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EXAMINING INDUSTRIAL CLUSTERS FROM AN ECOLOGICAL PERSPECTIVE: EVIDENCES FROM NORTH-EAST CHINA

ABSTRACT

Industrial clusters are increasingly seen as essential in effectively combining, developing and enhancing like-minded businesses. Industrial clusters irrespective of their location are providing positive outcomes for ecological derivatives in supporting effective industrial developments. This perspective is addressed within this paper via employing the 'Logistic Model of Ecology'; through the application of differential equations. This paper explains key interspecies relationships; competition, predation and symbiosis, operating within a regional cluster in the Jilin Province in the north-east of The Peoples' Republic of China. The paper draws the conclusion that 'intense competition' is the key factor contributing to the successful existence of the cluster.

Key Words: industrial cluster, enterprises, ecology, logistic model, China

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INTRODUCTION

The notion of employing the term *'cluster'* as a means of describing how and why like-minded businesses might more strategically collaborate was arguably first introduced by Porter (1990); who saw new global perspectives of business competitiveness and cooperation requiring a more informed means of describing their mutual associations. Indeed the potential cooperation and competitiveness of clusters is of key importance to global, national, regional and local business/ organisational analysis.

Possibly the most popular definition of a *'cluster'*; established to serve the growth, knowledge and capability enhancement needs of businesses and organisations more generally, is that provided by Porter (1998: 77) who defines a cluster as a, *"a geographic concentration of interconnected companies, specialized suppliers, service providers, associated institutions and firms in related industries."* Whilst offering a view on geographic concentration of related businesses and organisations, the definition is none the less narrow in its attention to how and why so-called related businesses not simply join with each other but remain in a sustainable association. Equally; the definition appears to offer no advice on how new forms of technology might permit a concentration based on capability and knowledge, as distinct from the geographic concentration that encouraged and fostered clusters in the first place. Hence; there is a significant need to highlight the existence of capabilities and knowledge per se, not simply a geographic concentration of like-minded business and organisations, in complimenting cluster membership. Such a perspective would seem to be missing from most explanations.

Another definition of a *'cluster'*; this one provided by Csaba (2008: 291), creates similar problems;

> *"a concentration of firms across several industries that creates quality jobs, exports goods and services, shares common economic foundational needs, and unites the public sectors of economic development, legislatures at all levels, universities, community colleges, the K-12 educational community, workforce development, support foundations, and all community economic stakeholders"*

Whilst this definition seems unnecessary inclusive; it highlights in a similar approach to that of Porter (1990, 1998). *'Clusters'* may be established by separate and unique, yet

complimentary entities, in order to achieve goals and objectives of common and mutual benefit that under normal circumstances may not be achieved. Indeed, that may not be achievable, by one such entity operating in isolation. But also like Porter (1990, 1998) it fails to acknowledge new and emerging possibilities of what a 'cluster' might represent.

Having said that; Staber (2007: 341) brings a more postmodern description to our understanding of what a 'cluster' might be; to wit, the 'political' realities of a business/organisational type cluster, describing them in somewhat vague, if not cynical terms as a;

> *"cultural phenomenon that is created and reproduced by human agents*
> *as they selectively perceive and enact the ideas that draw their attention.*
> *The outcome is not necessarily a distribution of ideas that benefits the*
> *individual members of the cluster or enhances the performance of the*
> *cluster as a whole."*

Whilst somewhat vague in its perspective, it raises the possibilities of a *'cluster'* being structured on a basis other than through a 'geographic concentration of like-minded businesses.' A further definition; advanced by Bahlmann and Huysman (2008: 306), moves away from the geographic perspective, and takes a knowledge based view of 'clusters' being formed to support; *(i)* tacit dimensions of knowledge; *(ii)* transitions from an industrial to a knowledge-based economy; *(iii)* important socio-economic and territorial factors; and *(iv)* challenge formal economic explanations for cluster development. Further support is provided by Kitagawa (2004) and Kamarulzaman and Norhashim (2008: 352), the latter importantly defining clusters as:

> *"a set of actors (firms from at least one industrial sector, agencies, and*
> *institutions) that have commonalities and complementarities; and a*
> *significant geographical concentration of the actors giving rise to close*
> *proximity between actors leading to linkages and interactions through*
> *formal and informal setups between actors, agglomeration economies,*
> *and high social capital; that; characteristically, besides the various*
> *economic activities, undergo a significant level of knowledge /*
> *technology-intensive activities that promote transfers as well as spillovers;*

> *and collectively make a significant impact on the larger economy*
> *(regional or national)."*

Indeed Bahlmann and Huysman (2008: 304) acknowledge the increasing interest in and importance of *'clusters'* as *'knowledge repositories,'* suggest that hitherto, and with respect to knowledge development, knowledge enhancement and fostering expertise, has not been seen as significant reasons for the development and maintenance of *'clusters.'* Indeed they point to the potential of *'multidisciplinarity'* as being of more strategic benefit to the work and operations of a well-designed *'cluster.'*

These though are separate and legitimate goals in their own right. They should not be seen as being mutually exclusive, but rather sensible and realisable goals associated with any legitimate business/ organisational cluster established for the purposes such as those outlined in earlier definitions and critique. To this end; all are required but not necessarily at the same time, or at least within the one cluster. This perspective is supported by researchers like; Millard (2005), Bahlmann and Huysman (2008), and West (2009) each of whom call for the development of a *'Community of Innovation.'* Given improved technologies, such *'communities'* would certainly not be restricted by concepts of geographic proximity and concentrations, but rather by like-mindedness in achieving and enhancing the overall and ongoing expectations of the cluster. It is argued therefore that proximity of 'mind and idea' will be the key success factor. This emphasises the importance of what Kamarulzaman and Norhashim (2008: 356) refer to as *'social capital'* benefits; where people have a desire to be involved, and are prepared to be involved, bringing with them key skills and knowledge that adds significant value to the whole, irrespective of their geographic location.

It is very much a synergy, where the sum is certainly; and has the potential to be greater than simply the sum of its parts. This is supported by Kamarulzaman and Norhashim (2008: 353) who argue that;

> *"the 'actors' are at the very core of the cluster, and their effective activity;*
> *their critical mass; how well integrated and interconnected they are, and*
> *their centrality to the focus of the cluster, are critical to cluster success."*

Nevertheless; distinctions in the types of clusters that might exist have been highlighted by authors such as St John and Pouder (2006: 141) who write of distinctions between 'Technology-based' and 'Industry-focused' clusters; with respect to; "*(i) regional resource profiles; (ii) different ways of accumulating resources; (iii) cultivating different capabilities, and (iv) deriving different types of regional advantage.*" Further; Rocha and Sternberg (2005: 267-292) distinguish between *'clusters'* on the one hand, and *'industrial agglomerations'* on the other, and recommend a *'cluster'* approach in support of entrepreneurial activity in regional areas. Also Staber (2007: 341) who goes on to refer to clusters as being, *"loosely connected agglomerations of firms driven by intense distrust and rivalry rather than trust and cooperation, and with outcomes that may or may not be advantageous."* Thus, reinforcing his earlier judgement as to what 'clusters' actually achieve (*sic*). Others such as; vom Hofe and Bhatta (2007) distinguish 'clusters' on the basis of geographic and industrial perspectives. Whereas Parker and Beedell (2010) provide their distinction between 'clusters,' on the basis of cluster *'type'* and cluster *'objective.'* In the process they point to important issues associated with 'Land-based Economic Clusters' and their sustainability linked to economic and environmental benefits.

Importantly within the context of the research reported in this paper, vom Hofe and Chen (2006: 2-28) point to the growing popularity of *'regional industrial clusters'* in contributing to economic growth and the competitiveness not only of the 'cluster,' but significantly of the region in which it exists. In so doing, they provide a rich coverage of various cluster perspectives and types, including the various approaches that can be taken and benefits that may be derived.

In addition; a number of authors look to specific industry type clusters. For example; Smith and Ibrahim (2006) provide coverage of a cluster based in the British Aerospace Industry. More specifically; this study sought to understand the impact of particular types of corporate strategies, industry evolution, and technological and development concerns generally. Yet others; such as Staber (2009) again, write of the mechanisms and biases associated with collective learning which has traditionally been seen as a core feature of 'cluster' development and outcomes. This perspective receives support from Braun, McRae-Williams, and Lowe (2005) who seek to understand small business clustering in a large regional centre in Australia and who in so doing, point to learning and knowledge access as key derivatives of the local networks that were reviewed. Whereas from a purely theoretical perspective; Benneworth and Henry (2004: 1011-1023) raise particular

concerns associated with the *'value added'* that a *'cluster approach'* might actually bring to more informed debate on and practice in economic geography. This extends to the need to review the emerging importance and potential benefits to be derived from *'cluster'* applications, with Benneworth and Henry (2004: 1011) arguing that; *"'this work in progress' must be deepened and extended if the potential of cluster is to be realised."* So whilst acknowledging the potential for beneficial outcomes in broad terms, they nevertheless, raise some level of scepticism as to the potential for real and lasting positive outcomes. Thus whilst supporting in part Staber's (2007) perspective, they take a far less cynical view.

Clusters are also seen by writers such as McDonald, Tsagdis, and Huang (2006) and Jucevicius and Puidokas (2007); as having the potential to derive key strategic outcomes associated with specific government and public policies more generally; including policies to regionalise businesses and industry, and to support and sustain broad economic policy, especially macroeconomic stabilization, privatization and the opening of new markets, including challenges associated with the knowledge based economy and the enhancement of individual and organisational capabilities. This is emphasised by Peters and Hood (2000) in their review of Scottish experiences and policy development. Also; Wonglimpiyarat (2006) in her review of the strategic management of industrial clusters in Thailand, whereby, *"the Thai Government has implemented cluster development strategies to improve (Thailand's) national economic performance and technological capabilities."*

In addition; writers such as; Roberts and Enright (2004); Parto (2008); Basu, Sarkar, and Bhattacharyya (2010) and Ghanbari, Nazeman, Meibodi, and MirHosseini (2011) have each examined industrial clusters in similar ways, but more specifically in the context of how developing economies/ countries/ regions can benefit from the increased competitiveness and the encouragement of new business that such business arrangements derive. Whilst issues linked to the sustainability of clusters; and in particular the level of support, including the distribution of benefits amongst members, have also been considered by Perry (2007). Whereas Lang (2009: 73) identifies six negative elements that mitigate against the competitiveness of clusters; to wit, *"(i) the development of a homogeneous macroculture; (ii) discrepant social identity; (iii) power imbalance; (iv) market rationalization, (v) lack of untraded interdependencies and (vi) overwhelming negative externalities."* Staber (2009: 553) also points to the potential for negative outcomes associated with learning in clusters such as, *"… social biases linked to collective mindsets, distrust and rivalry."* Significantly; Staber (2009: 553) also points to the failure of many 'cluster' studies, *"to document the high levels of interfirm*

collaboration that cluster theory predicts." In part this situation is reflected in an analysis by Bailey (2003) of the crisis surrounding the threatened closure of BMW in the British Midlands whereby significant conflict was seen to exist between fragmented government policies regarding emerging 'clusters'; and the needs of BMW with respect to the tensions in the auto industry clustering. As noted by Bailey (2003: 67) *"the case also raises the critical issue of coordination of regionally based cluster policies where the cluster in question clearly crosses administrative regional boundaries."*

The global perspective on 'clusters' is further enhanced by De Martino, Reid, and Zygliodopoulos (2006) who examine how internationalisation strategies, affects traditional and intimate local cluster relationships. A further international perspective is offered by Pandit and Beaverstock (2008: 23) who examine reasons for multinational enterprises locating, based on geographic business clusters. Recommendations from the study question the value of clusters for very large operators; with suggestions that high expenses and congestion when locating in key global financial centres; such as London, can lead to less than satisfactory outcomes. Whilst; traditionally held views as to the value of clusters may run counter intuitive, to the first recommendation, especially where large operators are concerned, choosing not to locate themselves in a relevant cluster may provide advantages over and above those available to smaller operators.

The importance of researching clusters more broadly is also integral to the potential application of clusters employing perspectives from multiple sources and multiple disciplines. Indeed, Navickas and Malakauskaites (2009) argument that; clusters are of growing importance in the economic and global development of small to medium sized organisations, supports this perspective and raises questions as to how clusters might be best organized. Bell, Tracey, and Heide (2009) introduce a model that seeks to explain the way businesses transact between themselves and thus which might be seen as the most appropriate form of governance.

Nevertheless; *'clusters'* have traditionally been formed to support and encourage what Danese, Filippini, Romano, and Vinelli (2009: 80) describe as, *(i)* a geographic concentration, or proximity of actors, *(ii)* the presence of different types (multidisciplinary / multifunctional / multi-skilled) of *'actors,'* and *(iii)* the efficient and effective interaction of the *'actors.'* Others such as Rocha and Sternberg (2005); McDonald, Huang, Reid, Carroll, and Smith (2007); Csaba (2008); Pilinkiene and Kardokaite (2008); Liela, Zeibote and Stale (2010); Brown, McNaughton, and Bell (2010); Engel and del-Palacio (2011);

offer further perspectives that clusters appear because of various needs associated with contributing to improvements in; productivity, business synergies, the integration and adaptation of businesses to regional areas, response to passive and active externalities; competitiveness, entrepreneurial characteristics, obtain external economies of scale; support innovation, new ways of thinking about business and improvements to regionalisation goals and objectives; as well as socio-political dynamics; employment growth and global linkages that support the mobility of people and the development of new capabilities.

Improvements to business practices, including activities surrounding where products and services are both produced and provided including how knowledge is developed and enhanced has seen work on what is called *'Innovative Clusters.'* On the notion of innovation, Millard (2005) suggests that clusters seek to be innovative by: *(i)* concentrating knowledge and expertise relevant to a particular issue of interest and/ or expertise; and through this to, *(ii)* support the ease and speed of accessibility amongst members, who would have available to them, appropriate and required technology. Each would be required in order for any proposed cluster to establish a sound strategic presence. Dohse and Soltwedel (2006) also address this issue in their relatively recent review of this approach to clustering arguing its clear importance to national, regional and local government strategies; whilst at the same time reflecting Rosenfeld's (1995), in Dohse and Soltwedel, 2006: 1167) view that benefits to be derived exist outside of government, but within the regions themselves. Nevertheless; Ibrahim and Fallah (2005: 33) make the point that;

> *"while existing literature supports the notion that clustering results in increased innovation output, little is known about the specific mechanisms by which knowledge is exchanged in these areas and the dynamics that lead to increased innovation generated by companies operating in such environments."*

Navickas and Malakauskaite (2009: 256) continue by emphasising a number of potential benefits of *'clusters'*; such as, *(i)* reducing operational costs; *(ii)* increasing personal qualifications; *(iii)* improving the technological base of the cluster; *(iv)* advancing innovation in the area under investigation; *(v)* creating new products and businesses; and *(vi)* increasing sales and competitiveness.

INDUSTRIAL CLUSTERS IN THE PEOPLES' REPUBLIC OF CHINA

Many of the principles associated with the development and enhancement of the various clusters types identified above, can also be seem to exist in various studies undertaken in and across cities and regional locations in The Peoples' Republic of China (PRC). The potential benefits can also be seen in terms of advancing key strategic partner associations for various collaborative business activities, as well as deriving joint and mutual benefits. Whilst benefits linked to contributions to key strategic outcomes, at various levels, such as a stronger ability to attract new foreign business can be found. Indeed according to Danese et al. (2009: 79) a significant challenge of recently emerging *clusters* is; *"to reproduce the advantage of a local cluster within a global context."* Clearly; this is an important consideration and a key challenge in effectively developing, managing, and enhancing any proposed new cluster and clearly reflected in some of the mistakes noted in cluster methodology. Application to The Peoples' Republic of China is no different.

Examples of such studies in the PRC include; Weng and McElroy's (2010) explanation as to why talent gravitates to industrial clusters; Ruan and Zhang's (2009) study on financial investment in industrial development clusters; Wu, Gu, and Zhang's (2008) study on how innovation networks are formed and the subsequent development of technological capabilities; Lawrence and Sun's (2010) explanations associated with enhancing Chinese-American trade opportunities. Further example include, Kiminami and Kiminami's (2009) explanations of rural development through industrial clustering; Lai, Chui, and Leu's (2005) study on innovation capacity in various Chinese cities; Shao, Chen, and Cheng's (2008) analysis of the factors involved in cluster innovation; Wang's (2006) explanations associated with the formation of a consumer goods manufacturing cluster. Moreover Lin and Sun's (2010) explanations of how industrial clusters can potentially become nationally competitive; Barbieri, Di Tommaso, and Huang's (2010) coverage of industrial development policy and innovation; Lee and Jin's (2009) coverage of the origins of business groups in China; Keane's (2008) explanation of the creative economy; Zheng and Sheng's (2006) explanations of learning in clusters; Lin's (2009) coverage of regional development in globalizing China; and significantly, as it ties directly to the study reported in this paper, Jin and Zheng's (2008) coverage of realized path analysis of spillover effect on industrial clusters.

Whilst a great deal has been undertaken in order to understand the various types of clusters, including their formation and application in providing more informed understanding as to the advancement of business, organisational arrangements the actual mechanics of clustering efforts, the Peoples' Republic of China have not been fully explored. Employing the '*Logistic Model of Ecology*'; (Swann, and Prevezer,1996) through the application of differential equations, this paper explains key interspecies relationships; competition, predation and symbiosis, operating within a particular cluster within the regional Jilin province of The Peoples' Republic of China.

METHODOLOGY

Secondary data were collected from three industrial clusters located in the Jilin province, P.R.China. In ecology, the interspecies relationship delineates the association between different species including competition, predation, symbiosis, parasitism, and allelopathy. First; three relations are the most popular ones Researchers in this area have already developed useful models to illustrate the details. For example, Lotka-Volterra competition model (Lotka, 1925; Volterra, 1926) which evolved from the logistic equation. By hypothesizing this model it may identify specific aspects of the relationship between cluster members in the particular industrial cluster (IC) investigated.

Hypothesis 1: for the purpose of the study, it is assumed that, $x(t)$ indicates the output of the enterprises. This means that the average output of the enterprise is a function of time t. For this study, the meaning of t has been slightly modified. Hence; t not only has the normal general meaning, but also manifests in each change in the factors which influence the variation of the output, such as technology, information, specialization and work-division, transaction cost. Each factor is a function of time, so t has a much broader meaning in this article. Therefore, the output of the enterprise can be used to portray the dynamic form process of the industrial cluster.

*Hypothesis 2: f*or the purposes of this study in terms of the natural state means; in a given period of time and geographical space, various kinds of natural endowment factors; i.e., technology, raw materials, labour, capital and market scale etc., remain stable. Thus the factors can be effectively composed and utilized. In this way, each enterprise has a limitation for its output. In other words, there is a maximum output N. Therefore, the implication is that the growth rate of each enterprise's output will decline with the eventual increase output level equalling zero.

Hypothesis 3: The saturation ratio of the natural market scale has a block effect to the output growth rate. $\frac{x(t)}{N}$ is the saturation ratio of the natural market scale. N has the same meaning in hypothesis 2, $x(t)$ is the enterprise's output.

Therefore, by imitating the Logistic model of ecology the descriptive differential equation of the enterprises evolvement can be derived.

$$x(t)=\frac{dx(t)}{dt} = rx\left(1 - \frac{x}{N}\right), r > 0, N > 0 \qquad (1),$$

Where r is the growth rate of the average industrial output of the studied enterprises.

Competitive relation

Suppose there are only two enterprises A and B in an industrial cluster. Their output variations adhere to the 'Law of Logistics' when they are alone in the market environment. Separately, x_1, x_2 indicates the output of the two enterprises. Whilst r_1, r_2 is the average output of their respective industries and N_1, N_2 is the maximum output.

Suppose for example that two enterprises use the same resources (for example: raw materials), and the output of A is higher than the output of B. Therefore, it can be assumed that

$$x_1(t)=r_1 x_1\left(1 - \frac{x_1}{N_1} - \sigma_1 \frac{x_2}{N_2}\right) \qquad (2)$$

σ_1 is an index of the competition of the two enterprises. The bigger σ_1, the greater the threat from B on A. Similarly the equation of B is

$$x_2(t)=r_2 x_2\left(1 - \sigma_2 \frac{x_1}{N_1} - \frac{x_2}{N_2}\right) \qquad (3).$$

Now the stability of the equations set can be examined. First assume $\sigma_1 < 1, \sigma_2 < 1$, in order to get the balance point, let x_1, x_2 be the constants.

$$\begin{cases} r_1 x_1\left(1 - \frac{x_1}{N_1} - \sigma_1 \frac{x_2}{N_2}\right) = 0 \\ r_2 x_2\left(1 - \sigma_2 \frac{x_1}{N_1} - \frac{x_2}{N_2}\right) = 0 \end{cases} \qquad (4)$$
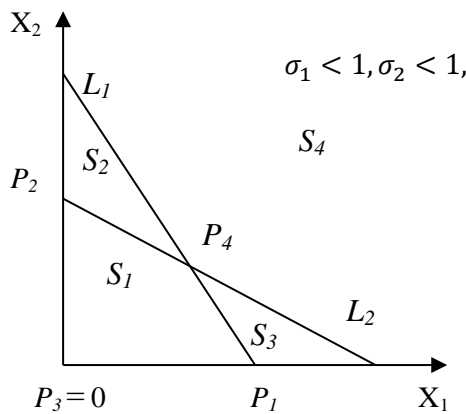
This results in four balance points:

$$P_1(N_1, 0), P_2(0, N_2), P_3(0,0), P_4 \left(\frac{N_1(1 - \sigma_1)}{1 - \sigma_1 \sigma_2}, \frac{N_2(1 - \sigma_2)}{1 - \sigma_1 \sigma_2} \right).$$

The stability of these balance points on the x_1, x_2 plane (which we call the phase plane) can be expressed as

$$\text{line } L_2 \colon 1 - \sigma_2 \frac{x_1}{N_1} - \frac{x_2}{N_2} = 0.$$

The first quadrant $x_1 > 0, x_2 > 0$ of the phase plane can be separated into four areas, see Figure 1.

Figure 1: Stable Symbiosis

Assume that the initial phase point (x_1, x_2) is in the region S_1, and with the increase of time t, x_1, x_2 increase too. The path curve slopes upward to the right and the external phase point will enter S_2 or S_3 (or might reach P_4). Assume the phase point (x_1, x_2) is in the region S_2, x_2 decrease when x_1 increase, that means the path curve slopes downward to the right, but cannot rise above L_1 or L_2, and finally tends to point P_4. If the initial phase point is in region S_3, x_1 decrease when x_2 increase, that means the path curve slopes upward to the left and finally enter region S_2 or S_3 (or reach P_4). The path curve will be a point if the initial phase point locates on P_1, P_2, P_3 or P_4. To sum up, unless the initial phase point locates in P_1, P_2 or P_3, the path cure must tend to P_4, that is, P_1, P_2, P_3 is the unstable point but P_4 is the balance point. If $\sigma_1 > 1, \sigma_2 > 1$, there are four balance

points P_1, P_2, P_3 and P_4. Using the same analysis method, we propose that P_3, P_4 are neither stable balance point but the initial phase point located in one path curve τ and it tends to phase point P_2, otherwise it tends to phase point P_1, that means P_1, P_2 are partial stable.(see Figure 2). If $\sigma_1 < 1, \sigma_2 > 1$, there are only three balance points P_1, P_2 and P_3, P_1 is stable but P_2, P_3 are not stable (see Figure 3). If $\sigma_1 > 1, \sigma_2 < 1$ similarly, there are only three balance point P_1, P_2 and P_3, P_2 is stable.
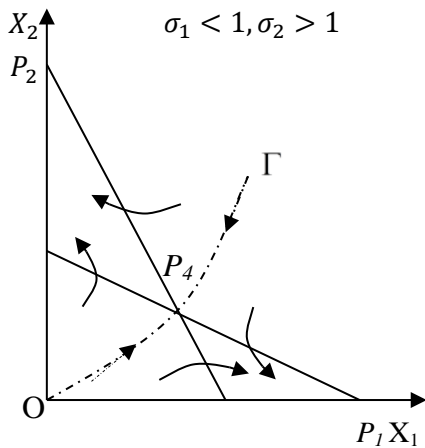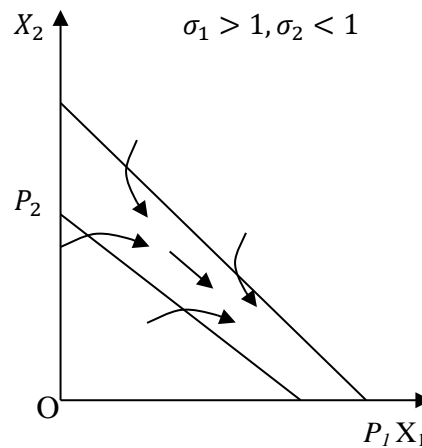
Figure 2: Competition among Discrepant Segments

Figure 3: Unstable Competition

Interpretation of the Model

According to σ_1, σ_2 and other numeric constants/variables in the modelling process, the economic meaning of the results can be defined:

(1) $\sigma_1 < 1, \sigma_2 < 1$, the two enterprises compete with each other not very fiercely and can coexist.

(2) $\sigma_1 > 1, \sigma_2 > 1$, the two enterprises have a cut-throat competition which the dominate party will overwhelm the other and ultimately make the other retreat from the competitive market.

(3) $\sigma_1 < 1, \sigma_2 > 1$, the existence of A is a fatal threaten to B but B is not as dangerous as A.

However, B is bound to quit when A comes into being.

(4) $\sigma_1 > 1, \sigma_2 < 1$, this is an opposite situation to (3), B will quit when A comes into being.

Because σ_1, σ_2 are the indicators of the competition level between the two enterprises, if they are totally homogeneous, $\sigma_1 = \frac{1}{\sigma_2}$, then there will be no $\sigma_1 < 1, \sigma_2 < 1$. This means the two enterprises cannot coexist. The finding is the basic prerequisite for the two enterprises coexisting in the competitive state; they must be heterogeneous, but not totally homogeneous.

Symbiosis relation

When there is interdependence between the two companies, the allied model can be developed but one more hypothesis should be added.

Hypothesis 4: Assuming that the enterprises geographically concentrated in the IC can act as a growth catalyst to each other. For scale economy/external economies (Krugman, 1991)/division and specialization can reduce the trade cost, develop the efficiency, and improve the motivation even optimised the innovation. According to Knorringa and Meyer-Stamer (1998) there are three kinds of industrial clusters, they (Italianate/Satellite/ Hub and spoke) have different characterises. But Porter (1998) provides a simple definition of two types of clusters: vertical and horizontal clusters.

Symbiosis Model of Italianate IC

Firstly, we try to find out the symbiosis relation between SME located in the Italianate IC (Mainly SME's strong specialization, strong local rivalry and networking/competition; and trust based relationships)(Knorringa and Meyer-Stamer, 1998). Assuming there are two enterprises (A, B) in the network, and this assumption has no influence to the nature of the IC. $x_1(t), x_2(t)$ are the output of the enterprises. When they exist separately the output meet the Logistic Model;

$$\frac{dx_1(t)}{dt} = r_1 x_1 \left(1 - \frac{x_1}{N_1}\right) \qquad (5)$$

$$\frac{dx_2(t)}{dt} = r_2 x_2 \left(1 - \frac{x_2}{N_2}\right) \qquad (6).$$

When they both appear in the IC, their existence plays a facilitating role to each other's output. Therefore, the output of A and B can be replaced respectively by

$$\frac{dx_1(t)}{dt} = r_1 x_1 \left(1 - \frac{x_1}{N_1} + \frac{\delta_1 x_2}{N_2}\right) \qquad (7)$$

$$\frac{dx_2(t)}{dt} = r_2 x_2 \left(1 - \frac{x_2}{N_2} + \frac{\delta_2 x_1}{N_1}\right) \qquad (8)$$

and $\delta_1 > 0, \delta_2 > 0$. δ has the same meaning as above. δ_1 means the contribution to A's output by per unit natural size market saturation of B. δ_2 means the contribution to B's output by per unit natural size market saturation of A. Further, we can use the differential equations to describe the steady state equilibrium of A and B.

$$\begin{cases} f(x_1 x_2) \equiv \dfrac{dx_1(t)}{dt} = r_1 x_1 \left(1 - \dfrac{x_1}{N_1} + \dfrac{\delta_1 x_2}{N_2}\right) = 0 \\ g(x_1 x_2) \equiv \dfrac{dx_2(t)}{dt} = r_2 x_2 \left(1 - \dfrac{x_2}{N_2} + \dfrac{\delta_2 x_1}{N_1}\right) = 0 \end{cases} \qquad (9)$$

Solution of the Stable Point

According to the differential equations, the stable point is

$$E_2: \ (x_1, x_2) = \left(\frac{N_1(1 + \delta_1)}{(1 - \delta_1 \delta_2)}, \frac{N_2(1 + \delta_2)}{(1 - \delta_1 \delta_2)}\right)$$

When $x_1 > 0, x_2 > 0$ that means $\frac{N_1(1+\delta_1)}{(1-\delta_1\delta_2)} > 0, \frac{N_2(1+\delta_2)}{(1-\delta_1\delta_2)} > 0$. These two enterprises can aggregate. Therefore, the condition of A and B's symbiosis is $\delta_1 \delta_2 < 1$.

Stability Analysis of the Balance Point

Taylor expansion of the differential equations:

$$\frac{dx_1(t)}{dt} = r_1 \left(1 - \frac{2x_1}{N_1} + \frac{\delta_1 x_2}{N_2}\right)(x_1 - x_1^*) + \frac{r_1 x_1 \delta_1}{N_2(x_2 - x_2^*)}$$

$$\frac{dx_2(t)}{dt} = \frac{r_2 x_2 \delta_2 (x_1 - x_1^*)}{N_1} + r_2\left(1 - \frac{2x_2}{N_2} + \frac{\delta_2 x_1}{N_1}\right)(x_2 - x_2^*)$$

when E_2： $(x_1, x_2) = \left(\frac{N_1(1+\delta_1)}{(1-\delta_1\delta_2)}, \frac{N_2(1+\delta_2)}{(1-\delta_1\delta_2)}\right)$, the equation matrix A is:

$$A = \begin{bmatrix} \dfrac{r_1(-1-\delta_1)}{(1-\delta_1\delta_2)} & \dfrac{r_1 x_1 \delta_1(1+\delta_1)}{N_2(1-\delta_1\delta_2)} \\ \dfrac{r_2 x_2 \delta_2(1+\delta_2)}{N_1(1-\delta_1\delta_2)} & \dfrac{r_2(-1-\delta_2)}{(1-\delta_1\delta_2)} \end{bmatrix}$$

According to the stability theory of differential equations, the stable point is a stable node point must be $\delta_1\delta_2 < 1$. This means $\delta_1\delta_2 < 1$ is the condition that the two enterprises symbiosis. And for the symmetry, the condition can be changed into $\delta_1 < 1, \delta_2 < 1$.

Interpretation of the Stable Symbiotic Conditions

$\delta_1 < 1, \delta_2 < 1$ means that in the symbiotic model of the industrial cluster, there are not too much contribution to each other (but, from the whole IC view, the unit enterprise can get considerable contribution from others for the numerous enterprises). This can be proved intuitionistic in economy: in this model, the contribution of A and B mainly depend on the division caused expand of the market scale/ imitation of the technology and management/sharing of product-needed information/trust, but not the direct order received from the core enterprise in the hub and spoke IC. In other words, competition is the power of this kind of IC. For example, in 1980s there were 120 enterprises in the Sa Thoreau ceramic tile IC of Italy and nearly 300 robot makers in Japan in 1986 (Poter,2002).

Symbiosis Model of Hub and spoke

Hub and spoke industrial cluster usually has large local firms and local SMEs and a clear hierarchy (Knorringa and Meyer-Stamer, 1998). $x_1(t)$ means the output of the large firms(cores),correspondingly $x_2(t)$ means the surrounding SMEs'(satellites) outputs. If there were no satellites and the cores meet the Logistic Model:

$$\frac{dx_1(t)}{dt} = r_1 x_1 \left(1 - \frac{x_1}{N_1}\right) \qquad (10)$$

When satellites introduced, according to the assumption they play a catalytic role to the output of the cores. For example, the satellites can provide intermediate products to the cores. The location superiority can decrease the cost of the raw material. Fierce competition of the numerous satellites not only can reduce the price of intermediate products but also increase the quality of the products. Moreover, the prosperous phenomena of numerous satellites supporting give more advertise effect to the cores. The imitation and learning in the competition can improve the technology and management. The trust developed from the association decrease the transaction fee. So the output the core is:

$$\frac{dx_1(t)}{dt} = r_1 x_1 \left(1 - \frac{x_1}{N_1} + \frac{\delta_1 x_2}{N_2}\right), \delta_1 > 0 \qquad (11)$$

δ_1 means the contribution to core's output by per unit natural size market saturation of satellites. Here we have the similar description of the satellites. Assume that the output of the satellites will decrease and reach zero finally without the cores. This assumption comes from the facts: the satellites come into being after the cores. Therefore, the negative growth rate of the satellites is r_2. If there are only satellites in the market the output of them is:

$$\frac{dx_2(t)}{dt} = -r_2 x_2 \qquad (12)$$

But if there are cores in the market, the output of the satellites will increase. The existence of the cores means direct expand of market scale and stable need. This can be deduced from that the cores usually give orders/research/information to the satellites. So the output of the satellite changes into:

$$\frac{dx_2(t)}{dt} = -r_2 x_2 \left(-1 + \frac{\delta_2 x_1}{N_1}\right), \delta_2 > 0 \qquad (13)$$

δ_2 means the contribution to satellite's output by per unit natural size market saturation of cores. Furthermore, the ideal market saturation of the satellites have block effect to their own output so as the cores.' This means:

$$\frac{dx_2(t)}{dt} = -r_2 x_2 \left(-1 + \frac{\delta_2 x_1}{N_1} - \frac{x_2}{N_2}\right) \qquad (14)$$

from the equations above, the differential equation of the stable state of the symbiosis is:

$$\begin{cases} f(x_1, x_2) \equiv \dfrac{dx_1(t)}{dt} = r_1 x_1 \left(1 - \dfrac{x_1}{N_1} + \dfrac{\delta_1 x_2}{N_2}\right) = 0 \\ g(x_1, x_2) \equiv \dfrac{dx_2(t)}{dt} = -r_2 x_2 \left(-1 + \dfrac{\delta_2 x_1}{N_1} - \dfrac{x_2}{N_2}\right) = 0 \end{cases} \quad (15)$$

Solution of the Stable Point

The balance point of the differential equation is:

$$E_1: \ (x_1, x_2) = \left(\frac{N_1(1 - \delta_1)}{(1 - \delta_1 \delta_2)}, \frac{N_2(-1 + \delta_2)}{(1 - \delta_1 \delta_2)}\right)$$

this means the outputs of cores and satellites are separately $\frac{N_1(1-\delta_1)}{(1-\delta_1\delta_2)}$ and $\frac{N_2(-1+\delta_2)}{(1-\delta_1\delta_2)}$. If they are not zero, then the symbiosis of the industrial cluster can be realized. Therefore, the condition of E_1 has economical meanings are $\frac{N_1(1-\delta_1)}{(1-\delta_1\delta_2)} > 0 > 0$ and $\frac{N_2(-1+\delta_2)}{(1-\delta_1\delta_2)} > 0$.

Solution of the in equation:

$$\begin{cases} \dfrac{N_1(1 - \delta_1)}{(1 - \delta_1 \delta_2)} > 0 \\ \dfrac{N_2(-1 + \delta_2)}{(1 - \delta_1 \delta_2)} > 0 \\ \delta_1 > 1, \delta_2 < 1, \delta_1 \delta_2 > 1 \, or \, \delta_1 < 1, \delta_2 > 1, \delta_1 \delta_2 < 1 \end{cases}$$

The Stability Analysis of the Balance Point

The linear system of the nonlinear system nearby the balance point is the first-order Taylor expansion.

$$\frac{dx_1(t)}{dt} = r_1 \left(1 + \frac{\delta_1 x_2}{N_2} - \frac{2x_1}{N_1}\right)(x_1 - x_1^*) + \frac{r_1 x_1 \delta_1 (x_2 - x_2^*)}{N_2}$$

$$\frac{dx_2(t)}{dt} = \frac{r_2 x_2 \delta_2 (x_1 - x_1^*)}{N_1} + r_2 \left(\frac{\delta_2 x_1}{N_1} - 1 - \frac{2x_2}{N_2}\right)(x_2 - x_2^*)$$

The relative coefficient matrix is A, then

$$A = \begin{bmatrix} r_1 \left(1 + \dfrac{\delta_1 x_2}{N_2} - \dfrac{2x_1}{N_1}\right) & \dfrac{r_1 x_1 \delta_1}{N_2} \\ \dfrac{r_2 x_2 \delta_2}{N_1} & r_2 \left(\dfrac{\delta_2 x_1}{N_1} - 1 - \dfrac{2x_2}{N_2}\right) \end{bmatrix}$$

Put the balance point E_1: $(x_1, x_2) = \left(\frac{N_1(1-\delta_1)}{(1-\delta_1\delta_2)}, \frac{N_2(-1+\delta_2)}{(1-\delta_1\delta_2)} \right)$ into A, according the determinant method of the differential equation, the condition of balance node is $\delta_1 < 1, \delta_2 > 1, \delta_1\delta_2 < 1$. $\delta_1 < 1$ manifest that the contribution of satellites to the cores is relatively less. And this can be intuitionistic explained in economics. From the division view, every satellite can do one or several working procedures. All the final products of the satellites are the intermediate manufactured goods of the cores. For there are numerous satellites competing with each other, the more fierce the competition is the more choices the cores have. So the contribution of the satellites is not too much. $\delta_2 > 1$ means the contribution from the cores to the satellites is reiteratively big. The order given by the cores has high percentage of the satellites' output. And the cores give market need structure/trend analysis and sometime even the direct investment to the satellites. These is very important. Therefore the contribution of the cores is relatively high. $\delta_1\delta_2 < 1$ means single core and satellites can realize the symbiosis state in this kind of structure, there must be a small δ_1 but a big δ_2. In fact, this means the core must have large scale and the division of labour is very high. Nemours satellites can cause fierce competition which will bring powerful rivals up.

CONCLUSION

From an ecology perspective, this paper explains the competitive and symbiosis relations between the enterprises in the industrial cluster. If the enterprises can coexist in a competitive environment; they must be diverse but not totally identical. No matter what kind of industrial cluster (Italianate or Hub and spoke), the key point of the symbiosis is the intense competition. On the one hand, the entry of new enterprises can cause the market share of the antecedent enterprises shrink; the contention of the skilful worker and managers can increase the manufacture cost; the quick spread of the technological and process flow innovation makes the comparative advantage not sustainable; the share of information of the product orientation and market development cause the carving up of the privatizing profits. But on the other hand, several competitions can bring many benefits: better infrastructure/acceleration of the information flow/accumulation of the technology and talents/improvement and innovation. All these call more attention of the government and form the supportive policy. So the strong competition is the key point of the industrial cluster's existence.

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