RESEARCH ON CLUSTERS OF INDUSTRIAL TOWNS OF THE DELTA OF PEARL RIVER BASED ON PRODUCT-COMPETITION NETWORK

Munan LI, Jian-mei YANG

School of Business Administration, South China University of Technology,
Wushan Road, 510641, Guangzhou,China
nells_li@hotmail.com,
fbajyang@scut.edu.cn

Abstract: This paper presents a modeling theory of product-competition network. In the light of theoretical analysis and deduction, we provide some explanations for dynamic mechanism about the clusters of industrial towns of the delta of Pearl River in China. In the light of the analysis of real demonstrations in the delta of Pearl River, this theory of product-competition network and its practical consequences sound reasonable and suggestive.

1 INTRODUCTION

Industrial town is one of the important economic features in the delta of Pearl River in China. We make use of the product-competition network based on complex network to study the industry clusters of those specialization (industrial) towns. Through observing the features of statistical physics of the network underlying in the relations of competition, we attempt to analyze quantitatively some dynamic mechanisms of industry clusters of those specialization towns in the delta of Pearl River. Product-competition network is a network of competition and cooperation in the occupation of the manufacturing resources and market shares by producing and selling the same categories of merchandise [1]. The study on the production-centered expanding structure of enterprise helps study further on the competitive relation-network, a typical enterprise network in the Chinese economy. This paper proposes, above all, a novel theory of constructing the product-competition network and a theoretical deduction which is stemmed from the modeling of the network and is considered as economically significant. The third part of this paper is contributed to the discussion and analysis of the statistical features of such a network based on the research on the demonstration cases in the delta of the Pearl River in China. Besides, the theoretical deduction and hypotheses in the second part are partly validated in this part. Finally, we point out the weaknesses of the product-competition network in theory and practice as well as the possible directions of the future research.

2 THE PRODUCT-CENTERED COMPETITIVE NETWORK

The product-competition network is a corporation network in which all the corporations connect with one another by common competitive relations concerning the products. We abstract the competitive relations among the corporations with same or similar category of products as an edge between two vertexes (enterprises), thousands of which will ultimately form a network of competitive relations in as many fields as the supply of raw material, labor market, product sale and so forth. Research on the development structure of the corporations around products will be of great meaning in promoting further studies on the typical competitive networks in the domain economy.

2.1 A General Review of the Product-Competition Network

It is now a common phenomenon in Chinese domestic territory economy that different enterprises cluster in a compact community engaging in the same category of products. Like the industrial towns in the city of Shunde city and Dongguan city in Guangdong province. The industrial cluster is, in a common sense, considered as the network of corporations around the supply chain. Take the Toyota Corporation for example, it has 168 first-level supplementary enterprises, 4,700 second-level, 31,600 third-level and the countless below, not to mention all its sales agencies and medium organizations throughout the world. It is the mountain of such clusters that constructs the Kingdom of Toyota Corporation, which could be considered a typical industrial cluster defined by M. Porter [2]. This is, after all, a highly-developed monster of industrial cluster which is still very rare in many other regions. In most of these regions, there are just a few or several hundreds of enterprises clustered together. The delta in the Pearl River is the case discussed where the most important feature of territory economy is the industrial towns specialized in certain products.

Table 2-1: Number of the industrial towns in parts of the delta of the Pearl River (Dongguan city, Shunde city and Foshan city) *

ID	Industrial Categories	Number of Industrial Town
1	Electronic Components & Supplies	6
2	Logistics Services	3
3	Home Appliances	6
4	Furniture & Furnishings	5
5	Apparel & Fashion	9
6	Hardware Components	8
8	Home Supplies	2
9	Paper Products	1
10	Printing & Packaging	1
11	Automobile	3
12	Machinery Equipment	2
13	Food Processing	1
14	Aluminum Models & Materials	1
15	Motorcycle	1
16	Container & Supplementary	1

* **Source from:** Guangdong Science & Technology Bureau; **Date of gathering:** September of 2006

17	Farm Products Processing	3
18	Shoes	2
19	Toys	1
20	Agriculture & Travel	1
21	Lights & Lighting	1

In these industrial towns, the competitive enterprises specialized in certain products vary in amount from less than hundred to several hundreds, which is mainly the result of the different scales of production. This is an essential network structure based on the product to the development of the clusters of the industrial towns. Our interest will be the problem of whether such an economic phenomenon is the necessary result of the development of the traditional culture of trade or it is just a requirement of efficiency by the territory economy itself.

2.2 Product-Competition Network based on competition-decision modeling.

This paper focuses on the study of the clusters concerning the Home Appliances. We try to study its features of statistical physics through the simple network of product-competition. To simplify this model, we let the computing equation of degree of node as follows:

$$k_i(t) = c(t) \qquad (2\text{-}1)$$

The equation (2-1) represents that the i^{th} node (enterprise) has the $k_i(t)$ degree at the time t, and the degree of i^{th} node is equal to the amount of enterprises competed with it. In fact, the computing equation of degree can be designed into more complex equation, for example, we can take the weights of competition relation into account. Here, we just want to observe several indications of statistical physics, and such simplification of the competition network is feasible within the range of estimation precision.

Compared with the fitness model of complex network [3], we provide a novel method of modeling, i.e. a modeling based on the degree of competition-decision. This novel method of modeling contains the following three rules:

1) Growing of network: In a network of production-competition with m_0 nodes, a new node links with m node according to a probability distribution. And the fitness of each vertex subjects to such probability distribution as $\rho(\eta)$, which satisfies the equation (2-2).

$$\rho(\eta_i) = \frac{\alpha V_i + \beta T_i}{\sum_j \alpha V_j + \sum_j \beta T_j} \qquad (2\text{-}2)$$

In the equation (2-2), V is the annual revenue of vertex (enterprise); T is the age of vertex. Therefore, the fitness of vertexes is in a direct proportion to their ages and revenues; α and β are the weights of age and revenue.

2) Preferential attachment: A new enterprise chooses to link the hub node of network with the probability Π_i, which satisfies the equation (2-3).

$$\Pi_i = \frac{\eta_i k_i}{\sum_j \eta_j k_j} \qquad (2\text{-}3)$$

3) Avoidance of the super competitors. Each new vertex (enterprise node) tries to avoid meeting with those much stronger nodes than itself. Therefore, a new vertex links the i^{th} vertex with the probability Π_i^*, which satisfies the equation (2-4).

$$\Pi_i^* = \frac{\sum_j \eta_j k_j - \sum_l^i \eta_i k_l}{\sum_j \eta_j k_j} \qquad (2\text{-}4)$$

In equation (2-4), $\sum_l^i \eta_i k_l$ represents the sum of degrees of the 10% vertexes, whose degrees are closer to the i^{th} vertex than the rest in the network; $\sum_j \eta_j k_j$ is the degree sum of all of the nodes. In our model, the degree of vertex represents the amount of competitors. Therefore, when a new vertex chooses rationally the product or the competitor in a cluster, it will try to avoid competing with those enterprises too strong. This rule is the modeling rule of competition-decision, which represents the rationality of the real corporation.

Without considering the rule of avoidance, basically, this model will be similar to the fitness model, and the degree distribution will subject to the power-law distribution. But in a real industry clusters, there are two types of new comers: 1) those connecting to the hubs (the dominating enterprises) by being the suppliers of those hubs; we call these comers as *attachments*; 2) those choosing the same products to compete with those existed enterprises; we call these comers as *competitors*. Therefore, in those industry clusters of specialization towns, these two rules in dynamic increase maintain some equilibrium in the network of enterprises.

To simplify the decision of selecting, we suppose that the probability of selection-Π_c (*attachments* or *competitors*) subjects to the even distribution, i.e. each comer may become *attachments* or *competitors* with a probability of 1/2.

Assume that *m(t)* is the function of added edges at the point of time *t*. Here we need not consider the amount of vertexes. On the other hand, the resource of industrial towns has the threshold, therefore, the *m(t)* could not be a linear-increase function or other increase function without limitation. We suppose the *m(t)* satisfies the equation (2-5).

$$m(t)=\lambda t^{\theta}, \text{ and } \theta\in(-4,0) \qquad (2\text{-}5)$$

In equation (2-5), λ is a constant. *t* is the time variable, the unit of *t* can be either the year or the quarter. This equation means that the enterprise network of industrial town will be more and more stable due to the constraints of resource during a period. Intuitively, this prearrangement is understandable. At this time, the model of competition-decision can be defined as a nonstationary network [4]. From the work of reference [5], we can get the degree exponent γ of our model which satisfies the equation (2-6)

$$\gamma = \frac{3-\theta}{1-\theta} \qquad (2\text{-}6)$$

In equation (2-6), because $\frac{d\gamma}{d\theta} = \frac{2}{(1-\theta)^2}$>0, it is easy to get the scope of γ, i.e., $1.2<\gamma<3$. Therefore the degree distribution subjects to the power-law, i.e. $P(k) \propto k^{-\gamma}$.

From the above deduction, we assume $\Pi_c = 1/2$, and then the model of competition-decision embodies features of scale-free network [6]. If the Π_c does not subject to the even distribution, the conclusion has to be reconsidered. For example, a new *competi-*

tor decides to enter the cluster by referring to the decision function, which is defined as D_i:

$$D_i = \begin{cases} 1 & \dfrac{\sum_{\omega} k_{\omega}}{\sum_{j} k_j} \geq \tau_i \\ 0 & \dfrac{\sum_{\omega} k_{\omega}}{\sum_{j} k_j} < \tau_i \end{cases} \qquad (2\text{-}7)$$

In the equation (2-7), τ is the threshold, and a constant. $\sum_{\omega} k_{\omega}$ represents the sum of the largest 1% of degree k. Therefore, if the cluster owns super enterprises, the new *competitor* is very likely to give up the attempt of entering the cluster. In the scale-free network, the calculus- $\sum_{\omega} k_{\omega} \Big/ \sum_{j} k_j$ will be much larger than the 0.01. But in the even network, $\sum_{\omega} k_{\omega} \Big/ \sum_{j} k_j$ should be closer to the 0.01, and it is difficult to satisfy the equation (2-8), because most degrees of vertexes are very close to each other.

$$\frac{\sum_{\omega} k_{\omega}}{\sum_{j} k_j} >> 0.01 \qquad (2\text{-}8)$$

In the following sections, we select the degree distributions of the two clusters of industrial town as the inquisitional objects of demonstration analysis with one cluster owning a super enterprise (hub vertex) and the other not.

3 DEMONSTRATIONS AND ANALYSIS

In section 2, we can provide two hypotheses if we take the decision function into account: 1) The industry clusters owning super vertexes grow more slowly than those clusters without super vertexes, because the potential competitors is very likely to choose not entering the cluster; 2) The vertex amount of clusters without super enterprises is possibly larger than that of the clusters with super enterprises. The former will tend to be active due to the fierce competition.

3.1 The network of industry cluster with super enterprise

Here, we choose the Beijiao town as our inquisitional object. Beijiao town is a well known base of refrigeration products in China. The super vertex is the Midea Group whose revenue in 2005 is about $ 5.3 billions. We choose 325 related enterprises in this town as the vertexes of network. The fitness of vertex is the ratio of its revenue in 2005 to the total revenue of all the vertexes in 2005. The degree distribution is shown in fig 3.1.

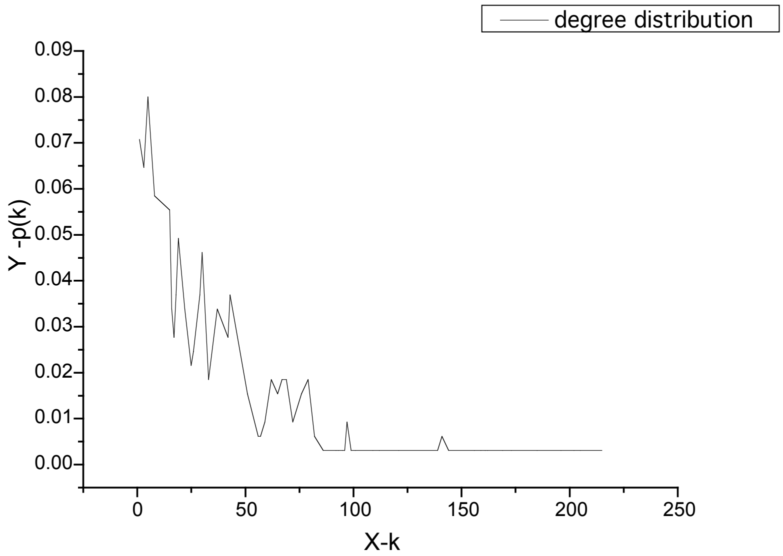

Fig 3.1 Degree distribution of refrigeration product-competition network in Beijiao town

Here, we intentionally neglect the noise of the gathering data and the small amount of vertexes. However, the result of the calculation is fairly acceptable. From the Fig 3.1, we can make a conclusion that the product-competition network is nearly a scale-free network (power-law distribution). And we estimate that the degree exponent $\gamma \approx 1.23$, which satisfies the equation (2-6) and that the average length of path $L \approx 2.1$. Therefore, this product-competition network has the features of small world [7] and scale free.

3.2 Product-competition network without super enterprise

Here, we choose the Ronggui town as inquisitional object. Ronggui town is the largest cluster producing mainly gas burner and heating appliance in China. We choose 569 enterprises producing the related products as the vertexes to construct the product-competition network. The total revenue of the largest enterprise in 2005 in the 569 manufacturers is about $ 0.7 billion. The degree distribution is shown in Fig 3.2.

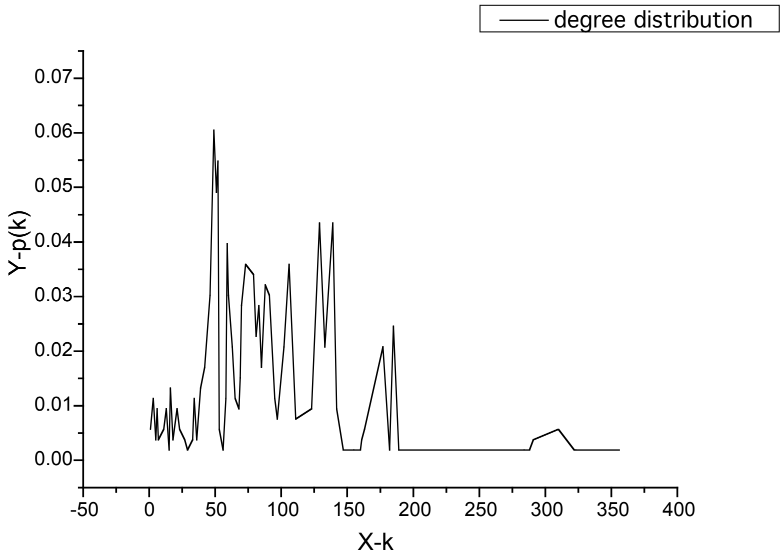

Fig 3.2 Degree distribution of heating appliances related product-competition network in Ronggui town.

From the Fig3.2, the degree distribution of cluster without super enterprises subjects to the approximate Poisson distribution. The average length of path $L \approx 2.36$, therefore, this network exhibits the feature of small world too, but does not subject to the distribution of scale-free network. In addition, the manufacturers of refrigeration product are only about three hundred in Beijiao town, but there are over five hundred manufacturers of heating appliance in Ronggui town. Therefore, the clusters with hub vertex have the potential power of excluding certain amount of new competitors. On the other hand, the clusters without super vertexes prove to be more active. For example, the vertexes join or quit more frequently than the clusters with super enterprise. The demonstration is shown in the table 3-1.

*Table3-1 the proportion of the enterprises join and those quit in recent five years**

Town / Year	Beijiao town		Ronggui town	
	Join(%)	**Quit(%)**	**Join(%)**	**Quit(%)**
2000	9.1	3.3	15.2	9.3
2001	12.2	5.1	16.1	8.1
2002	13.2	3.7	18.3	10.8
2003	9.6	4.3	13.7	7.9
2004	7.8	2.3	15.2	6.3
2005	6.3	2.9	13.4	9.2

* Data from: Guangdong Industry & Commerce Bureau; Date of gathering: August of 2006

4 Conclusions

Through analysis of the product-competition network of clusters in industrial towns, we find that the dynamic feature of industry clusters in specialization towns in the delta of Pearl River is related to the topology of the competition network. As to the modeling rules of product-competition network, we verify and improve the fitness model and figure out two hypotheses based on the modeling method. Through the demonstration of two industry clusters of specialization town in the delta of Pearl River in China, it proves that our deductions are reasonable and the model of product-competition network is competent in explaining some economic phenomena in the clusters of industrial towns.

The industrial town is one of the important features in the delta of the Pearl River and the delta of Changjiang River in China. Frequently, the economy of the specialization towns is compared to one of the engines promoting the growth of Chinese GDP. How to promote the creativity and vigor of those industry clusters in Chinese towns is very meaningful. Recently, the industry clusters of those specialization towns have to confront the crisis of the increase in cost and the shortage of skilled employees and so on. Our work may be helpful to study the dynamic mechanisms of those clusters of industrial town. In this sense, our future works will contain the following aspects: 1) more detailed analysis of product-competition network; 2) proposal of the theory of dynamic evolution of the product-competition network; 3) gathering more data for demonstrations of the industrial towns in the delta of both Pearl River and ChangJiang River.

REFERENCES

1 Yang Jian-mei, Lu lvping, Xie Wangdan. Complex Network Analysis to competitive relationship of Guangzhou software enterprise. The Proceeding of the 2nd conference of Chinese Complex Network, 2005, pp: 616-618.

2 Xu Jiqin. Industry Clusters and the Creative System of territory economy. Beijing: Economics Press, 2006.

3 Bianconi G, Barabàsi A L. Bose-Einstein condensation in complex networks. Phys. Rev. Lett, 2001, 86: 5632-5635.

4 Dorogovtsev S.N,Mende J.F.F, Samukinhin A. N. Structure of growth networks with preferential linking. Physical Review Letter, 2000, 85: 4633-4636.

5 Shi D.H., Chen Q.H., Liu L.M. Markov chain-based numerical method for degree distribution of growing networks. Phys. Rev. E71, 2005, 036140.

6 Barabàsi A L, Albert R. Emergence of scaling in random networks. Science, 1999, 286(5439): 509-512.

7 Watts D J, Strogatz S H. Collective dynamics of ‘small-world’networks. Nature, 1998, 393(6684): 440-442.