Chapter 145
The Evolution Process of Agri-Products Supply Chain System of "Company & Farmer"

Jiemei Li, Youjin Gu and Hao Wu

Abstract In order to study the evolution process of agri-products supply chain system of "company & farmer", a self-organization dynamic model is established on the basis of block growth model. Then the research analyzes the stability of the model and simulates the evolutionary process. The results show that cooperative and competitive effects have a close relationship with the system evolution directions. The system can be optimized by magnifying the cooperative effects. The farmer, as the initial smaller side in the system, will be going to die when the cooperative effect is negative. So in order to protect the farmers' interests, it is necessary for the government to encourage the organization of the farmers to amplify their scale.

Keywords "Company & Farmer" · Agri-products Supply Chain · Evolution · Simulation

145.1 Introduction

Agricultural industrialization is an important way to increase farmer's income and guide the transformation of agricultural growth mode [1] in China. During the period of the eleventh five-year-planning, various types of agricultural industrialization

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organizations in China came up to 250,000 and the farmer professional cooperatives reached to 370,000, the number of farmers driven by agricultural industrialization arrived 10.7 million [2]. At present the "company & farmer" is a popular industrialization mode in China. It has strong intrinsic rationality—it can effectively solve the problem of internal diseconomy of scale brought by the small farmers.

However in the practice of agriculture industrialization, the cooperative relationship between companies and farmers is extremely unstable. The breaching of contract phenomenon between farmers and companies is serious. Facing the plight of the farmers' interest losses, companies' operating risk increases, economies of scale forms difficultly.

Many scholars investigated the issues on the cooperation between company and farmer from different angles, such as the behavior choice of the company and farmer in participating in contract farming, and the measures of improving cooperation stability etc. However most of the existing researches only analyzed the superficial phenomenon of the problem. The research on the immanent evolution mechanism of "company & farmer" system hidden behind the phenomenon of interactive and disjointed relationship between company and farmer is lacked.

Since Prigogine put forward the Theory of Dissipative Structure and Haken founded Synergetic in 1970s, self-organization and synergetic theory has been widely applied in management science and system science [3]. Self-organization theory provides a new research angle for the analysis of the formation and evolution mechanism of "company & farmer" agricultural industrialization system. As a complex open system, "company & farmer" system is a typical dissipative system. Its development and evolution accord with the law of self-organization.

This paper attempts to establish a self-organization evolution model based on the analysis of the system self-organization evolution mechanism. It reveals the formation and evolution process and mechanism of the "company & farmer" system. It provides scientific basis of decision-making both for company and farmers.

145.2 The Self-Organization Evolution Mechanism of "Company & Farmer" System

Cooperation and competition is the natural attributes of "company & farmer" system. Their interactions are the dynamic sources of self-organization evolution of the system. The degree of the interactions determines the order and stability of the system [4]. The cooperation arising mainly from longitudinal relevance between the company and farmers based on different value creation segment. Mainly displays in two aspects: on the one hand, enterprises rely on alliance farmers to provide the primary products or raw materials, needn't to rent land and establish farms themselves. This can not only form a stable source of raw materials, but also save a lot of capital and cost. The company can focus on product development and

technological innovation, and then gain more profit. On the other hand alliance farmers rely on dragon-head enterprise to sale their primary products. The farmers not only have a stable market, but also have access to technical services, and can share the processing value-added profit of the agricultural products.

Competition effects are mainly derived from the development difference of the main body in the system. This kind of difference is mainly derived from two aspects: one is from the asymmetry distribution of the cooperative income, the other is from the development difference of main body in the system, such as comprehensive strength, brand reputation, learning ability and adaptability. The company is relatively large in scale, strong in economic strength and strong in information collection and application ability. So it often holds the interest distribution initiative. While the farmers are often minor in production scale, weak and dispersive in strength and lack of organization on their behalf. As an independent market main body, both the company and the farmers pursue the maximizing of their own interests. Under the environment of incomplete and asymmetric information, it has the possibility for both sides to breach the contract because of the driving of opportunistic. When the market price is higher than the contract price, the farmers have the strong motivation to sale their products to market. Conversely, when the market price is lower than the contract price, the company is inclined to buy agricultural products from the market.

In the cooperation and competition system of company and farmer, the main function of cooperation is to make interdependence between company and farmers, and change the extent of interdependence through the feedback of cooperation benefit distribution. The main role of competition is to bring the pressure of survival and development for the company and farmers. This kind of pressure can not only promote the collaborative development for the company and the farmers on the basis of different value creating segment, but also make intense contention for the income distribution between company and farmers.

145.3 Self-Organization Model of the System

In order to quantitative analysis the cooperation and competition influence on the scale development of the company and farmer and for researching the evolution process of the system, a evolution model is established on the basis of block growth model.

Block growth model (Logistic model): $\frac{dx}{dt} = rx(1 - \frac{x}{km})$, $x(0) = x0$, is put forward by Verhulst—a Holland biologist, based on the research on the population growth change law in the middle of the nineteenth Century. In the equation r represents the inherent growth rate of population; the factor rx reflects the population growth trend itself. Because of the block effect on the population growth from natural resources, environment etc., and the growth rate will drop after population growth to a certain number. And with the increase of population,

the block effect becomes more and more large. *km* represents the largest population that the natural resources and environmental conditions can accommodate, called population capacity. The factor $\left(1-\frac{x}{km}\right)$ reflects the block effects on population growth because of the limited resources. Block growth model can not only describe the population and many species variation law, but also has a wide range of applications in social economic fields [5].

The scale of company and farmer on the one hand expands constantly because of the inherent growth rate, on the other hand the growth rate slows down because of the constraints of resources and environment. And finally tends to a steady value. In addition, the company and the farmer can break their own maximum size limits and reach a higher state due to the cooperation. At the same time, the growth of both the scale are blocked as the mutual competition between company and farmer.

It selects the scale of company and the scale of farmer as the order parameters to describe the evolution process of "company & farmer" system.

Hypothesis:

(1) The growth rate of the company scale and farmer scale remains constant in a particular stage of development;
(2) Both the company scale and the farmer scale are continuous, differentiable function of time;
(3) The increase of the company scale and the farmer scale accords with logistic growth regularity;
(4) There are only a company and a farmer in the system.

The system evolution model is as follows:

$$\begin{cases} \dfrac{dx1}{dt} = z1\left(1-\dfrac{x1}{k1}-b12\dfrac{x2}{k2}+a12\dfrac{x2}{k2}\right)x1 \\ \dfrac{dx2}{dt} = z2\left(1-\dfrac{x2}{k2}-b21\dfrac{x1}{k1}+a21\dfrac{x1}{k1}\right)x2\ . \end{cases} \tag{145.1}$$

In Eq. (145.1):

$x1, x2$ The scale of company and the scale of farmers at t moment;
$z1, z2$ Constant growth rate of company and farmer which is able to achieved by relying only on their own ability;
$k1, k2$ The largest scale of company and farmer which can be formed under the restriction of the scarcity of economic resources;
$b12, b21$ Competitive effect coefficient, represents the impact on the company from farmer's competition and the impact on the farmer from the company's competition respectively;
$a12, a21$ Cooperative effect coefficient, represents the impact on the company from farmer's cooperation and the impact on the farmer from the company's cooperation respectively;

Factor $\left(1-\frac{x1}{k1}\right)$ and $\left(1-\frac{x2}{k2}\right)$ reflect block growth action on company and farmer respectively caused by the consumption of limited resource. *bij* and *aij* are competitive effect coefficient and the cooperative effect coefficient respectively, they indicate the effects on development scale of both sides caused by the cooperation and competition between company and farmer. It reflects the internal nonlinear interactions.

145.4 Model Simulations

According to Eq. (145.1), a system dynamics model is established by using the VensimPLE software (as shown in Fig. 145.1) [6].

The system evolution process will be simulated under the conditions of different parameters [7]. The initial values of parameters are as follows: $X_{10} = 3$, $X_{20} = 1$, $k_1 = 5$, $k_2 = 5$.

(1) There are both cooperation and competition between company and farmer at the same time, and the positive effect caused by cooperation is greater than the negative effect caused by competition. The growth rate which can be achieved by their own core competencies is same. Make $z_1 = 0.06$, $z_2 = 0.06$, $a_{12} = 0.8$, $b_{12} = 0.5$, $a_{21} = 0.8$, $b_{21} = 0.5$. The simulation results are shown in Figs. 145.2 and 145.3.

The results show when the benefits of cooperation outweigh the benefits of competition, both company scale and farmer scale exceed the maximum size which is attained only relying on their own ability under the limit of scarce resources.

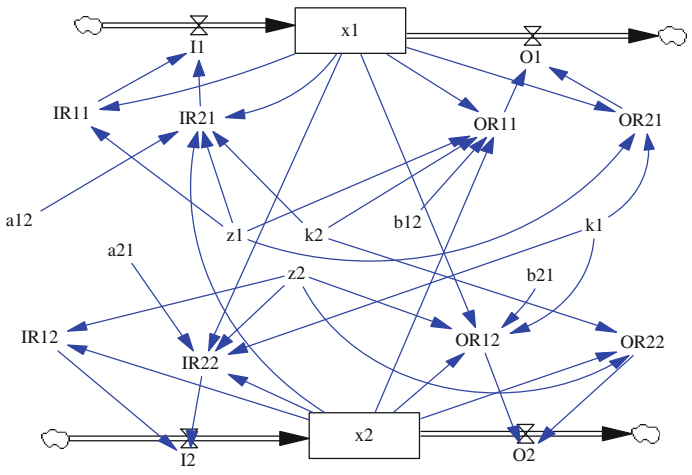

Fig. 145.1 "Company + farmer" cooperation and competition system dynamics model

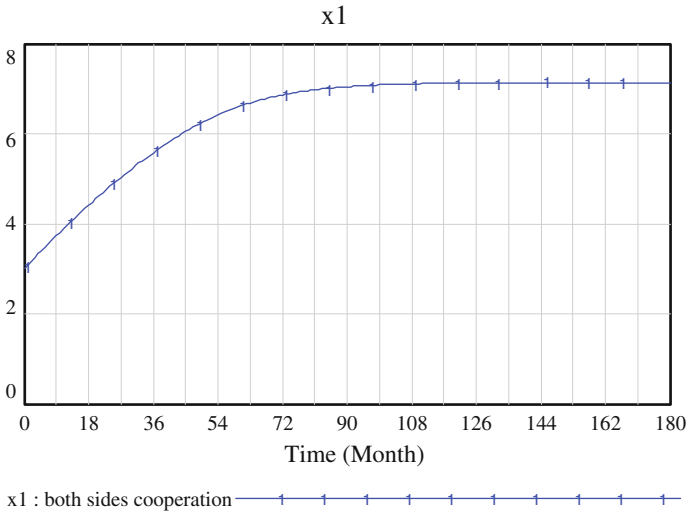

Fig. 145.2 The scale evolution process of company under effective cooperation

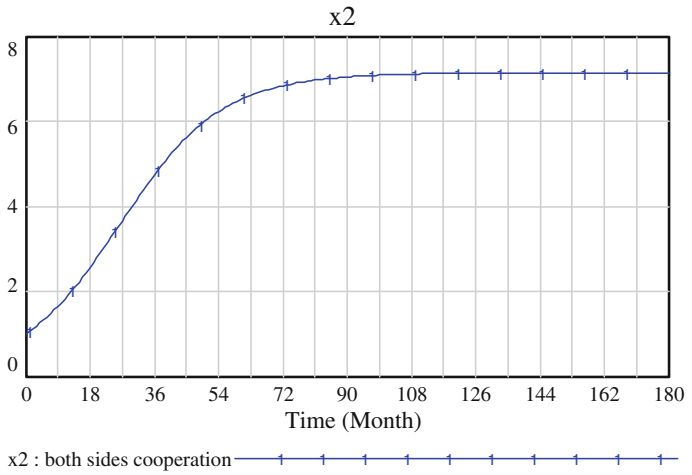

Fig. 145.3 The scale evolution process of farmer under effective cooperation

When the initial scale of the company and farmer is changed, make $X_{10} = 3$, $X_{20} = 0.5$, and other conditions keep the same, the system simulation results are not changed. This illustrates that the final running results of the system have no relationship with the initial size of company and farmer, and it is only related to the cooperative and competitive state between company and farmer.

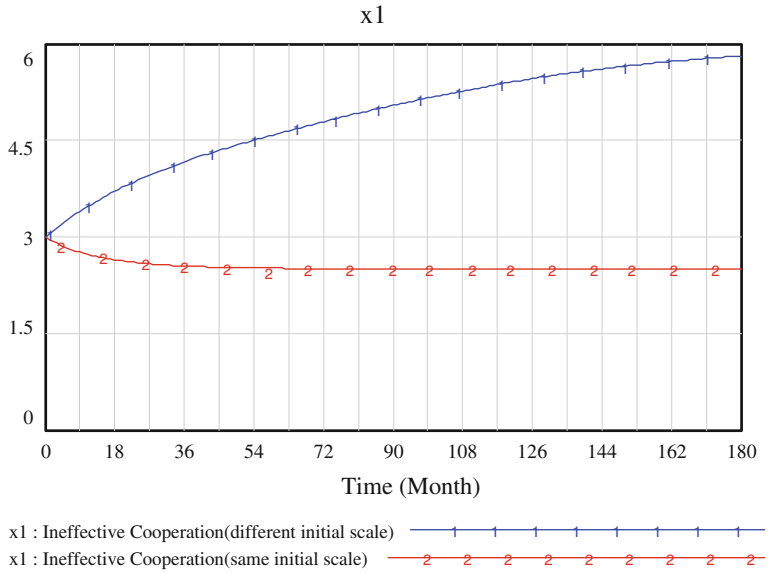

Fig. 145.4 The scale evolution process of company under ineffective cooperation

(2) When competition and cooperation exist between company and farmer at the same time, but cooperation brings negative effect, make $z_1 = 0.06$, $z_2 = 0.06$, $a_{12} = -0.8$, $b_{12} = 0.5$, $a_{21} = -0.8$, $b_{21} = 0.5$. Compare the two cases: the company and the farmer have the same initial size($X_{10} = 3$, $X_{20} = 3$); and the two parties have different initial size ($X_{10} = 3$, $X_{20} = 1$).The simulation results are shown in Figs. 145.4 and 145.5.

The results show that the initial size larger side can reach a maximum size, but the initial smaller side goes to die when the cooperation between the two sides brings negative effect and competition is intense. That is, the "company & farmer" system will break up when both the company and the farmer break a contract and there is a great discrepancy between the initial size of the two sides.

When the initial size of the two sides is identical, the operational efficiency is low and the final scale is smaller than the initial scale due to the negative effects of competition, but both sides can survive.

(3) There are competition and cooperation between company and farmer at the same time, but only one side is cooperative, and the cooperation effect from the other side is negative, make $z_1 = 0.06$, $z_2 = 0.06$, $a_{12} = -0.8$, $b_{12} = 0.5$, $a_{21} = 0.8$, $b_{21} = 0.5$ (farmer breaks contract and company is cooperative); *and* $z_1 = 0.06$, $z_2 = 0.06$, $a_{12} = -0.8$, $b_{12} = 0.5$, $a_{21} = 0.1$, $b_{21} = 0.5$ (farmer breaks contract and company is inefficient cooperative). The simulation results are shown in Figs. 145.6 and 145.7.

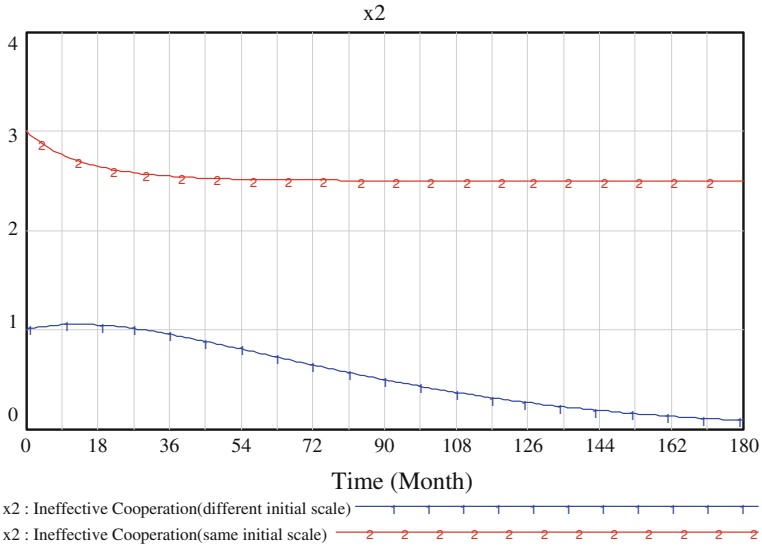

Fig. 145.5 The scale evolution process of farmer under ineffective cooperation

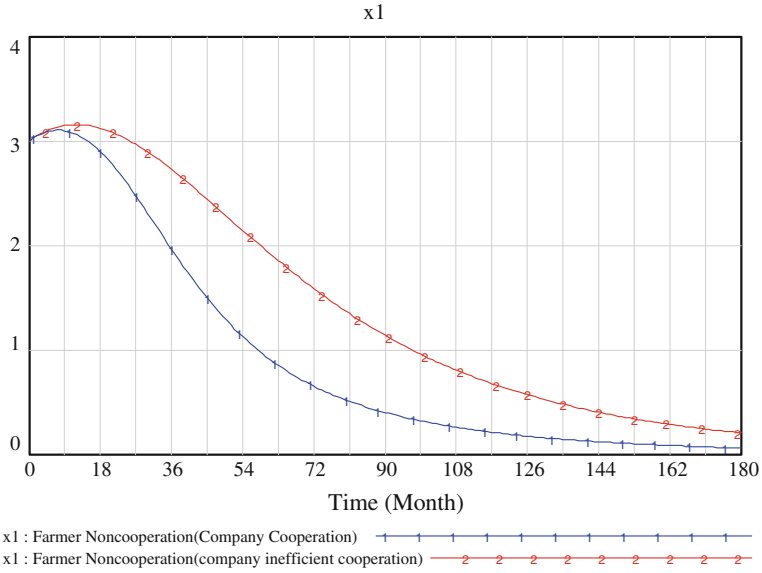

Fig. 145.6 The scale evolution process of company under farmer break contract

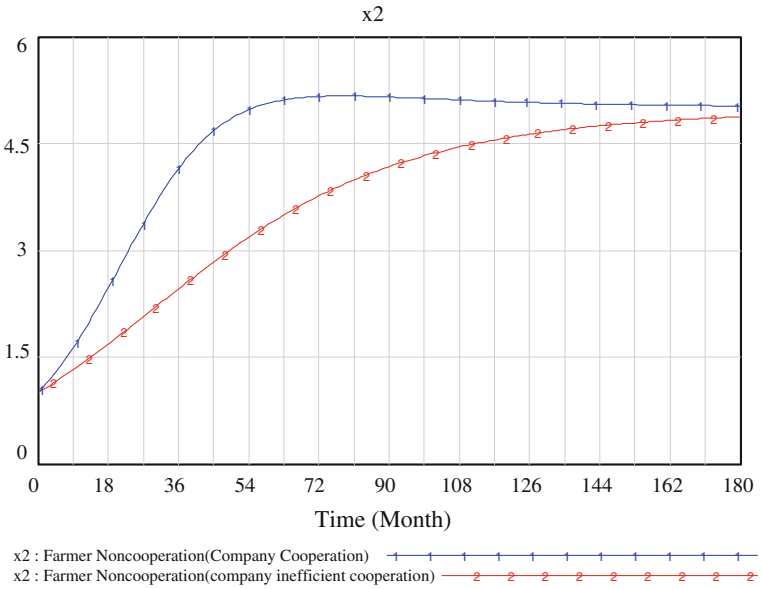

Fig. 145.7 The scale evolution process of farmer under farmer break contract

The results show that the company will go to die if the company continues to cooperate when the farmer breaks the contract. While the farmer will reach a certain scale, but can not achieve the optimal state. If the company takes negative cooperation ($a_{21} = 0.1$), the system would be in a more inefficiency state.

At the case of company breaches the contract and farmer is cooperative, make $z_1 = 0.06$, $z_2 = 0.06$, $a_{12} = 0.8$, $b_{12} = 0.5$, $a_{21} = -0.8$, $b_{21} = 0.5$, the system simulation results are similar: the farmer is eventually die.

This shows that as long as one side of company and farmer break the contract, the other party will go to die. And the breach side itself also can't achieve the optimal operational results. This causes destruction to both sides.

145.5 Conclusion

This paper establishes a system evolution model about cooperation and competition between company and farmer on the basis of analyzing the evolution dynamic mechanism of "company + farmer" system. It analyzes the stability of the model and simulates the evolutionary process. The following conclusions are obtained by simulation:

(1) The evolution results of the "company & farmer" system are closely related to the cooperation and competition effect. It's useful to amplify the cooperation

effect in the system, making the beneficial operation mode the leading role, and thus guide the system to the correct direction of evolution.

(2) Actively promote the organization of the farmers to expand the scale of agricultural production. In order to avoid the inherent defect of scale asymmetry of "company & household" mode, it's necessary to build new agricultural industrialization mode, such as "company + cooperation organization (the intermediary) + farmer" etc.

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