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The Dynamics Mechanism of Vulnerability for Resource-based Enterprise Communities in China

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ARTICLE INFO	ABSTRACT
	This paper has analyzed the dynamics mechanism of resource enterprises community vulnerability, selected the key factor of resources to establish a nonlinear dynamical model. The model reveals the constrained relationship between the number of vulnerable enterprises and resource shortage rate, and the same relationship between t vulnerable enterprise numbers and the owning rate of resource market by the biggest enterprise in resource-type enterprises community of China. The results showed that, the shortage rate of resources take up more percentage than the occupancy of resource rate of the strongest enterprises in Enterprise community when D>q. the characteristics and patterns of the Chinese enterprise evolution are as follows, (1) The strongest enterprises n1 will decline or transform in the enterprise community. (2) The enterprises which survived after the shortage of resources will go through three stages: ① resistance stage; ② recovery stage; ③ stable stage. We believe that there are three movements that can make sure the resource-based enterprises community keep growing continuously in the competitive market for resources, (1) understand the enterprise resources shortage rate and the strongest enterprises share in resource rate in enterprise community, (2) follow the even-odd symmetry or odd-even symmetry laws based on the familiarity of a resource economy, (3) put the enterprises in the suitable position.

1. Introduction

I n the process of economic globalization, the globalization of resources allocation and integration of international market are gradually becoming more significant, meanwhile, in a global scale, the adjustment and upgrading of industrial structure are having a rapid pace, it is also noticeable that the mergers of large enterprises and companies goes hand in hand with the rise of a large number of small and medium-sized enterprise communities. Particularly noticeable [1]. The Ministry of land and resources survey shows that, by the end of 2002, 2/3

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of large and medium-sized state-owned resource-based enterprises are facing depletion issues in China [2]. By the October of 2012, 5010 state-owned large-medium-sized enterprises and mines with exhausted resources in China have exited the market [3]. These symptoms are the comprehensive reflection of resource-based enterprises community vulnerability [4]. Since 1980s, Chinese government has started to assign large amounts of funds to support state-owned resource-based enterprises, trying to promote the development of other alternative industries, so that they are able to complete industry transformation successfully before the exhaustion of resources [5-8]. This paper considers that the resource-based enterprises community is the base for the survival of enterprises, formed by gathering some enterprises related to mining, processing and utilization in certain areas, and provide resources and primary processing products to society, with the features of opening, dynamic, nonlinear, complex adaptive etc. The vulnerability [9] refers to the character of resource-based enterprises community breakdown due to the depletion of resources, which can cause an enterprise with more instability, sensitivity and lack of recovery ability. In short, the vulnerability is the root of the resource-based enterprises community decline. When resource based enterprise confronted the resource constraint for some reason, vulnerability will become more obvious. Therefore, the resources are the largest contributors for community development [10]. Therefore, resources are selected as the key factor to prove.

The resources shortage will lead to the decline or transformation of some enterprises, but how the resources shortage affects and restricts mechanism of industrial economy and regional economy of China has not yet been understood profoundly, especially the new pattern of internal mechanism. The lacking knowledge of this area have led to the decline of part of industry and enterprise in China. Although there has been a lot of researches in this area [11-13], but it does not involve inherent dynamical mechanism in between. As the (nonlinear) mathematical difficulties, the relationship between mathematical constraints and dynamic mechanism so far has not been studied by resources economist of China. And this mathematical difficulty mainly due to resource market economic system is a very complex nonlinear system. With the development of nonlinear science and mathematics, quantitative research and dynamics mechanism research have been deep into the earth science, environmental science, resource science and economics etc [14-17]. Only a profound understanding of the intrinsic dynamic relationship and the development mechanism between management object (element) can enable the implementation of scientific and effective government management and reform, so as to achieve the maximum the utilization of limited resources. Therefore, it is necessary to study the intrinsic relationship between the shortage of resources and enterprise decline from the angle of nonlinear dynamics.

From the dynamic perspective, this paper will analyze the dynamic mechanism of vulnerability production of resource-based enterprises community, select the key factor as resources, set up a nonlinear dynamic model of enterprise competition for the first time in describing the enterprise community economy resource market evolution (development or recession), and using this model simulation studies the dynamic constraints relationship on a certain resources shortage rate that will cause Chinese enterprise decline, thus in the competition strength and the competition advantage of the asymmetric conditions, provide scientific theoretical basis with minimal resources shortage rate for the resource-based enterprises community development and positioning, the government and industry departments to study and formulate the governance model for the vulnerability of Chinese enterprise community *(community, population, and the dominant species in this paper refers to the resource type)* .

2. The Resource-based Enterprises Community Competition Dynamics Model

Assuming the total resources is 1 in one certain industry in China, p_i is the resources occupancy rate($0<pi<1$) which an enterprise (company) i hold on the resources rate under the resources market economy system; c_1 is resources occupation rate for the enterprise (company) i to peer (population) other enterprise (company) , namely, resource development capacity; m_i for enterprise i internal rate of decline; D is the resources shortage rate of China under the global resources market economy system.

The so-called enterprise decline under the global resources market economy system, in fact it is that enterprises share of resources Pi with time evolution problem when shortage of certain rate of resources. If Pi tends to zero with time increases and it means that the declining trend of the enterprise. Conversely, if the Pi tends to large with time increases, it means that the enterprise development and expansion.

Because the enterprise (company) share resources rate relate to its competition ability and internal decline rate. Zhenshan Lin put forward the following hypothesis relevant enterprise decline rate m_i and the company share of domestic resources rate (p_i^0 ($i = 1,2 \ldots n$)) when there is no shortage of resources. Hypothesis: each enterprise of peer (a group) has equal internal rate of decline, enterprises (a group) in China as no shortage of resources share on

the rate of domestic resources p_i^0 for the geometric series distribution;

$$m_i = m \quad p_i \big|_{D=0} = q(1-q)^{i-1} \qquad (1)$$

In the condition of no shortage of resources, stronger (large) companies have more share on the rate of resources.

Based on the above assumptions, we reference the dynamics model of metapopulation, the following dynamics model of competitive enterprise is proposed under resources market economy:

$$\frac{dp_i}{dt} = c_i p_i (1 - D - \sum_{j=1}^{i} p_j) - m_i p_i - \sum_{j=1}^{i-1} p_i c_j p_j \quad (i=1,2...n) \qquad (2)$$

Equation (2) illustrates the resources under the market economy system, enterprises in different countries (company) are the coexistence of the resources and the natural decline rate for dynamic balance between competitive ability, exploring different between enterprises, and this balance requires less competitive (small) firms with strong resources development ability. The right side sectors of Equation (2) means the enterprise resources on the successful occupation; enterprise nature (internal) rate decline due to the reduction of resource share; reduction rate of resources possession due to competitive factors.

3. The Dynamic Mechanism of Vulnerability Resource Type Enterprises, When D>q

3.1 Mathematical Derivation and Theoretical Analysis

Assuming that the global resources under the market economy system, the net resources shortage ratio in China is D, Chinese enterprise (a group) survival pattern reach a new equilibrium, enterprise occupies the resource ratio of p_i^e ($dp_i/dt=0$), namely the solution of steady state of (3):

$$p_i^e = \begin{cases} \hat{p}_i & if \quad \hat{p}_i > 0 \quad (\hat{p}_i = 1 - D - \frac{m_i}{c_i} - \sum_{j=1}^{i} p_j^e (1 + \frac{c_j}{c_i})) \\ 0 & if \quad \hat{p}_i \le 0 \end{cases} \quad (i=1,2...n) \qquad (3)$$

Obviously, $\hat{P}_i \le 0$ false,

$$D \ge 1 - m_i / c_i = 1 - (1-q)^{2i-1} \qquad (4)$$

When the condition is met, the top i of strong (large) enterprise (company) in the enterprise population will decline.

The formula (4) is the critical constraint relationship between the decline of large enterprises and the shortage ratio of resources and the strongest (large) enterprise occupies the share of resources.

Figure 1 demonstrates the critical decline constraint conditions of D=1- $(1-q)^{2i-1}$, the relationship between the

number of big business enterprise in the decline and resources shortage rate. The graph 5 curves respectively correspond to five kinds of enterprises (companies) situation as q=0.05, 0.1, 0.2, 0.3, 0.4. Wherein, q=0.4 represents the largest enterprise (company) in a certain industry (population) of China have 40% of resources ratio when without shortage of resources. The second companies share of resources $p_2 \big|_{D=0} = 0.4(1-0.4)^{2-1} = 0.24 =24\%=24\%$. Third companies share of resources $p_3 \big|_{D=0} = 0.4(1-0.4)^{3-1} = 0.144 =14.4\%,\dots$ While q=0.05 represents the largest enterprise (company) hold 5% of resources rate in a certain industry (population) of China when without the resources shortage. Second big enterprise resource share is $p_2 \big|_{D=0} = 0.05(1-0.05)^{2-1} = 0.0475 = 4.75\%$. Third enterprise resource share is $p_3 \big|_{D=0} = 0.05(1-0.05)^{3-1} = 4.5\%,\dots$ As you can see from Figure1., the bigger the q, namely stronger the largest enterprise in the enterprise community, lead to less the number of the decline of the enterprise (company) when the shortage of resources, that is weak (small) business are more not easy to decline.
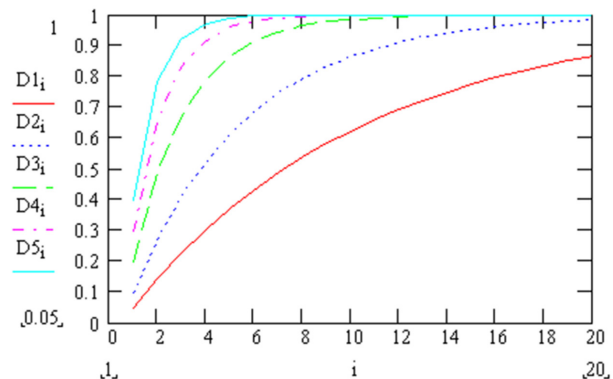

Figure 1. The relationship between enterprise decline and resource shortage rate in the critical decline constraint conditions of D=1-(1-q)$^{2i-1}$, The 5 curves correspond to the q=0.05,0.1,0.2,0.3,0.4, five kinds distribution structure of enterprises

Figure 2 demonstrates the relationship between the number of decline enterprise in community and the strongest (large) enterprise share of resources when in the critical decline constraint conditions of q=1-(1-D)$^{1/(2i-1)}$. The graph 5 curves respectively correspond to the five kinds of resources shortage as D=0.5, 0.4, 0.3, 0.2, 0.1. As you can see from Figure 2: (1) the bigger the q, namely the stronger the largest enterprise in the enterprise community, when the shortage of resources, the less the number of enterprises decline, that is weak (small) firms are less likely to be swallowed up by; (2) The smaller the D, the fewer number of enterprises lead to the decline under global resources market economy.
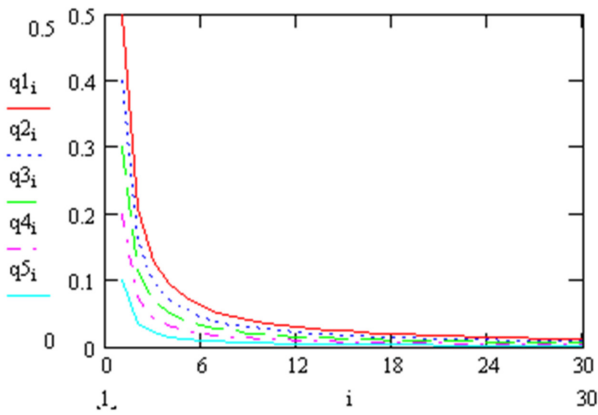
Figure 2. The relationship between the number of enterprise decline and share of resources strongest enterprise, In the critical decline constraint conditions of q=1-(1-D)1/(2i-1). The 5 curves correspond to D=0.5, 0.4, 0.3, 0.2, 0.1 the five cases

Table 1 reveals the relationship between enterprise decline number N and q, with the different resources shortage rate. Table 1 reveals that the strongest (largest) domestic enterprises play a certain protective role on the domestic weak enterprises, under the shortage of resources rate in the global resources market economy. As long as the strongest (large) business does not decline, other enterprises will not be decline because of resource rate shocks (note this theory is only suitable for the case of q<D. The situation of small enterprise first declines will be studied on another paper).

Table 1. The relationship between the number n of enterprise decline and q in shortage rate of resources

	D=0.5	D=0.4	D=0.3	D=0.2	D=0.1
n=1	0.5	0.4	0.3	0.2	0.1
n=2	0.206	0.157	0.112	0.072	0.035
n=3	0.129	0.097	0.069	0.44	0.021
n=4	0.094	0.07	0.05	0.031	0.015
n=5	0.074	0.055	0.039	0.02	0.012
n=6	0.061	0.045	0.032	0.02	0.00953
n=7	0.052	0.039	0.027	0.017	0.00807
n=8	0.045	0.033	0.023	0.015	0.007
n=9	0.04	0.03	0.021	0.013	0.00618
n=10	0.036	0.027	0.019	0.012	0.00554
n=11	0.032	0.024	0.017	0.011	0.0050
n=12	0.03	0.022	0.0145	0.00966	0.00457
n=13	0.027	0.020	0.014	0.00889	0.00421
n=14	0.025	0.019	0.013	0.00823	0.00363
n=15	0.024	0.017	0.012	0.00767	0.00363
n=16	0.022	0.016	0.011	0.00717	0.00339

Table 2 gives the different Q values, the relationship between the shortage of natural resources and enterprise decline number n. Table 2 shows that the maximum enterprise n1 is weak (Q =0.05 small), and smaller shortage

rate of D=q=0.05, it will lead to decay or transform; but n2, n3, n4 resistance is nonlinear increase in turn. When D increases to 6 times, n4 will decline. While q is large, n3, n4...etc. almost will not deteriorate in the condition of the shortage of resources. This means, under these conditions, that the small enterprises "adapt" to the changes of resources and environment actively, and It has the potentiality to develop into new large enterprises (the theory is only suitable for the case of q<D. Small enterprise first decline will be another paper).

It is necessary to point out that, the relevant conclusion shows one-sidedness from Table 1 and Table 2 In the future research, we will reveal that the shortage of resources lead to decline of the small business in enterprise community.

Table 2. When different q values, the relationship between resources shortage rate and enterprise decline number n.

	q=0.05	q=0.1	q=0.2	q=0.3	q=0.4
n=1	**0.05**	**0.1**	**0.2**	**0.3**	**0.4**
n=2	**0.143**	**0.271**	**0.488**	0.657	0.784
n=3	**0.226**	**0.41**	0.672	0.832	0.922
n=4	**0.302**	0.522	0.79	0.918	0.972
n=5	**0.37**	0.613	0.866	0.96	0.99
n=6	**0.431**	0.686	0.914	0.98	0.996
n=7	**0.487**	0.746	0.945	0.99	0.999
n=8	0.537	0.794	0.965	0.995	1
n=9	0.582	0.833	0.977	0.998	1
n=10	0.623	0.865	0.986	0.999	1
n=11	0.659	0.891	0.991	0.999	1
n=12	0.693	0.911	0.994	1	1
n=13	0.723	0.928	0.996	1	1
n=14	0.75	0.942	0.998	1	1
n=15	0.774	0.953	0.998	1	1
n=16	0.796	0.962	0.999	1	1

3.2 Dynamic Simulation

Dynamics simulation of Fig.3 reveals that the domestic Enterprises (enterprise community) have dynamics characteristics in the condition of large enterprises decay (D > q) change: (1) the D=0.3 is much greater than q=0.03, namely the resource shortage rate is relatively larger, the strongest enterprises in the domestic Enterprise Inc (enterprise community) will inevitably decline, transform or even conduct mergers and acquisitions of overseas resources. The relaxation time of the strongest enterprise n1 declining is about 220 -1800 months. (2) With the decline of strongest enterprises, the order to the critical threshold of the enterprises were second, third, fourth, fifth strongest enterprises, when D>q, the strong enterprises of China's will decay before the weak enterprises. (3) on the condition of high rate resources shortage, the survival firms will experience the following stages of development and adaptation: ① forced adaptation

or resistance stage: in the short time period after the shortage of resources (1/m), the share of resources of all enterprises fell sharply. But the weakest companies declined minimally, namely the smallest enterprise in the resource-based enterprises community has the strongest resistance. ② The recovery stage: This is the nonlinear interaction process on a very complex resource type enterprises competition, the concrete manifestation is: Chinese enterprises community within the multi equilibrium coexistence and the strongest enterprises constantly replaced, usually according to the weakest, the second weakest... Order to serve as the strongest enterprises. The recovery phase clearly reveals the local strong enterprises (dominant) are frequently established and alternated. This indicates the resource competition is very fierce; all the surviving enterprise share resource rate changes are periodic in a long period of time. ③ the stable stage: after a long term development, when the system reaches the new equilibrium state, the original top 5 enterprises are orderly decline after the fall, n6, n8, n10 (note not n7!) become the strongest, second strongest and the third strongest enterprises.

We believe that, when the resources shortage ratio D is greater than a certain threshold, the first decline is the most competitive enterprise instead of the weak enterprise that generally thought, the implication behind are as follows: (1) from a perspective of competition mechanism between enterprises within the community, the ability of exploiting resources of strong enterprises is insufficient, and the weak enterprises can survive the condition with resources shortage, because they have strong resources development ability; (2) From the perspective of company stability, the weaker the enterprise to the impact of external resistance, the stronger with its recovery (adaptation) force; on the contrary, the stronger enterprises, the weaker its ability to adapt and recover. Since any strong (large) companies have limited resistance to resource degradation, once the resource changes (shortage) exceeds the limit , the self-adjustment ability will decline rapidly and even disappear, resulting in the strong business decline and transformation. Small businesses have strong recovery ability, so they can quickly adapt to the new situation of resources from resources challenges.

Figure 3(b) clearly shows that Chinese resource-based enterprises community in the recovery stage that excessive state small enterprises played a process of the strongest enterprises from weak to strong by the order (the most dominant species, the strength of possession resources rate are more than the original n1 0.037!) So, Chinese enterprises adaptive development is the revolutionary after the shortage of resources (the cost is the top 5 strong enterprises closed and recession), in the direction of the good (strong). The originally strongest enterprise n1 occupy resources rate of 0.037, while the share of resources rate of n9, n8, n7,

n6 are respectively 0.0543 (0.038/0.7), 0.057 (0.040/0.7), 0.06 (0.042/0.7) and 0.063 (0.044/0.7) in the development process; and are respectively 146.8%, 154.1%, 162.2%, 170.3% correspond to the original maximum enterprise resource possessed rate 0.037. Visibly, the ecological system of Chinese enterprises under the global resources market economy is more centralized and monopolized. It may be enough to cope with the new possible competition for resources, the ability of enterprise community against resources shortage has been greatly improved. From Figure 3 (b) can also see that the minimum n10 under natural resources shortage (under the global resources market economy) in 10 years later, n9 in 18 years, n8 in 30 years, N7 in 35 years, n6 in 70 years, respectively become the strongest enterprise of system process; But the strongest is the n6 survivors of final stable Chinese some industries and enterprises system. The enterprise strength order of new equilibrium state is n6-n8-n10 (even)-n7-n9 (odd); namely, the surviving even enterprise will become strong enterprises, and the survived odd enterprises will become the weak enterprises. This is an important symmetry law of business strength order distribution, the following will further study.
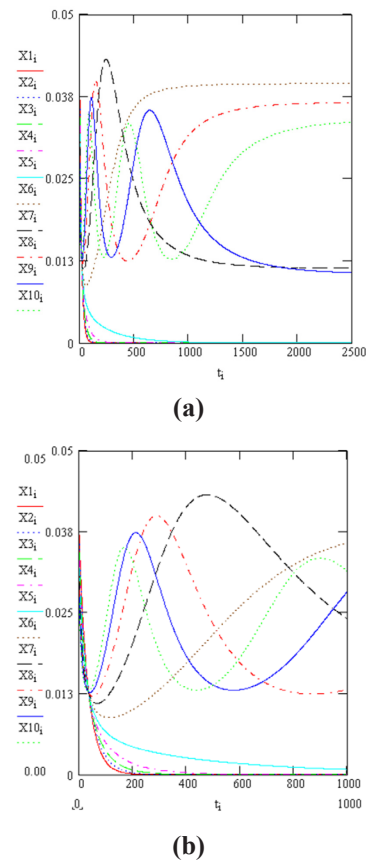

(a)

(b)

Figure 3. The relatively large shortage rate causes the decline of top 5 businesses in a resource-based enterprises community of China. The parameters : D=0.3, q=0.037,

m=0.1, n=10. (a),(b)respectively correspond to different time intervals

The parameters difference in Figure 4 and Figure 3 only lies in the enterprise internal different decay rate. Figure 4 m=0.2, while figure 3 m=0.1. The difference between the simulation results exhibit only shorten to the relaxation time of decay. m=0.1 (Figure 3), the enterprise decline relaxation time is 220 -1800 months, while m=0.2, the enterprise decline relaxation time is 100-900 months. Comparing Figure 4 and Figure 3 we can investigate that the change of m almost does not affect the peak values of the equilibrium state, but only change the peak time. When m is smaller, the emergence of the peak and equilibrium mutation time is longer; when m becomes larger, occurrence of each peak and equilibrium mutation time shorter. m smaller mean enterprise average life cycle increases, resulting in strong corporate succession time growth. While m becomes larger, means that enterprises average life cycle is shorter, resulting in strong enterprises to shorten the time of succession.
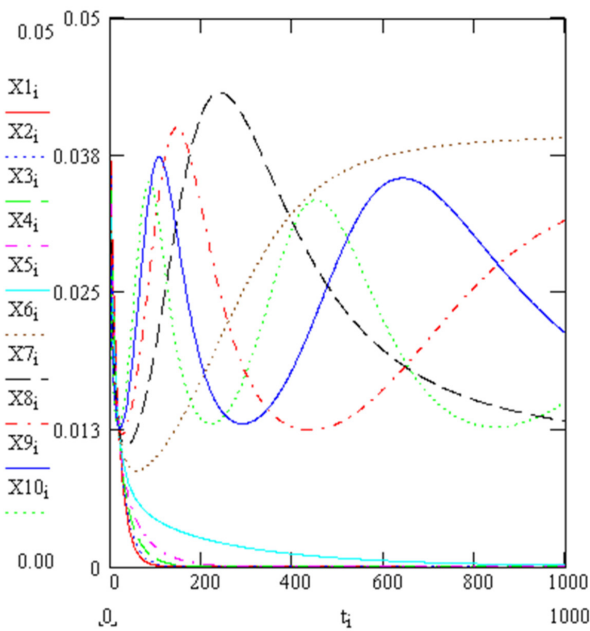

Figure 4. The relatively large shortage rate lead to the decline of top 5 business in a certain industry of China. The parameters: D=0.3, q=0.037, m=0.2, n=10. And the difference with fig.3 (m=0.1) is that shorten the relaxation time of enterprise decline. m=0.1 (Fig.3), 220 -1800 months is enterprise decline relaxation time, m=0.2, enterprise decline relaxation time is 100-900 months

In order to further illustrate the dynamic characteristics and response process of adaptation of enterprise community to the shortage of resources, we are given n=10, D=0.3, and Q respectively 0.1 and 0.15 (corresponding to different industries population structure) of the simulation

results, as shown in figure 5a-b.
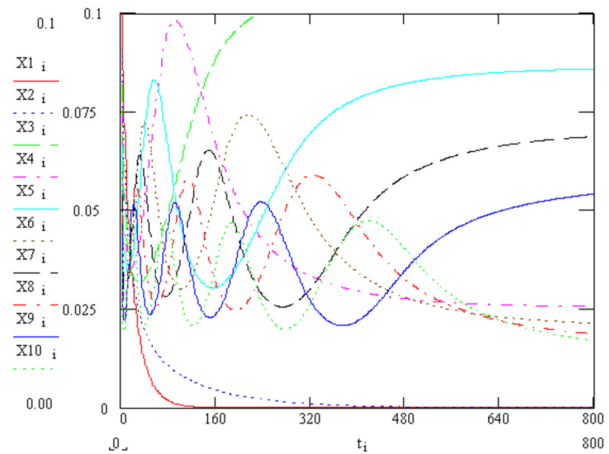
(a)
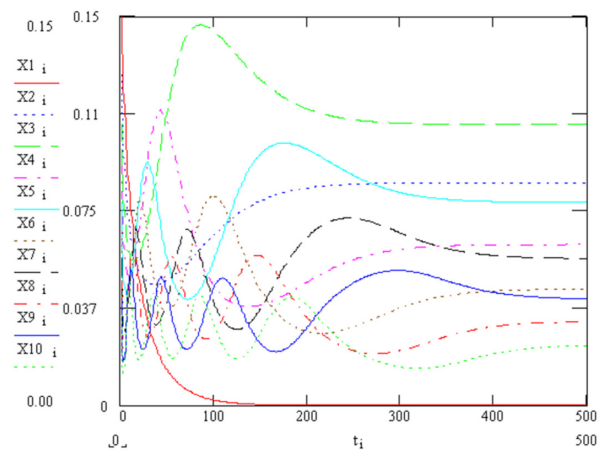
(b)

Figure 5. Response and adaptation process on enterprises for resource shortage. n=10, D=0.3, m=0.02. (a) q=0.1; (b) q=0.15

From figure 5(a-b) and Figure 3 the dates show that: (1) in the premise of D>q, the larger values of D/q, the more the number of the enterprise decline due to the shortage of resources caused by. D/q=0.3/0.037=8 (Figure 3), resource-based enterprises community the top 5 strong enterprises will turn all decay or transformation, and when D/q=0.3/0.15=2 in community only the strongest enterprise N1 decay; (2) After equilibrium coexistence and the strongest enterprises (optimal) continuous replacement process, the ecological system of resource type enterprises achieve new equilibrium state, Chinese (a resource-based industries) enterprises system strength sequence will strictly abide by the even-odd symmetry or odd-even number symmetry laws. It is concluded that if because of the shortage of resources and cause the sys-

tem to have an odd number of enterprise decline, then after the adaptive stability system (a business) enterprise strength order obey the odd-even symmetry laws, namely the original number-even enterprises become strong, while the original number-odd enterprises turn into the weak. If the community has an number even of enterprise decline, then the enterprise strength order after the adaptive stability system obey the odd-even symmetry laws, namely the original number odd enterprises become strong, while the enterprise for original serial number even into a weak. For example, when D/q=0.3/0.1=3, the top 2 enterprises of the system will decline, then the new equilibrium state enterprises strong weak ordering: n3→n5→n7→n9→n4→n6→n8→n10. And when D/q=0.3/0.15=2, the top 1 enterprises of the system will decline, then the enterprises new equilibrium state strong-weak order: n2→n4→n6→n8→n10→n3→n5→n7→n9.

We believe that under the global resources market economy, different resource type enterprise in China can continue to grow and develop based on following rules, grasping the information of industry resources shortage rate and the resources share of the strong enterprises, recognizing the odd-even symmetry or odd-even symmetry rules under the resources market economic system, and understanding the correct position in business activities.

4. Conclusions

We have used mathematical analysis and numerical simulate and systematically studied the enterprise decay dynamics mechanism and constraint relation for different resource-based enterprise communities in different case of shortage of resources. The results show that in the case of D>q (namely, the rate of resources shortage is greater than the strongest enterprise in the enterprise community share resource rate) and D<q (i.e., the rate of resources shortage is less than the most enterprises in the enterprise community on the rate of resources share), community evolution complies with two distinct dynamics mechanism. In the circumstance of D>q, which refer as resource shortage rate is greater than resource share rate of the strongest enterprise in enterprise community, Chinese enterprises evolution under the global resources market economy has the following rules and characteristics:

(1) The dominant species (strong) enterprise n1 will inevitably decline and undergo transformation in the resource-based enterprises community. With the resource shortage rate increased, the weaker enterprises will decline along with the strongest enterprises. The larger value of D/q comes with more decline of strong enterprise in community. The relaxation time order of magnitude which leads to decline or transit buffer is ranging from 5 to 40

years.

(2) When the strongest enterprises n1 is weak in the resource-based enterprises community (q minor), the small disturbance resources (shortage) can cause it to decline and even transform. But the resistance of n2, n3, n4 is increasing nonlinearly in turn. While q is large, n3, n4...... will not decline under the condition of the shortage of resources, which means that the large enterprises in industry system come stronger. When resources shortage appears, the less enterprises decline, and the weak enterprises will not easily decay. This means that small enterprises have become adaptive for the changes of resources environment, which is helpful to further evolve into new large (strong) enterprises at any time.

(3) The surviving enterprises after the resources shortage in the community will experience three stages of evolution: ① The resistance stage: in this stage, the enterprise community (all species) the steeply decline in share resource rate. But the weakest company declined minimally, namely the weakest enterprises in the enterprise community have relatively stronger resistance. ② The recovery stage: This is a complex nonlinear interaction process of many enterprises in various group, except for the n1, all companies in enterprise community have served as the strongest enterprises sequentially according to the weakest, the second weakest... order, showing the frequent establishment and alternation of local area advantage enterprises. China enterprises adaptive evolution is revolutionary evolutions which continuously develop itself in a good way after resources shortage risks. The highly adaptive large enterprises in the community can be more centralized and monopoly sufficient to cope with more potential resources challenges. ③ The stable stage: after multiple equilibria coexist and the strongest enterprises (optimal) continuous replacement process, the enterprise ecological system achieves a new equilibrium state, the system order is strictly abided by the even-odd symmetry or odd-even symmetry law. That is, if because of resources shortage and lead to an odd number of enterprise decline in enterprise community, when it adapted to stability, the community enterprise strength order is following odd-even symmetry rules, namely the enterprises that original serial number for even number will evolve into the strong, and that the original serial number for odd number will evolve into the weak. If there is an even number of enterprises decline in the community, when it becomes stable, the order will obey the odd-even symmetry rules, namely the original odd number of enterprises become strong, and that the original even number evolve into the weak enterprise.

(4) The change of enterprise decline rate m almost does

not affect the peak value of each equilibrium state of enterprise community; it only changes the peak time. When m comes smaller, the time of the peak emergence and equilibrium mutation become longer; and vice versa.

(5) Whether the declining reason is caused by q or D changes, the dynamic mechanism are the same for large enterprises, the dynamics of changes of q and D is equivalent.

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Conflicts of Interest

The authors declare no competing financial interests.

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