

Research on Corporate Social Responsibility of Supply Chain System Based on the Self-organization Theory

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Abstract: In this study, the characteristics of supply chain system are analyzed based on the Self-organization theory from the angle of view of supply chain system. The mathematical models when the system fulfilling social responsibility including self-organization evolution model and self-organization function model are developed to discuss the formation and function of self-organization in supply chain system and coordination. Some basic conditions and tactics about self-organization establishment and good function in fulfilling social responsibility are put forward in order to promote the system's social responsibility performance.

Keywords: Corporate social responsibility, dissipative structure, self-organization evolution, self-organization function, supply chain system

INTRODUCTION

We are puzzled by Chinese enterprises do not actively fulfill social responsibility even trample upon it. Repeatedly occurring affairs lose ethics, endanger the society and people health. The government, society and consumers' sanctions and supervisions do not forming the driving force for the enterprises to fulfill social responsibility. We have to rethink the reasons why the enterprises challenge the bottom line of ethics and harm the interests of the masses under the background of Chinese improving legal environment, close government supervision and public opinion tremendous force. It is easy to recognize more enterprises act independently but not link with their supply chain when fulfilling social responsibility. They are often suffered by other enterprise's bad behaviors. So we should consider how to form a supply chain system which works well in fulfilling social responsibility.

The self-organization is the macroscopic and ordered phenomenon which is spontaneously formed in nature and the society. In 20th century, Prigogine and Allen (1982) built dissipative structure theory and gave a birth to the research of self-organization theory. In 1970s, the creation of Haken's synergy science theory (Hermann, 1988), Eigen. Manfred's hypercycle theory, Rene Thom's, catastrophe theory and chaos theory represent the remarkable achievements on recognizing world's scientific thinking. The self-organization emphasizes on how the system evolve

from chaos to order, from simple to complex and focuses on the conditions, mechanisms and rules of the formation of stable and order structure (Xu *et al.*, 2011; Gao, 2009). The theory consider the opening is the prerequisite, the non-linear is the essential basis, far-from-equilibrium is the necessary requirement of the generation of self-organization and the fluctuation is the important opportunity of adjusting the self-organization behavior (Faisal, 2010). If the system matches the above characteristics, it can enter into the self-organization situation with the induction of fluctuation, that is, under certain conditions, the system how to evolve from disorder to order automatically and from lower order to higher order (Wei and Yue, 2010). The formation of self-organization is helpful to reach the order situation in time, space and function when the supply chain enterprises to fulfill social responsibility, avoid not fulfilling social responsibility or fulfilling disorderly (Smith, 2010; Salam, 2009).

Therefore, it is important that create certain conditions to form self-organization in supply chain system and it is beneficial for its enterprises to well fulfill social responsibility (Risso, 2012; Chi, 2011). The study will analyze the self-organization characteristics of supply chain system and discuss the system's self-organization evolution using system dynamics approach. Meanwhile, further study how the system's self-organization works well and then propose some basic conditions and tactics about self-organization establishment and good function in fulfilling social responsibility. All of these provide

certain theoretical guide and practical help for supply chain enterprises in fulfilling social responsibility.

The study define the supply chain system consists of three node enterprises, that is supplier, manufacturer and seller and name the supply chain system as the SCS.

THE SELF-ORGANIZATION CHARACTERISTICS OF THE SCS

There are some self-organization characteristics in the SCS.

The opening of the SCS: The system exchange materials, energies and information with external environment. The external environment, including social environment and natural environment, expect the enterprise fulfill the environmental responsibility actively and the enterprise also treat it as their operating goals. This is an interactive process.

The far-from-equilibrium of the SCS: Through the exchange with external environment, the interior of system presents the characteristics of far from even and single. It is an active state which have certain regularity and good circulation state. The system reaches non-equilibrium through two kinds input of entropy: system positive entropy change (dS_i) and system negative entropy change (dS_e). The processes of operation and management are to make system total entropy change (dS) be less than zero. That is, $dS = dS_i + dS_e < 0$. The introduction of negative entropy can make the system be far from equilibrium and develop towards non-equilibrium, meanwhile, adjust by itself and strengthen self-organization abilities (Xu *et al.*, 2011).

The non-linear of the SCS: The relationship among the sub-systems is not a simple cause-effect or superposition relationship, but a kind of complex co-relationship. In the system, the function of every factor and sub-system is not even and symmetric. The change of every factor and sub-system can cause the change of other factors or sub-systems and influence the whole system's development and change. The research results of self-organization show that the interaction of inside system and outside system are both non-linear.

The fluctuation of the SCS: The fluctuation is the deviation from the system's stable and average state. It can destroy the system's stability and build the new stability. According to the research of synergetic, there are no random fluctuations in the enterprise system, there is no enterprise development. The existing differences among systematic factors or sub-systems lead to the deviation and form the fluctuation. The favorable fluctuation can cause the other factors or sub-systems' responses and relatedness effect, magnify it to huge fluctuation. Thus, the system form a more stable and order situation.

As analyzed above, the SCS have the characteristics of self-organization. So the system can achieve the self-organization evolution and could achieve a high level order situation in fulfilling social responsibility.

The self-organization evolution model establishment of the SCS:

Basic model: The SCS consists of five sub-systems, which are material flow (A), capital flow (B), information flow (C), market flow (D) and management flow (E) and every node enterprise cannot operate without them. When the SCS fulfilling social responsibility, the self-organization equation of motion can be used to describe the sub-systems' situation change and their interaction:

$$\begin{cases} dA / dt = -a_1A + b_1(B, C, D, E) + F(t) \\ dB / dt = -a_2B + b_2(A, C, D, E) + F(t) \\ dC / dt = -a_3C + b_3(B, A, D, E) + F(t) \\ dD / dt = -a_4A + b_4(B, C, A, E) + F(t) \\ dE / dt = -a_5A + b_5(B, C, D, A) + F(t) \end{cases} \quad (1)$$

where,

a_1, a_2, a_3, a_4, a_5 : The change rate of A, B, C, D, E respectively

b_1, b_2, b_3, b_4, b_5 : The degree which the interaction among every sub-system influence the change rate of A, B, C, D, E respectively

F_t : The random fluctuation

t : Time (Huang and He, 2010)

When the SCS move from disorder to order automatically and from lower order to higher order, the system's order parameters play decisive roles. So the research of the self-organization evolution of the SCS when fulfilling social responsibility does not need consider all variables. The profitability and coordination are the most important order parameters which influence the self-organization evolution. Analyzing their evolution regular can seize the SCS's evolution regular.

The SCS self-organization evolution model when fulfilling social responsibility:

The Langevin equation bellow can be used to describe the SCS self-organization evolution in fulfilling social responsibility:

$$dq_i / dt = -y_i q_i + G_i(q_i) + F_i(t) \quad (2)$$

where,

q_i = The situation variable to express the sub-systems' correlation and coordination

y_i = The damping coefficient

G_i = The coordination function

$F_i(t)$ = The random fluctuation

Equation (2) shows existing coordination among every sub-system in the SCS. The existence of $F_1(t)$ shows a small random fluctuation at critical point can make the SCS produce structural change, then form the more stable new structure and show self-organization (Faisal, 2010).

As discussed above, the self-organization degree of the SCS when fulfilling social responsibility is driven by the profitability and coordination. The two order parameters make the sub-systems restrict mutually and interdependency through the coordination and produce the synergistic effect, the situation of fulfilling social responsibility in the SCS changes from lower order to higher order, that is self-organization system. Use q_1 expresses the profitability of the SCS and q_2 expresses the coordination ability, s expresses the sub-systems. The differential Eq. (3) derived from Eq. (2) shows how the q_1 and q_2 influence the self-organization evolution:

$$\begin{cases} dq_1 / d_t = (\alpha - \gamma_1)q_1 - \lambda_1 q_1^2 - \beta_1 q_1 q_2 + F(t) \\ dq_2 / d_t = -\gamma_2 q_2 + \beta_2 q_1^2 \\ ds / d_t = \alpha_3 q_1 + \alpha_2 q_2 + \alpha_3 s + \alpha_4 q_1 q_2 \end{cases} \quad (3)$$

where,

- α = The profit gain coefficient
- γ_1 & γ_2 = The damping coefficient
- β_1 = The interaction coefficient between q_1 and q_2
- β_2 = The relation between the profitability and the coordination ability
- λ_1 = The attenuation coefficient of the profitability of the SCS as time goes on
- α_1 = The influence which the order parameter profitability produces to the sub-systems' self-organization evolution
- α_2 = The influence which the order parameter coordination ability produces to the sub-systems self-organization evolution
- α_3 = The self-feedback coefficient of the sub-systems
- α_4 = The influences on sub-systems' self-organization evolution which are produced by the interaction between the profitability and coordination ability
- $F(t)$ = The random fluctuation of the SCS

So the first two equations describe the order parameters, which are the profitability and coordination ability, dominate the SCS's self-organization evolution and the last equation is to describe the two order parameters how to act on the sub-systems (Gao, 2009).

The solution of the SCS self-organization evolution model when fulfilling social responsibility: If the internal sub-systems do not act and the order parameters do not change, the SCS will be stable. It means the SCS

will maintain the original state in fulfilling social responsibility, then $q_1 \geq 0, q_2 \geq 0, s \geq 0$. We should find a balance point $(0, 0, 0)$ to study the SCS's evolution process from one kind of balance to another balance (Salam, 2009).

Solve the characteristic matrix according to the model, thus:

$$\begin{pmatrix} \alpha_3 & \alpha_1 + \alpha_4 q_2 & \alpha_2 + \alpha_4 q_1 \\ 0 & (\alpha - \gamma_1) - 2\lambda_1 q_1 - \beta_1 q_2 & -\beta_1 q_1 \\ 0 & 2\beta_2 q_1 & -\gamma_2 \end{pmatrix} \quad (4)$$

The characteristic equation at the balance point $(0, 0, 0)$ is:

$$\begin{vmatrix} \lambda - \alpha_3 & \alpha_1 & \alpha_2 \\ 0 & \lambda - (\alpha - \gamma_1) & 0 \\ 0 & 0 & \lambda + \gamma_2 \end{vmatrix} = 0 \quad (5)$$

So the characteristic roots are:

$$\lambda_1 = \alpha_3, \lambda_2 = (\alpha - \gamma_1), \lambda_3 = -\gamma_2$$

According to the Qualitative theory of differential equation, the positive or negative of characteristic roots determine the stability of the balance point. The SCS's balance point is stable only when the roots' real parts are all negative; The SCS's balance point is not stable when the roots' real parts have one positive root. As γ_2 is the damping coefficient, $-\gamma_2$ is constant negative, that is, $\lambda_3 < 0$. So $\alpha_3 = 0$ or $\alpha > \gamma_1$.

We discuss it in two cases:

- When $\alpha_3 < 0$ and $\alpha < \gamma_1$, the SCS's balance point is stable. It shows the SCS's profitability is not enough to change its state; the SCS does not have enough profit to fulfill social responsibility. Even if the $F(t)$ works, the SCS is also stable.
- When the SCS does not satisfy the condition $\alpha_3 < 0$ and $\alpha < \gamma_1$, the small random fluctuation may produce internal large actions. The SCS will have structural changes; form the more stable new structure, that is, self-organization. Following the profitability become greater, the small $F(t)$ can lead to higher order structure. Every enterprise in the SCS may have new social responsibility concept and have more positive practices in it Risso (2012).

THE ESTABLISHMENT AND ANALYSIS of SCS's SELF-ORGANIZATION FUNCTION MODEL

From the above analysis and model derivation, we get the SCS may achieve the self-organization evolution under the random fluctuations. According to theory which is founded by Prigogine and Allen (1982),

the evolution will form the dissipative structure. The dissipative structure means that the new order structure need exchange materials, information and energies with the external to maintain its function. The next question is how the random fluctuation is produced and worked.

The establishment of the SCS self-organization function model when fulfilling social responsibility: Prigogine and Allen (1982) considered the far-from-equilibrium and opening system may form the dissipative structure and established a total entropy change model that was the mathematical model of the dissipative structure. The model is shown as Eq. (6):

$$ds = ds_i + ds_e \quad (6)$$

where,

ds = The SCS total entropy change in fulfilling social responsibility

ds_i = The SCS positive entropy change in fulfilling social responsibility, that is internal increasing entropy

ds_e = The SCS negative entropy change in fulfilling social responsibility, that is external inputting negative entropy

The SCS would rely on the input and output of materials, information and energies spontaneously and continuously to maintain its opening and far-from-equilibrium, keep its order structure (Gao, 2009; Faisal, 2010).

The fulfillment of social responsibility are related to the all respects in the enterprises's operation and management. The increase of ds_i mainly comes from the enterprises and their managers only pursuit the profit maximization, disregard the social responsibility ideas and practices. Thus, the enterprises choose to ignore responsibility and keep current situation. The increase of ds_e mainly come from the input of advanced concepts and practices in the process of exchange materials, information and energies with outside. Thus, the enterprises have more wider vision and the concept of sustainable development, discard the old thought and have more deep understanding in social responsibility (Wei and Yue, 2010; Smith, 2010).

Assume that the materials, information and energies from external and internal of the SCS are Q_e and Q_i respectively and define the exchange volume of materials, information and energies per unit time as fluctuation, that is, dQ_e/dt and dQ_i/dt represent the external and internal fluctuation of the SCS system. So the Eq. (6) can be written as:

$$ds = ds_i + ds_e = -\frac{dQ_e}{dt} + \frac{dQ_i}{dt} \quad (7)$$

When the value of time variable is larger, the

Eq. (7) can be expressed as:

$$\Delta s = \Delta s_e + \Delta s_i = -\frac{\Delta Q_e}{\Delta t} + \frac{\Delta Q_i}{\Delta t} \quad (8)$$

The analysis of the SCS self-organization function model when fulfilling social responsibility: On the basis of the establishment of the SCS self-organization model when fulfilling social responsibility, we can do the further analysis on it in different cases. We discuss the Eq. (8) in three cases:

- From Eq. (8), we know that when the external inputting negative entropy equals to internal increasing entropy within a certain time period, that is, $\Delta Q_e/\Delta t = \Delta Q_i/\Delta t$, the internal increasing entropy is offset by the external inputting negative entropy, $\Delta s_e = \Delta s_i$, $\Delta s = 0$. Every enterprise of the SCS keeps relative stability. The enterprises would keep silent in fulfilling social responsibility, remain impervious to the government's propaganda and guidance and public opinion's supervision. So the enterprises may do nothing.
- When the external inputting negative entropy is less than internal increasing entropy within a certain time period, that is, $\Delta Q_e/\Delta t = \Delta Q_i/\Delta t$, the enterprises of the SCS would pursue profit maximization and focus on cost saving and income improvement. The enterprise adjust by itself to reduce the investment in fulfilling social responsibility, let $\Delta s_e = \Delta s_i$, make the SCS reach negative equilibrium; If some enterprises put profit above conscience, disregard of law and human security of life and property, Δs_i is greater than the absolute value of Δs_e , these enterprises of the SCS would not like to maintain negative equilibrium, let $\Delta s > 0$, the external inputting negative entropy cannot offset the internal increasing entropy. Thus, the dissipative structure of the SCS system is destroyed and the SCS system is out of order. In this case, the enterprise will tread on social responsibility at any cost and do lots harm to the society and people. In this case, even if some enterprises have the ideas and wish in fulfilling social responsibility and have certain profitability, the others lack of the concept of system and coordination and then have bad influences on the whole system. So the SCS will also be disorder and cannot form the order self-organization system (Huang and He, 2010).
- When the external inputting negative entropy is greater than internal increasing entropy within a certain time period, that is, $\Delta Q_e/\Delta t > \Delta Q_i/\Delta t$, $\Delta s_e > \Delta s_i$, $\Delta s < 0$. Thus, the enterprises of the SCS form new dissipative structure change from disorder to order and reach positive equilibrium. In

this case, the enterprises of the SCS adapt the trend of the times; fulfill economic, law, ethics and charity responsibility actively. So the enterprises build good social image, strengthen competitive power and achieve sustainable development. This situation is our expectation. The enterprises of the SCS invest suitable capital and maintain certain coordination ability. The self-organization is formed. Even if some enterprises' profitability is relatively low, their collectivity idea and coordination idea will also impel them to act from the whole and protect the interest of the SCS. If not, these enterprises will be pushed out of the SCS and their image and reputation are also damaged. Therefore, in the game among the SCS's enterprises, the best choice is cooperation and maintains the common interests. In this case, the SCS will be more order and higher class stable structure (Smith, 2010).

THE SUGGESTIONS OF THE SCS'S SELF-ORGANIZATION ESTABLISHMENT AND FUNCTION

Based on model establishment and analysis, we know that it is helpful for the enterprises of the SCS to form self-organization when fulfilling social responsibility. We would like to know some basic conditions and tactics about self-organization establishment and good function. So some suggestions are put forward below.

Promoting the SCS further opening: The exchange of materials, energies and information with external environment may make the SCS produce a vigorous and order structure. Meanwhile, the materials, energies and information should spread within the system. The approaches for the system to improve its opening degree are to perfect communication infrastructure, raise the consciousness of social responsibility and reduce the artificial barriers.

Promoting the SCS far-from-equilibrium: Far-from-equilibrium is a critical condition of self-organization formation. The differences among sub-systems decide the close or far- from-equilibrium. The differences include the different ideas, the different ways and decision-making procedure and content in fulfillment of social responsibility. The greater the differences are, the further far-from-equilibrium. Under the condition of non-equilibrium, the random fluctuation can appear and further form huge fluctuation in the cooperation and competition. These lead to the sub-systems' collective action in fulfillment of social responsibility (Tate *et al.*, 2010).

Cultivating non-linear system: In a natural state, the sub-systems have weak non-linear and co-relationship,

the non-additivity of the system is also not strong. So increasing the relationship of sub-systems can establish non-linear system and produce coordination or synergy in fulfillment of social responsibility (Cruz, 2009).

The input of the control parameters should reaches a certain threshold value: The input of external materials, energies and information functions well only up to a certain threshold value. Different threshold value in different systems is the characteristic of the dissipative structure. The quantities of input are related to the hierarchy of system, the degree of complication of system structure and the content of input. So the input of policies, information and resources should keep a certain strength and frequency. The input parties of the control parameters (order parameters) may strengthen publicity and pay attention to the different requirements for the control parameters (order parameters) in different levels and different stages (Chi, 2011).

Equal participation of sub-systems is the guarantee of dissipative structure development and self-organization formation: In the SCS system, the sub-systems should participate in fulfilling social responsibility equally. It needs the external promotion and mechanism. Only do all sub-systems introduce and accept external resources actively and spontaneously, they can reach synergy and maximize utilization of resources. The sub-systems should unite thoughts and behaviors and keep the consistency in fulfilling social responsibility (Wei and Yue, 2010).

CONCLUSION

In this study, we put forward the concept of the SCS and from the supply chain study its fulfillment of social responsibility based on self-organization theory. The SCS have some self-organization characteristics. We also seek for the SCS how to form self-organization and work well in fulfilling social responsibility. From the mathematical model establishment and analysis, we endeavor to solve three questions. The first is the SCS's self-organization evolution mechanism and two order parameters in fulfilling social responsibility. The second is the SCS's self-organization structure's function mechanism in fulfilling social responsibility. The third is some basic conditions and tactics about self-organization establishment and good function in fulfilling social responsibility. The coordination and profit sharing model using the Nash equilibrium, the Stackelberg equilibrium and Cooperative game model will be the further study in the future.

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