma, its core concepts and basic connotations are widely misunderstood, and the theory is often misapplied.

3. The Impact of Disruptive Innovation on Industrial Clusters

Disruptive innovation can lead to cluster decline. Taking the wireless communication technology industry cluster in North Jutland, Denmark as an example,

when the communication standard changed from 1 G to 2 G, and from 2 G to 3 G, the industry cluster survived and developed [8], but in the transition from 3 G to 4 G. The cluster failed to adapt to disruptive technologies. The R&D facilities of Motorola and Texas Instruments, the core enterprises in the cluster, closed in just a few months. Large multinational corporations and highly skilled employees leave the cluster in large numbers. Industry associations closed, GDP shrank, and unemployment rose [9]. Ostergaard [9] argues that this industry cluster has fallen into decline in the face of 4 G technical standards. The reasons for the decline are technology lock-in and the departure of key manufacturers. Many scholars believe that disruptive innovation will change the basic knowledge base of an industry. If the cluster enterprises cannot enter the new technology field, it will easily lead to the decline of the cluster [4] [10].

Disruptive innovation may also be an opportunity for industrial clusters to seek further development. Menzel [11] pointed out that a decaying cluster can transform itself by entering a completely new field. The Castellon tile cluster in Spain provides a good example, successfully using the disruptive technology of digital inkjet to successfully upgrade a low-tech industrial cluster to a high-tech industrial cluster. Molina [1] argues that disruptive technology affects the basic strategy of cluster enterprises and the overall strategy of industrial clusters. Taking digital printing technology as an example, this disruptive technology enables companies to solve two fundamental strategic issues of product differentiation and cost reduction at the same time, and opens up new opportunities for diversification strategies for clusters. Disruptive innovation could be a key element in revitalizing those clusters that are considered to be at the end of their life cycle. And because opportunities are not limited to the same industry, disruptive innovation can be seen as a key driving force for the development of industrial clusters in different industries.

4. Obstacles to the Development of Disruptive Innovation in Industrial Clusters

1) Lock-in

Lock-in is one of the main obstacles to the development of disruptive innovation in industrial clusters, which means that the ability of industrial clusters to identify and adapt to external changes is reduced. Lock-in mainly includes three forms: functional lock-in, cognitive lock-in and political lock-in. Among them, functional lock-in refers to the obstruction of key functions such as research and development of suppliers, resulting in a lack of innovation by suppliers, resulting in supplier dependence syndrome. Cognitive lock-in means that the mental models of cluster enterprises are the same. Managers pay too much attention to the inside of the cluster, ignore external changes, and easily ignore external signals, which makes it difficult for the cluster to adapt to external changes. Political lock-in refers to the efforts of cluster institutions to maintain the status quo, undermining cluster creativity [12]. Lock-in has a negative impact on the devel-

opment of industrial clusters. If the cluster enterprises pay too much attention to the current products and technologies, or the enterprises do not yet have the ability to innovate, cognitive lock-in, functional lock-in and political lock-in will limit the development of technology, resulting in technology lock-in. The lock-in of existing cluster firms leads to a lack of innovation in the cluster, which in turn makes the cluster less adaptable when technology changes.

2) Cluster inertia

Cluster inertia is the second obstacle that industrial clusters need to overcome to develop disruptive innovation. The inertia of the cluster manifests itself in the fact that the cluster relies too much on existing local knowledge and is unwilling to change [13]. Pouder [14] argues that the cluster economy, institutional interests and managers' thinking patterns in industrial clusters will form a homogeneous cluster culture, inhibit innovation, and be more vulnerable to environmental shocks. The inertia of the cluster is inseparable from the characteristics of the cluster network. In industrial clusters, the network of formal and informal relationships is the center of cluster innovation, and these relationships are closely linked [1]. Emerging novelties cannot achieve their potential within the systemic constraints imposed by existing structures, practices, and ways of thinking if the cluster network cannot cope with new knowledge [15]. Due to bounded rationality and path dependence, the incumbent enterprises in the cluster will try their best to avoid disruptive innovation, and tend to recombine existing knowledge to maintain the central position of the cluster network, thereby forming organizational inertia and reducing the ability to adapt to disruptive innovation. This organizational inertia is propagated through the cluster network. The incumbent enterprises and other enterprises have formed a value exchange network. The cluster network is a complex system, and the organizational inertia in the center of the cluster network will spread to other parts of the cluster, resulting in a slow response time to disruptive innovations, causing the cluster network to fall into inertia [16].

3) Negative effects of institutional isomorphism

The above two obstacles stem from the negative effects of institutional isomorphism. In a cluster, institutional isomorphism refers to the local environment that constrains and shapes an organization, increasing the similarity between firms and reducing cluster heterogeneity [14]. In industrial clusters, due to the existence of social capital, collective knowledge and collective mental model based on trust and repeated interaction, cluster enterprises generally have a very high collective identity and understanding of "who we are" [17]. This collective identity and understanding drives the isomorphism of cluster firms to gain legitimacy to access local networks and tacit knowledge by adopting similar industry standards, business practices, cultures, and norms. Institutional isomorphism has a dual impact on the disruptive innovation of industrial clusters. On the one hand, institutional isomorphism may lead to cluster inertia, thereby affecting the adoption of disruptive innovations. Trust, repeated inter-firm interactions and other social aspects make SMEs in cluster networks dependent on

leading companies or other centres of the cluster (eg technology transfer institutions or universities). Leading companies will tend to avoid disruptive knowledge in order to maintain their network-centricity. Due to the existence of a solid collective identity, the generally accepted organizational practices, structures and norms of cluster enterprises make it necessary for enterprises to integrate into the network to obtain the legitimacy of tacit knowledge. This network characteristic and institutional integration background make the existing technology paradigm locked and transferred. To a new technology paradigm is more difficult, to a certain extent, the cluster is more inclined to adopt sustaining innovation, which leads to the inertia of the cluster.

On the other hand, the disruptive innovation of industrial clusters is also inseparable from institutional isomorphism. Staber [17] revealed how collective identities transform manufacturing clusters into international trade clusters. Hervas [18] pointed out that cluster identities and institutional isomorphisms can also be assets for promoting change. The key to this is having the right policy based on the cluster. Under the premise of correct policy implementation, institutional isomorphism can take a positive role and act as a "lever" for positive changes in the face of changes. Cluster-based policies can activate and leverage cluster identities to influence collective understanding, thereby stimulating change towards disruptive innovation.

5. Strategies for Industrial Clusters to Deal with Disruptive Innovation

1) Policy formulation and collective action to promote disruptive innovation

The institutional innovation literature emphasizes the systematic nature of institutional innovation, which is related to the interaction between subjects. In times of uncertainty brought about by new disruptive technology life cycles, there is room and need for policy and collective action to strengthen existing capabilities to better capture the new opportunity [8]. Traditional policymaking does not take into account the role of technology gatekeepers in the cluster, nor does it adequately distinguish the impact of different types of firms in guiding the evolution of the cluster. Policy making requires a shift in decision-making to the micro level, namely cluster firms and their interactions with clusters [18]. Hervas [18] argues that institutional isomorphism in clusters is a double-edged sword. If institutional isomorphism plays a positive leverage role in realizing change on a collective basis, it can surpass the negative effect of cognitive inertia. The basic principle is: Sound local policies based on local environmental and social relationships can turn potential negatives into positives for change. In the phase of the transition to Industry 4.0, the Valencian Regional Agency for Commerce and Competitiveness of the Spanish Tile Industry Cluster acts as a policy maker, in collaboration with cluster actors such as the Ceramic Technology Institute and industry associations, to fund digital manufacturing platforms. At the same time, a bottom-up and collaboration-based policy was adopted in

the cluster to jointly develop a situation-specific industrial strategy, thereby enhancing regional capabilities and leading the transition of the industrial cluster to a digital manufacturing cluster. Tan *et al.* [19] reveal the importance of government in developing disruptive innovations.

There are two important subjects for creating and implementing subversive innovation policies based on industrial clusters, one is policy makers such as government agencies, and the other is cluster actors represented by professional associations and technology intermediaries. Policy makers can act as public entrepreneurs to co-design and implement strategies conducive to the implementation of disruptive innovations with other regional stakeholders [20]. Cluster actors can act as agents for leading and activating place-based policies [21]. Cluster actors need to collaborate with policy makers to co-create regional advantages and build local-based regional policies on the basis of existing regional advantages [22]. Effective place-based decision-making should enable cluster participants to co-create existing regional capabilities [23]. By promoting institutional reforms, establishing or adjusting regional institutions can facilitate dynamic interactions between different actors and stakeholders. Technological transformation can thus be supported and led by public and private actors, with the aim of fostering collective action and institutional change building on existing regional capacities to build regional innovation ecosystems. Among them, policy makers are key players who can influence existing institutions to facilitate change and avoid cognitive inertia.

2) Introducing new knowledge from external knowledge sources

A cluster is a tight network of strong ties where firms can benefit from taking advantage of the opportunities presented by high-quality information exchange, tacit knowledge and collaborative exchange, but at the same time may have problems accessing new and valuable information. Hervas [24] points out that how a cluster evolves in its life cycle depends on the increase or decrease of the heterogeneity of the cluster firms, and the question is how to increase the heterogeneity to update the cluster and start a new growth phase. The diversity and heterogeneity of knowledge within the cluster provides the basis for the development of the cluster, and when the heterogeneity cannot be maintained, the cluster gradually declines [11]. Pinkse [25] argues that although heterogeneity may lead to more divergence among members, heterogeneity is still needed for clusters because it facilitates change, fosters creativity, drives cluster renewal, and adapts to changes in the environment.

Heterogeneity is particularly important in cluster development, and how to obtain heterogeneity has become an important condition for disruptive innovation in cluster development. Albors [26] emphasized the importance of knowledge sources outside the cluster, arguing that new knowledge originates from different industries and knowledge domains. Molina [1] argues that in order to overcome the barriers to generating disruptive innovations, it is necessary to open clusters to external knowledge sources. Heterogeneity in clusters relies on acquiring new knowledge from external knowledge sources, in which entrepre-

neurial firms play an important role. Menzel [11] argues that new firms bring new knowledge, thereby increasing knowledge heterogeneity. Knowledge therefore needs to be brought in from "beyond the thematic focus of the cluster" in order for creative destruction to occur in geographic clusters.

3) Encouraging spin-off enterprises

Entrepreneurs play an important role in implementing disruptive innovations in industrial clusters. The new company provides an opportunity for the cluster to enter the relevant field of expertise. New players play a decisive role as sources of innovation. These actors do not belong to the traditional technical gatekeepers, but are able to provide the cluster with new ideas or original visions that are far from the state-of-the-art of the cluster [1]. New firms can also be drivers of change when clusters experience shocks and need to adapt to change. Menzel [11] argues that one way of reorganization and recovery of declining clusters is entrepreneurship. Simmie [27] finds that the Cambridge high-tech cluster, recovering from the recession in the early 1990s, continued to expand to subclusters based on a strong knowledge platform in advanced mathematics and computing, with new companies playing a role in the process. Played an important role, conversely, a lack of new firms could lead to a decline in the cluster. Ostergaard [9] also holds the same view, innovation and the formation of new enterprises are considered to be important factors for clusters to overcome the threat of recession.

What kind of entrepreneurial enterprises can effectively introduce knowledge from outside the cluster and promote the diffusion of disruptive innovation in the cluster? Albors's view is that the status quo can be disruptively changed only by visionary entrepreneurs outside the cluster or within its boundaries, but with a deep understanding of the industry, who bring knowledge from outside the cluster to the cluster, acting as a catalyst for a new paradigm [15]. He believes that this development cannot take place outside the cluster, because the fundamental elements of successful development are understanding the heterogeneous needs of customers, the ability to identify key users through initial trials of the testing technology, and understanding the future performance of the new technology. Outlook, and this process must be carried out within the cluster. According to this view, among the different types of participants entering the cluster, spin-off firms are particularly important to cluster evolution. Derivatives are businesses established by entrepreneurs with experience with existing businesses in the same industry, often located close to the "parent company," outperforming other entrants, thereby driving the development of the cluster. Albors [26] further gives the conditions that startups must possess to generate disruptive innovation capabilities: the internal drive to generate and explore radical new ideas and concepts, utilize internal and external resources and capabilities, and experiment with what is found in the blank areas of the market. Potential opportunity model solutions and develop them into marketable and effective innovations.

4) Encourage alliances and cooperation between incumbent enterprises

and start-up enterprises

Inter-organizational interaction is a key part of a cluster's innovation engine, the real power of a cluster lies in its systematic behavior, and the mechanism of innovation diffusion is difficult to replicate elsewhere [24]. A strong coalition-based network in a cluster is seen as a typical mechanism for disseminating knowledge and making the cluster an innovation system. For this reason, the new firm alone cannot perform all the functions required for cluster innovation. New companies acting alone cannot successfully cause disruption and replace existing technology or knowledge. New companies need access to established networks led by incumbents from which to acquire complementary assets (such as business networks) to commercialize innovations [13]. Molina [1] believes that close cooperation between relevant players would be a good approach. When this happens, the internal and external relationships of the cluster are redefined, and not only the strategy of a single company needs to be adjusted, but the strategy of the entire cluster needs to be adjusted.

The alliance and cooperation between incumbent enterprises and innovative enterprises is very important. Because existing networks facilitate the rapid dissemination of new knowledge by harnessing the existing stock of resources to guide new knowledge. Therefore, alliances and a combination of incumbent and new firm resources may be the best option for creating new knowledge in clusters [24]. As evidenced by the Spanish tile industry cluster, the incumbent company Ferro has partnered with start-up Kerajet to provide research laboratory facilities and part of the initial investment in the project. Albors [26] argues that once a new technology becomes more mature, existing technology gatekeepers will also become adopters in order to keep up with the new technology's development track, thereby striving to maintain its previous network-centricity.

5) Overall strategy

The above summarizes four strategies for industrial clusters to deal with disruptive innovation. In fact, these four strategies are inseparable. As shown in **Figure 1**, in the industrial cluster, there are public organizations and private organizations, and public organizations include government agencies, industry associations, intermediary organizations, universities, scientific research institutions and other organizations. Among them, government agencies, as policy makers, are at the core of public organizations, and private organizations include incumbent enterprises, start-up enterprises and other enterprises. Incumbent enterprises occupy the core position in the cluster network, and start-up enterprises are at the edge of the network. Oghazi, *et al.* [28] argue that ecosystem transformation can be achieved through disruptive innovation.

The first is bottom-up, place-based, disruptive innovation policies. The policy must involve the participation of cluster enterprises, and enterprises should lead the direction of technological innovation. Government agencies play a key role as policy makers, and industry associations or intermediary organizations can act as policy facilitators to promote the implementation of innovation policies

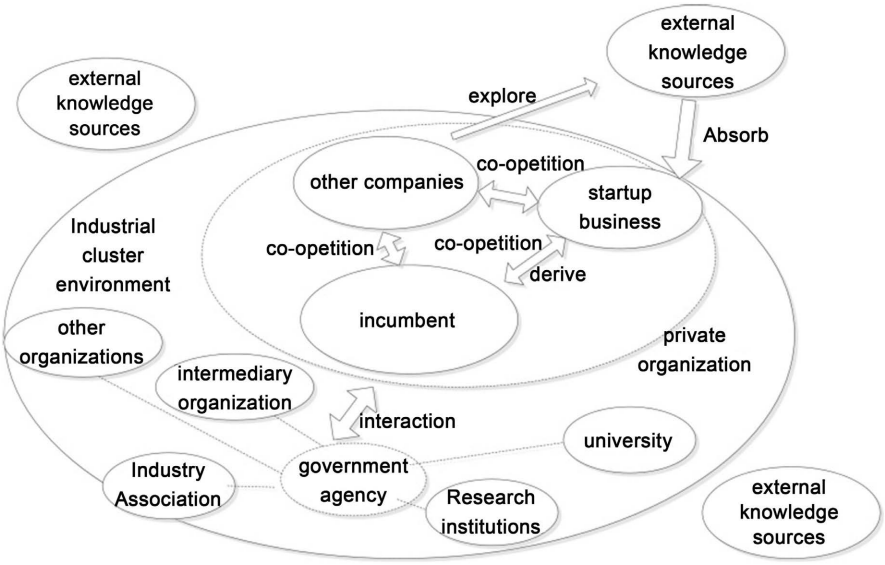

Figure 1. The overall strategy of industrial clusters to deal with disruptive innovation.

and provide support. In short, local-based disruptive innovation policies promote collective action and facilitate the building of regional innovation ecosystems. The second is the important role played by entrepreneurial enterprises. Start-up enterprises are often derivatives of cluster enterprises, inheriting the knowledge of existing enterprises in the cluster. However, because it is located at the edge of the cluster network, it is less affected by technology lock-in and cluster inertia, and can maintain contact with external knowledge sources, introduce new external knowledge, and increase the heterogeneity of the cluster. If the regional innovation ecosystem is effectively constructed, the derivation of new enterprises will be very active, which can effectively increase the opportunities for the cluster to contact external knowledge sources and bring heterogeneity to the cluster. Thirdly, entrepreneurial enterprises introduce new knowledge from external knowledge sources and combine with their own knowledge to generate new knowledge of disruptive innovation. The knowledge outside the cluster is quite different from the knowledge inside the cluster. Only when the two are combined can the knowledge base for disruptive innovation be generated. However, the knowledge base is still not perfect, the new technology is also in the new stage, the cost performance is low, and it cannot meet the needs of mainstream customers. At this time, start-up enterprises need to form alliances and cooperation with enterprises in the cluster, and embed into the cluster network to obtain supplementary assets, which promotes the dissemination of disruptive innovations. Even if entrepreneurial firms are reluctant to form alliances with other firms, due to the nature of cluster networks, informal relationships make it extremely difficult for new knowledge to be confined to one firm. In other words, innovation has the characteristics of a quasi-public product. Even if other enterprises cannot fully grasp new knowledge, they can imitate entrepreneurial enterprises to contact external knowledge sources and obtain similar external knowledge. Therefore, disruptive innovation in a cluster is a complex "competi-

tive competition" among enterprises in the cluster. Therefore, disruptive innovation is spread and disseminated in the complex competition and cooperation relationship of clusters. Alliances and a combination of incumbent and new company resources may be the best option for creating new knowledge in a cluster.

6. Conclusions

Numerous real cases show that disruptive innovation may be a fatal threat to industrial clusters, or it may be a major development opportunity. The key lies in how industrial clusters respond. At present, there is still little research on disruptive innovation based on the meso-industry level. This paper discusses how to develop disruptive innovation based on the industrial cluster level. The main obstacles to disruptive innovation in the development of industrial clusters are lock-in and cluster inertia. These two obstacles originate from the negative effect of cluster system isomorphism. To develop disruptive innovations in industrial clusters, it is necessary to play the positive role of institutional isomorphism and restrain its negative role. To this end, industrial clusters can establish overall coping strategies, including adopting bottom-up local subversive innovation policies, introducing external knowledge, encouraging spin-off entrepreneurial enterprises, and encouraging alliances and cooperation between incumbent enterprises and entrepreneurial enterprises, etc., to effectively develop disruptive innovation.

Possible future research directions include the following topics: the structure, classification, and measurement of disruptive innovations, the diffusion process of disruptive innovations in industrial clusters, knowledge creation at the firm and cluster levels, and the impact of cluster cognition on cluster actions.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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