Research on Construction and Stability of Green Building Industrial Chain Based on Symbiosis Theory

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ABSTRACT: Green Building has shown great advantage in promoting the economic efficiency. However, it also has exposed some problems in the developing process, among which the matter of Industrial Chain stability is the vital one. This article, employing with the theory of biocenosis and differential stability, analyses the composition of the Green Building Industrial Chain (GBIC) Symbiosis System, divides the types of firm symbiosis on the basis of study on Eco-industrial chain. Through the Logistic model, the enterprises growth is described under different symbiosis relationship and analyzed the stability.

KEYWORD: green building industrial chain (GBIC); symbiosis system; stability analysis; logistic model.

1 INTRODUCTION

After the industrial civilization, human activities drastically impact on the ecological system. The destruction of the natural environment in the field of construction industry is the most powerful, under this background, Ecological Architecture emerges as the times require. With the development of economy the traditional industrial mode no longer meets the development requirements and needs to upgrad. Therefore, it is necessary to build an industrial chain suitable for eco-architecture. In this paper, we use the symbiosis theory of biology to build the GBIC and analyze its stability.

2 SYMBIOTIC SYSTEM

Symbiotic Units are the smallest unit of symbiotic system, which are connected to each other by means of the exchange of energy (Ahmdajina V, 1986). All the service subjects related to the production of green building products are taken as symbiotic units according to the theory of biological symbiosis, so we define them as Upstream-Midstream-Downstream industry, which is shown in Fig.1.

Fig.1 symbiotic units of GBIC

Fig.2 Three elements of Symbiotic System

Symbiosis mode refers to the way of interaction between symbiotic units (Chunqing YUAN). Given the characteristics of GBIC and the co-competition between enterprises, symbiotic mode is grouped as Table 1 according to the pattern of behavior (Delian FENG, 2001).

Table1 Comparative analysis of symbiotic relationship

Symbiotic relationship	Symbiotic characteristics	Developing ways	Symbiosis Efficiency
Independent symbiosis	unaffected party-unaffected party	independence-independence	lowest
Parasitic symbiosis	beneficial party-injured party	beneficial party-dependence injured party-independence	low
Commensalism symbiosis	beneficial party-unaffected party	independence-independence	lower
Asymmetrical mutualism symbiosis	beneficial party-beneficial party (asymmetrical)	independence-dependence	higher
Symmetry mutualism symbiosis	beneficial party-beneficial party (symmetric)	independence-independence dependence-dependence	highest

Symbiotic Environment is the sum of all the factors except symbiotic unit (Ye XIAO, 2015). The specific symbiotic environment in GBIC includes: natural environment, social environment, economic environment etc. According to the different effect of symbiotic environment, it can be divided into Ea, En, Ep, which is shown in Fig.2. The model of GBIC symbiotic system is built through the integration of the symbiotic elements above, which appears in Fig.3. The double-headed arrow in the figure indicates the two-way transmission of material, knowledge, information and capital between the parties in the symbiotic system.

Fig.3 The model of green building industry chain symbiotic system

3 STABILITY ANALYSIS ON THE SYMBIOTIC SYSTEM OF GBIC

Logistic model is a common model used to analyze the law of population growth (Xiaoxia LIAO, 2012). The GBIC symbiotic system aims at building the relationship in material and energy flow between industries, which is similar to the logistic model. Therefore, it is reasonable to draw lessons from this model. For convenience, the economic, social and environmental benefits of GBIC symbiotic enterprises are simplified as eco-efficiency, symbols are described as follows:

x_i represents the ecological benefits of enterprises, x is a function of time t . N_i represents the maximum ecological benefit of enterprises can be achieved. r_i represents fixed benefit growth rate of enterprises. k_{ij} represents the positive or negative effects of enterprises affected by competition. σ_i represents the positive or negative effects of enterprises affected by cooperation. Each individual has one unit of biomass increase by using biomass $1/N$, x units of biomass are increased by using biomass x/N , the remaining quantity available is $(1-x/N)$. Thus, equations are established by means of differential methods:

$$\frac{dx_i}{dt} = r_i x_i \left(1 - \frac{x_i}{N_i} - \sum_{j \neq i} k_{ij} x_j + \sum \sigma_i \frac{x_j}{N_j} \right) \quad (1)$$

For simplicity, the symbiotic relationship between two companies is only considered, we may set to E1 and E2, and multiple enterprise is applicable.

(1) Independent Symbiosis

According to the characteristics of independent symbiosis, let $k_{ij}=0, \sigma_i=0$ in formula (1):

$$\begin{cases} \frac{dx_1}{dt} = r_1 x_1 \left(1 - \frac{x_1}{N_1} \right) \\ \frac{dx_2}{dt} = r_2 x_2 \left(1 - \frac{x_2}{N_2} \right) \end{cases} \quad (2)$$

According to method for judging stability of balance point (Hritonenko N, 1999), (N_1, N_2) is a stable point, which means emerging industries prone to independent symbiosis in the early stage. For example, construction waste recycling industry is in the initial stage of development at present, enterprises cannot carry out intensive trading activities, the industry is bound to demise with the phenomenon of “self-supporting” in enterprises. Therefore, the government departments should support it actively.

(2) Parasitic Symbiosis

Assuming E1 as a parasitic, E2 as the host. The growth level of both sides is not only affected by the impact of their own block, but also affected by the development of the other side. Expressed as:

$$\begin{cases} \frac{dx_1}{dt} = r_1 x_1 \left(-1 - \frac{x_1}{N_1} + \sigma_1 \frac{x_2}{N_2} \right) \\ \frac{dx_2}{dt} = r_2 x_2 \left(1 - \frac{x_2}{N_2} - \sigma_2 \frac{x_1}{N_1} \right) \end{cases} \quad (3)$$

Equilibrium

points: $P_1 (N_1, 0), P_2 ([N_1(1+\theta_1)]/(1+\theta_1), [N_2(\theta_2+1)]/(1+\theta_1))$, θ_i represent the variance of ecological benefits. P_1 is a stable point when $\theta_2 < 1$, which means E1 relies on E2 to acquire resources and E2 falls into a decline with the discontented requirement from E1 eventually, the dependence or damage degree of E2 to E1 has a great impact on the stability. P_2 is also a stable point when $\theta_1 > 1$, which means both sides can develop independently but are less developed than their respective independent development. In GBIC, there is a parasitic relationship between enterprises causing construction waste and environmental pollution and the government, the capacity of information and technology sharing should be strengthened to realize mutual symbiosis.

(3) Commensalism Symbiosis

Assuming the benefit side as E2, E2 has a positive effect on E1, expressed as:

$$\begin{cases} \frac{dx_1}{dt} = r_1 x_1 \left(1 - \frac{x_1}{N_1}\right) \\ \frac{dx_2}{dt} = r_2 x_2 \left(1 - \frac{x_2}{N_2} + \frac{\sigma_2 x_1}{N_1}\right) \end{cases} \quad (4)$$

Equilibrium point: $(N_1, (1+\sigma_2)N_2)$, it is a stable point when $\sigma_2 > 0$, which means E1 can eliminate the blocking effect through symbiosis, E2 can expand their own advantages beyond the limits with the help of E1. There could be a commensalism symbiosis relationship between enterprises causing construction waste and the government. Enterprises rely on the support of the government to expand, and the government in the state of non-income need to build the symbiotic relationship with enterprises for eliminating blocking effects affected by environmental protection.

(4) Symmetry Mutualism Symbiosis

When both sides grow up independently, formula (1) is expressed as:

$$\begin{cases} \frac{dx_1}{dt} = r_1 x_1 \left(1 - \frac{x_1}{N_1} + \frac{\sigma_1 x_2}{N_2}\right) \\ \frac{dx_2}{dt} = r_2 x_2 \left(1 - \frac{x_2}{N_2} + \frac{\sigma_2 x_1}{N_1}\right) \end{cases} \quad (5)$$

Equilibrium

point: $([N_1(1+\theta_1)]/(1-\theta_1\theta_2), [N_2(\theta_2+1)]/(1-\theta_1\theta_2))$, it is a stable point when $\sigma_1\sigma_2 < 1$, it shows that the cooperative utility of both sides is relatively small, but a relatively stable state of symbiosis is achieved for close cooperation and a good division of labor, as well as resource sharing. Moreover, $(1+\theta_1)/(1-\theta_1\theta_2) > 1, [N_1(1+\theta_1)]/(1-\theta_1\theta_2) > N_1$, it means that the ecological benefits achieves the effect of “1+1>2” and symmetry mutualism symbiosis model is turned out to be the most ideal symbiotic cooperation model, the cooperation between enterprises in GBIC should be as far as possible towards this symbiotic model to achieve the maximization of eco-efficiency.

Asymmetrical Mutualism Symbiosis

Assuming that E1 develops independently, E2 develops dependently, formula (1) is expressed as:

$$\begin{cases} \frac{dx_1}{dt} = r_1 x_1 \left(1 - \frac{x_1}{N_1} + \frac{\sigma_1 x_2}{N_2}\right) \\ \frac{dx_2}{dt} = r_2 x_2 \left(-1 - \frac{x_2}{N_2} + \frac{\sigma_2 x_1}{N_1}\right) \end{cases} \quad (6)$$

Equilibrium

point: $P_1(N_1, 0), P_2([N_1(1-\theta_1)]/(1-\theta_1\theta_2), [N_2(\theta_2-1)]/(1-\theta_1\theta_2))$, For P_1 , it is a stable point when $\theta_2 < 1$, it means that E1 has a small positive cooperative effect on E2, and resource demand of E2 is not satisfied, finally E1 will be replaced by E2. For P_2 , it is a stable point when $\theta_2 > 1$, which has a opposite situation with P_1 . Applied in the GBIC, the government can not only provide technical and policy support to the construction enterprises, but also can set up a fine for supervision. Enterprises could achieve the rational allocation of resources through cooperation and profits is relatively large, which puts more pressure on the government, i.e. non symmetric evolutionary.

4 CONCLUSIONS

Based on the Eco-industrial chain symbiosis system, the GBIC symbiotic system evolution model is built through Logistic model with the factors of competition and cooperation. By analyzing the symbiotic relationship that may exist, it is found that the industrial chain is able to achieve the maximum eco-efficiency in the case of symmetry mutualism symbiosis model and independent growth. Moreover, the model remains to be further improved, which is only considered the simplest one for all kinds of symbiotic relationship model, and the actual industrial chain relationship is complex, further discussion is needed in the future.

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