Analysis and Modeling on the Government's Co-agglomeration in Industrial Clustering

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Abstract. Industry clusters have been the focus of scholars and governments since the second half of the 20th century. During a cluster's growing process, the government plays an important role. In order to show the growing law of the clusters and how government did for co-agglomeration, we proposed two kinds of models: Logistic model and BA model with parameter α to describe the single and mass clusters separately, and we choose the gross industrial output value of the 13 cities in Jiangsu province as numerical verification, showing that the government is part and parcel of the industrial clusters.

Keywords: Industrial clustering, co-agglomeration, BA model, Logistic model.

1 Introduction

The last few years have witnessed tremendous development devote to the effect of industrial clusters. Today, the industrial cluster has become a global economic phenomenon. Industrial clusters are existed in many developed and developing countries both in high-tech industries and the labor-intensive industries. For example, the electronics and information industry cluster in U. S. Silicon Valley, auto industry cluster in Detroit, machine tool industry in Stuttgart, surgical instruments industry cluster in Tuttlingen, and so on. Italy, which we called "Kingdom of SMEs", has had the number of 199 clusters by the year 2002, of which there are 69 clusters of textile, 27 shoes, 39 furniture, 32 mechanical, 17 food, and a cluster of metal products, 4 clusters of chemical products and 6 clusters of paper and printing. Clusters in China have also led to Rapid economic growth.

More and more clusters are coming into being, such as clusters in Guangdong, Zhejiang and Jiangsu Province. Being interested in industrial cluster, the government is also taking action to promulgate mass of cluster policies for assistance.

As the reason for the forming of industrial cluster is not unique, government's behavior is also an important factor, especially in China. Whether government support or not is rather key to any sorts of industrial clusters. Recently, much attention has been paid to analyzing and modeling industrial clusters. An industrial cluster, however, is more similar to a population, so we choose Logistic model and complex network to describe the industrial cluster, and also we can see the importance of government during its development.

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2 Methods

2.1 Logistic Model for Single Cluster

Clusters' life cycle plays an important role on the competitiveness of industrial clusters. Tichy(1998) divided it into four phases: formative phase, growth phase, maturity phase and petrify phase.

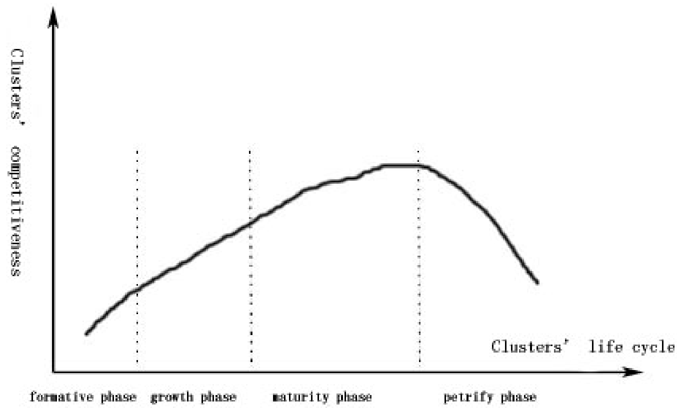

Fig. 1. The relationship between cluster's life cycle and its competitiveness

Population Ecology of the Logistic model described that in certain circumstances, at the force of self copy ability as well as limited resources and other populations' restrictions, the population growth process. Similarly, enterprises entering the cluster can be understood as a certain type of an economic population increase as well. As the industrial cluster has the characteristics of ecological, we try to use the Logistic model to describe clusters' life cycle.

The Logistic model of single industry cluster can be defined as

$$\begin{cases} \dfrac{dn}{dt} = r(1 - \dfrac{n}{K}) \\ N(0) = n_0 \end{cases} \tag{1}$$

where n is the number of enterprises in the cluster which depends on time t, $N(0)$ referrers to the enterprises number in year 0 (the original number) . In a certain period of time and space conditions, the elements of endowment unchanged. K is the maximum scale of the cluster, as $K = \lim_{t \to \infty} n(t)$. At the same time, r represents initial (or maximum) increasing rate. While the cluster's ability to use resource doesn't change with the cluster's scale changes, r can be considered as const. As the industrial cluster theory expounds, the cluster's increasing rate is the remainder of enterprise that enter and exit rate at a certain time frame.

According to Eq. (1), we can get

$$n = \frac{Kn_0 e^{rt}}{K + n_0 (e^{rt} - 1)} \tag{2}$$

Eq. (1)(2)show that an industrial cluster's Logistic increasing process from formative phase to maturity phase is associated with balanced scale and increasing rate.

With the help of government, in Logistic model, K and r are controllable parameters. The maximum number of enterprises K is mainly depends on nature resources, infrastructure, institutional environment, labor resources, technology and market demand. The increasing rate r is related with the ability a cluster uses resources. Except those nature resources which naturally existed, the government's co-agglomeration embodies the role of improving infrastructure such as electricity, traffic and communication equipment, completing the legal system to make a suitable environment, and also high level of education can improve the quality of labor force at the same time. The appropriate government policies and measures can promote cluster innovation, cluster learning and cluster brand building, so that its core competitiveness will be greatly enhanced (as the dotted line in Fig. 2.).

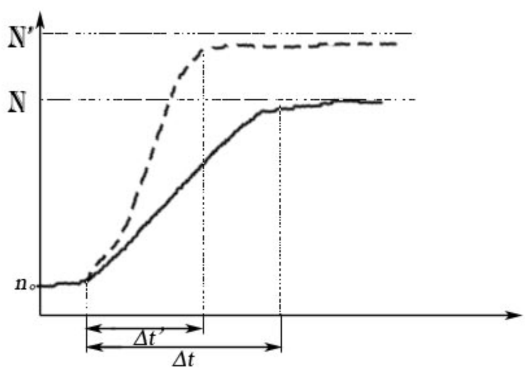

Fig. 2. Logistic growth process of an industry cluster from its formative to maturity phase is related to its balance scale N and growth rate r. When the value of K is higher, the upper limit N' of the curve in Fig.4. is higher, that is to say, the maximal number of enterprises in this industry cluster is larger; when the value of r is higher, the curve is steeper, that is to say, the time Δt from its growth to maturity phase is smaller and the growth rate is faster.

2.2 BA Model for Multiple Clusters

Self agglomeration is an important section during the evolution of complex network. Watts and Strogatz [8] brought up the concept of small-world networks and Clustering coefficient, and attracted much attention to the phenomenon of clustering, such as the analysis on the world wide web [9] and cell network [7]. At the end of the 20^{th} century, Barabasi, Albert and Jeong first brought up the concept of scale free network (BA model) [1]. Their analysis from the dynamic, growth perspectives showed the complex network has the characteristic of power-law distribution. BA model provides the concept of “priority connections” which greatly influenced Zhang Siying’s [6] self agglomeration model. However, in industrial clustering, enterprises entering a certain area rely on government’s co-agglomeration as well.

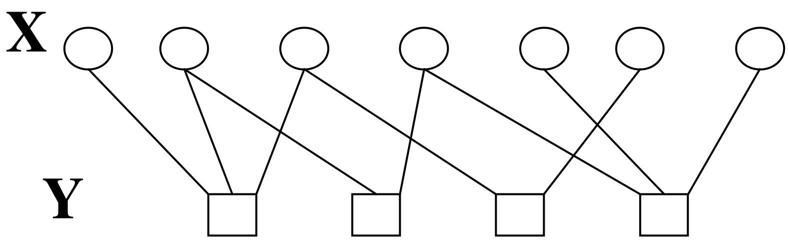

Fig. 3. A basic bipartite network

Basic on Zhang’s model, we changed the network into a bipartite network $G = < X, E, Y >$ [as illustrated in Fig. 3.], where E is the set of edges. The upper are X nodes, and the lower are Y nodes. In the model of industrial cluster, enterprises and the cluster areas are two different sorts of participants in the dual-mode network. The entering of enterprises established their relationship. Define node X as set of enterprises and node Y as set of areas. Both are finite sets. According to BA model [3], we repeat this process in every time step that, add a new node to set X and then connect to a node in set Y under the rule of preferential attachment. So the rate of a new node connected to node $y_i \in Y$ is

$$\prod(k_i) = \frac{k_i}{\sum_j k_j} \tag{3}$$

where k_i is the degree of the old node y_i. However, as the influence of government, the co-agglomeration model cannot be exactly linear. In other words, the connection rate is not fully proportional to the degree of the node. More reasonable we use

$$\prod(k_i) = \frac{\alpha_i k_i}{\sum_j \alpha_j k_j} \tag{4}$$

where α_i is a parameter mainly decided by the government's intention of area i. Cluster's scale usually grows slower while it's getting close to maturity phase, at this time α_i will be smaller or even minus sometime, so that the government must try to take some active measure to raise the value of α_i.

Besides, at the beginning of industrial clustering, we cannot ignore the original attraction [4], because each area has its nature resources more or less. That is $k_i \neq 0$ or $\prod(0) \neq 0$. So Eq. 4. will be amended as

$$\prod(k_i) = \frac{(k_i + \beta_i)}{\sum_j k_j + \beta_j} \tag{5}$$

where β_i is original attraction depended on the nature resources of area i. β_i managed to make the distribution of industries more balanced to a certain extent. It conforms to the policy that narrowing the gap between east and west China as well as southern and northern Jiangsu, inspiring weak regional governments actively creating a proper environment for industrial clusters.

Based on the method above, finally we get the equality as this

$$\prod(k_i) = \frac{f(k_i)}{\sum_j f(k_j)} \tag{6}$$

where $f(k_i) = \alpha_i k_i + \beta_i$ is pre-set function.

3 Numerical Results

We downloaded the data-set from The Statistics Information Network of Jiangsu (www.jssb.gov.cn), range from 1999 to 2006.

Fig. 4 and 5 are the numbers of industrial enterprises in Wuxi and Suzhou. The curve in Fig.4 is more approach to the Logistic model. It has experienced the former three phases of cluster's lifecycle: formative phase (1999-2000), growth phase (2000-2004) and maturity phase (2004-2006). Clearly we can get $n_0 = 677$, $K \approx 3000$. In the phase of growth (2000-2004), the average growth rate is $r = 554.75$. As a result, the government of Wuxi may pay more attention to find ways to break through the ceiling of 3000 from now on. The experience of Suzhou can be divided into two different periods. The former period is from the year 1999 to 2004. It is a classic Logistic model, and its $n_0 = 610$, $K \approx 1500$, $r = 672$, but it spent only one year to reach the first maturity phase. However, after three years, Suzhou experienced another growth phase. From 2004 to 2005, its growth rate, we express it as r', also reached 627, and the maximum number of enterprises, we express it as K', get to a new high of 2100. It was the effect of Suzhou government's co-agglomeration.

During the year 2002 to 2004, the government was busy in completing the building of traffic, communication, and other basic equipment. Its favorable conditions and desirable policy attracted lots of large enterprises. In these years, Suzhou government did a good job.

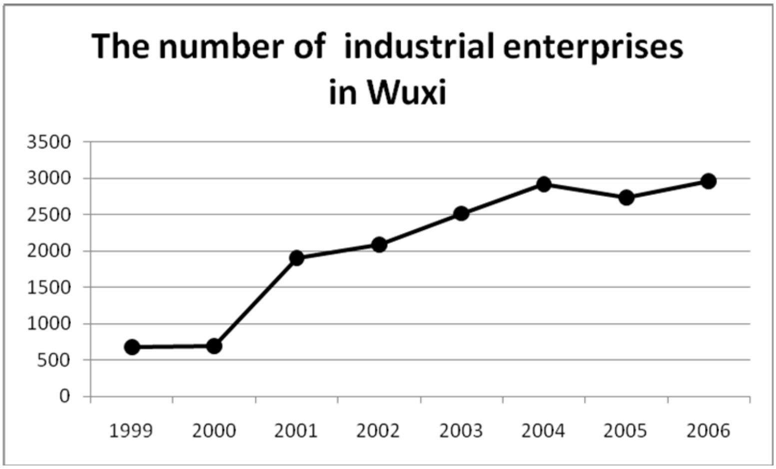

Fig. 4. The number of industrial enterprises in Wuxi

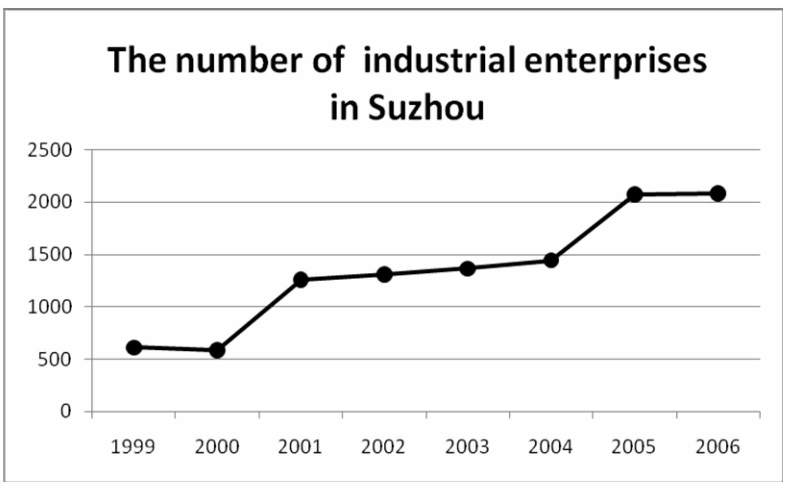

Fig. 5. The number of industrial enterprises in Suzhou

The following table shows the number of industrial enterprises in the 13 cities in Jiangsu province from 2000 to 2006.

Table 1. The number of industrial enterprises in the main 13 cities in Jiangsu province from 2000 to 2006

YEAR / AREA	2000	2001	2002	2003	2004	2005	2006
Nanjing	878	1408	1739	1818	1862	2024	1605
Wuxi	697	1903	2090	2517	2916	2732	2963
Xuzhou	268	257	282	329	375	486	576
Changzhou	727	804	2003	2290	2560	2885	3421
Suzhou	584	1256	1311	1366	1444	2071	2084
Nantong	375	476	521	583	674	829	939
Lianyungang	309	270	260	248	261	269	270
Huaian	132	344	379	417	498	584	716
Yancheng	140	144	149	172	409	462	573
Yangzhou	236	517	535	586	663	750	793
Zhenjiang	230	234	408	459	456	518	595
Taizhou	178	188	207	232	302	378	414
Suqian	19	21	26	28	152	182	279

From 2000 to 2006, the total number of industrial enterprises in Jiangsu province was increasing. Several industrial clusters have been in forming. In general, from the aspect of the number of enterprises, Changzhou, Wuxi, Suzhou and Nanjing were the top 4 cities. [as illustrated in Fig. 6.] Nantong, Huaian, Yangzhou and Zhenjiang were in the second group, and Xuzhou, Lianyungang, Yancheng and Suqian were the third. This is the same as the three area of Jiangsu province.

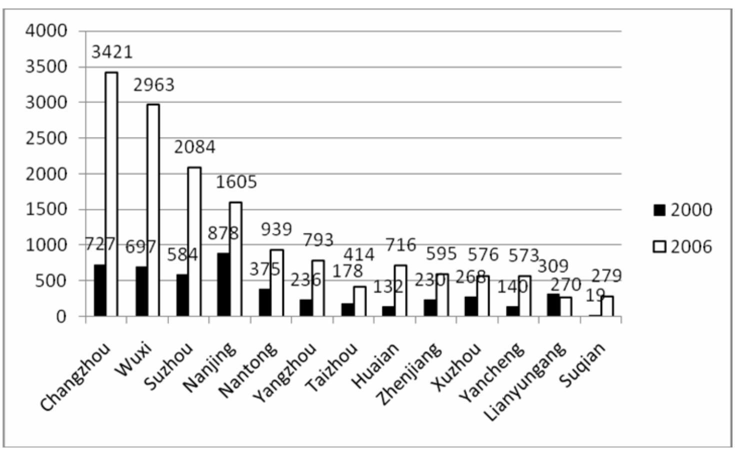

Fig. 6. The total number of industrial enterprises of the 13 cities in Jiangsu province

As the original attraction β_i does little to the co-aggregation model, we can ignore the parameter. Thus we get the average value of α in Fig. 7. We can get the conclution that in most cities, the average value of α is between 1 and 2, which means during these years, most clusters are still growing. Yancheng, especially Suqian, the value of α is larger than other cities, for the two clusters are in the beginning of growth phase. Although the αs of Nanjing and Lianyungang are both very close to 0, they are different. Nanjing is more possibly in the phase of maturity while Lianyungang is formative. Generally, the growing pace of the industrial clusters in Jiangsu province are complied with preferential attachment.

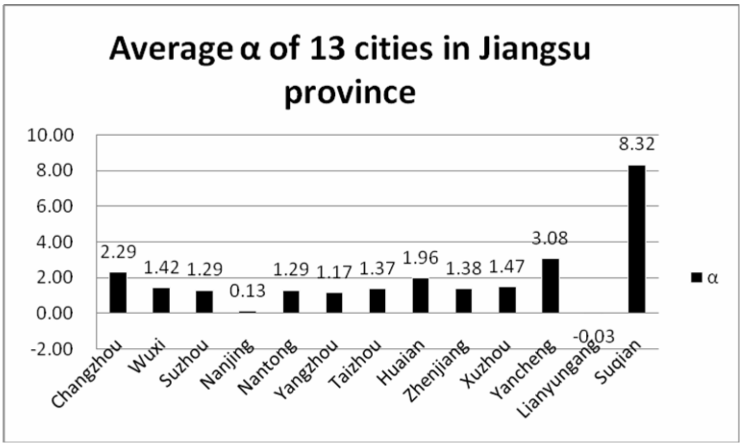

Fig. 7. Average α of the 13 cities in Jiangsu province

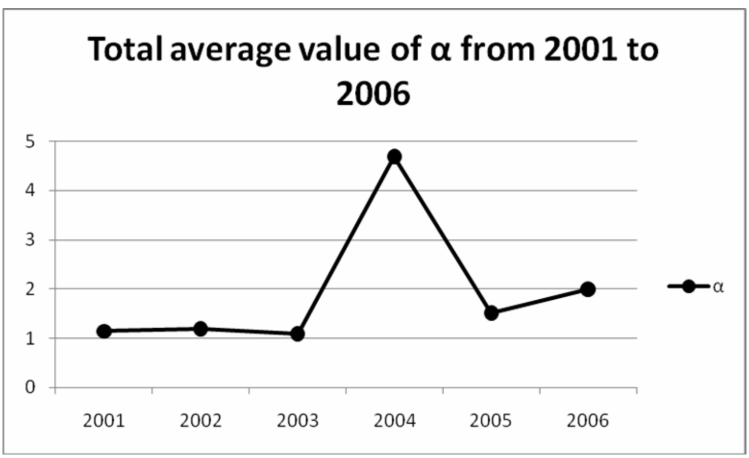

Fig. 8. This figure shows the total average value of α of the 13 cities from 2001 to 2006. Except in 2004, affected by Yancheng (11.77) and Suqian (37.82), the tendency of α is keeping on a rise.

Table 2. From the different average value of α, we can see that with the improvement of industrialization, the growth rate get slower. Pay attention to the total average. We removed the value of the year 2004, because of its erratic behavior.

Comparation of several average value of α	
Total average	1.3837
Average of 1st group	1.2821
Average of 2nd group	1.4512
Average of 3rd group	2.4203

4 Conclusion and Discussion

Bipartite network perfectly divided the nodes into two groups: the areas and the enterprises. The number of former is stable and the latter changes. As an enterprise enters a certain area, their relationship is established. Enlightened by BA mode and reference [5], we adopt the concept of preferential attachment. Parameter of co-agglomeration is the key problem in the co-agglomeration model. In this article we proposed the parameter α as a multiplicator, because the cluster may get smaller in some years, so that the parameter shall be minus which k^{α} cannot express. We also proved a single industrial cluster's increasing is similar to the Logistic model, and it may reveal another trend under the control of government, such as Suzhou is going through the second time of cluster's life cycle and Wuxi has a long growth phase.

As in most city, the value of α is normal, and the clusters in those cities are healthily and steadily growing under the control of government. If we have a more accurate data set, such as monthly data, or a longer time range data set, we can probably get a more accuracy result and can also analysize its distribution. For the total value of average α, it is better to set a weight to reduce the influence of less developed clusters.

Finally, as Michael Porter said, cluster policy must be an important part of state and local economic policy [2], so we cannot ignore the affect of government in the process of industrial clustering, from the angle of either qualitative or quantitative analysis. With the help of government's co-agglomeration, the industrial clusters can grow steady and healthy continuously.

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References

1. Vianconi, G., Barabasi, A.-L.: Competition and multiscaling in evolving networks. Europhys. Lett. 54, 436–442 (2001)
2. Porter, M.E.: Location, Competition and Economic Development: Local Clusters in a Global Economy. Economic Development Quarterly 14 (2000)

3. Barabasi, A.-L., Albert, R., Jeong, H.: Mean-field theory for scale-free random networks. Physica A 272, 173–187 (1999)
4. Jeong, H., Nda, Z., Barabasi, A.-L.: Measuring preferential attachment in evolving networks. Europhys. Lett. 61, 567–572 (2003)
5. Zhang, S.-y.: Self-Clustering, Attraction Kernel and Quantity of Clustering 自聚集、吸引核与聚集量. Complex Systems and Complexity Science 2(4), 84–92 (2005)
6. Mukkala, K.: Agglomeration Economies in the Finnish Manufacturing Sector. In: 43rd Congress of the European Regional Science Association, pp. 27–30. Jyväskylä, Finland (2003)
7. Gladarellia, G., Catanzaro, M.: The corporate boards networks. Physica A 338, 98 (2004)
8. Watts, D.J., Strogatz, S.H.: Collective dynamics of small-world networks. Nature 393, 440–442 (1998)
9. Barabasi, A.-L., Albert, R., Jeong, H.: The diameter of the world wide web. Nature (1999)