

Research Article

Research on Food Supply Chain Management Based on Fractal Theory

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Abstract: Ordering to overcome the shortcomings of the traditional food supply chain, we bring forward the concept of fractal food supply chain and analyze its characteristics, structure and functional model. Then basing on the fractal theory we propose the detailed design procedure of food supply chain and discuss the practical significance of fractal food supply chain further.

Keywords: Food supply chain, fractal theory, functional model

INTRODUCTION

Nowadays food supply chain has become an important source of the enterprises obtaining profits. And scholars domestic and abroad are devoting to seeking the approach to maximize the profits among the suppliers, manufacturers and distributors. Simultaneously, the circumstance enterprises facing are tremendously changeable and complex. With the globalization of economy and the rapid development of information technology, enterprises are facing increasingly fierce market competition: shorter product life and more product categories, stricter product and service requirements from the customers. These competition pressures are challenging the traditional food supply chain (Fang and Xia, 2004). From the perspective of the stability, the traditional food supply chain can be divided into a stable food supply chain and instable and distributors, whose structure is rigid and lacking of the ability of self-transformation; the latter one is chaotic structure of organizational behavior which is unstable and uncontrollable. The unsteady food supply chain is sensitive about the objectives and environmental parameters and the chain composes for a certain mutual target and disintegrates while the task done. For the unsteady organizational structure, such kind of food supply chain adjusts and changes itself frequently while the target and circumstance varies. To combine the comprehensive advantages of these two forms of the food supply chain and overcome the respective shortcomings, there is necessity to develop a food supply chain structure which owns both considerable structural stability and certain flexibility. And the Fractal food supply Chain matches the above requirements.

MATERIALS AND METHODS

The fractal theory and fractal food supply chain:

The introduction of fractal theory: Fractal theory is a scientific method which describes the chaotic and nonlinear internal structure and researches on the irregular, fragmented and fractal-dimension objects, such as coastlines, rock surface, clouds, etc. And the fractal theory focuses on Formation mechanism and mathematical models. These natural objects own complex structures to adapt to environmental changes (Xu *et al.*, 2002). Similarly in human society, an advanced manufacturing system must pay much attention to customer product design, manufacturing system and business process reconstruction. These logical processes are consistent with the research principal of the above natural objects. Therefore the fractal theory is the basis of analyzing unit of developing complex systems.

Similarity is the most important principle of fractal theory. Such characteristic shows to be fractal invariant through general geometric transformation. It also described as non-scaling, immediately no matter how we transform the observed scales, each constituting part still maintains the overall property. Fractal unit is an important concept of fractal theory; it refers to the relatively independent part which constitutes the fractal entirety. The fractal unit is also known as the generator and it is the basic unit of fractal organization.

The definition of fractal food supply Chain: Fractal food supply chain is made up of several fractal food supply chain units which share similarities in organizational morphology and operation mode. According to different backgrounds and food supply chain tasks, the self-organized mechanism would form reconfigurable task-oriented food supply chain of different sizes and levels and then the food supply chain would operate the overall or partial tasks through co-operation. While the task and environment changed, the fractal food supply chain unit would reorganize to

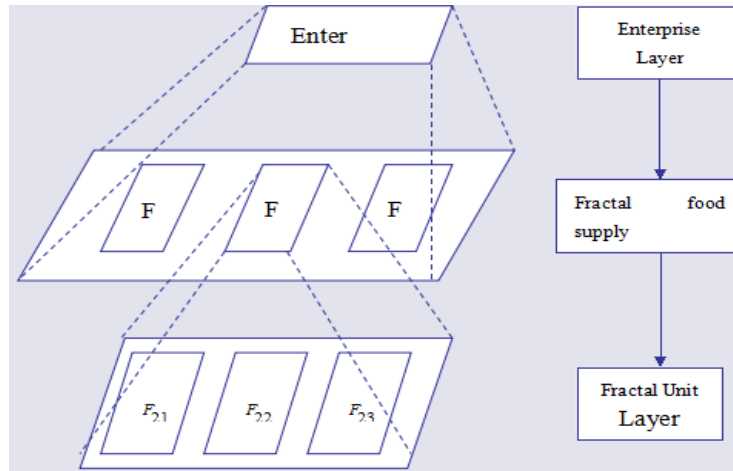


Fig. 1: The vertical structure of fractal food supply chain

achieve the reconstruction of fractal food supply chain system. The fractal food supply chain unit, self-organizing mechanism and optimization mechanism laid the foundation of reconstruction. Fractal food supply chain unit refers to the task as the driving force (Fan and Chen, 2008). Each unit has its own function and they respectively own certain independence and self-contain in the organization structure and operation mode.

The characteristics of fractal food supply chain: Fractal food supply chain has the following four characteristics:

Self-similarity: This is the most basic characteristic of fractal food supply chain. Such similarity not only means the structural similarity of each fractal unit, but also refers to the similarity of values, operation modes and corporate targets and so on. Similarity between fractal units also is reflected in the output effect of the system (Wang, 2004).

Self-organization: The self-organization of fractal food supply chain is mainly reflected in the operating and strategic goal setting. In the operation process, the fractal food supply chain is "automatically" organized by appropriate means; in the strategic goal setting, each fractal food supply chain unit set its own strategic objectives according to their understanding of the overall strategic objectives as well as their roles and abilities positioning in the food supply chain. These fractal food supply chain units coalize, operate and finally disband in certain self-organizing mechanisms.

Self-optimization: Fractal food supply chain emphasizes the self-development capacity of each fractal unit. In the self-activity space, fractal unit could maintain continuous self-improvement and development and make self-determination and

optimization of internal processes. Last the fractal unit gets the optimization results in the self-activity space.

Target-driven: Fractal food supply chain requires each fractal unit to negotiate and determine the overall objectives of the organization. Then decompose the overall objectives into a series of little objectives and distribute them to each fractal unit to implement. Such target-driven mechanism is the most reliable method to solve the conflict between the fractal units.

The vertical structure of fractal food supply chain: Here we take a simple manufacturing enterprise as example and then introduce the vertical structure of fractal food supply chain (Huang and Li, 2008). As shown in Fig. 1, the highest level is the enterprise layer; followed by fractal food supply chain constructed in accordance with different products; and the bottom layer is the manufacturing unit or suppliers. The enterprise, food supply chain or the manufacturing unit, suppliers are essentially fractal units. And they all share the characteristics of self-similarity, self-organization, self-optimization, though they may be at different levels.

RESULTS AND DISCUSSION

The structure of fractal food supply chain:
The transverse structure of fractal food supply chain: We still take manufacturer above as an example. Assuming that there are three departments in the company: D1, D2, D3 which are responsible for the manufacturing, production and sale of a certain product respectively. According to the customer orders (C1, C2, C3), the manufacturer would arrange three departments (M1, M2, M3) to produce. At the same time, each manufacturing department has two first-tier suppliers (S1~S6). The transverse structure is shown in Fig. 2.

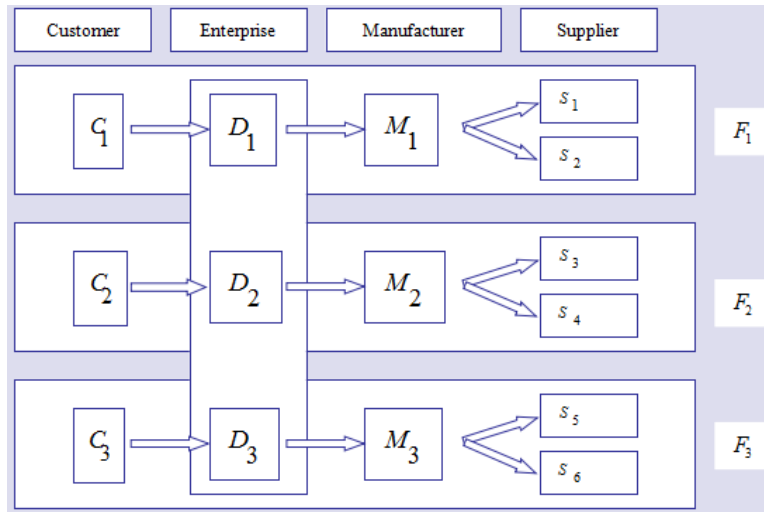


Fig. 2: The transverse structure of fractal food supply chain

Figure 2, F₁, F₂, F₃ all are fractal food supply chains and they are in charge of the production tasks of a certain product or some similar products. The fractal food supply chains mentioned are product-oriented. Among the food supply chain, all the enterprises (D₁, D₂, D₃), manufacturing departments (M₁, M₂, M₃) and the suppliers (S₁~S₆) are fractal units. And these fractal units above possess the characteristics of self-similarity, self-organization and self-optimization. According to the environment and the enterprise's target, the fractal units could organize to finish certain tasks of production and procurement by themselves. For the self-similarity of fractal food supply chain, the enterprise can imitate the existing food supply chain to construct and manage while developing new products and increasing the food supply chain. The activities involving procurement, manufacturing and sales in the operation are completed by each fractal units in accordance with their needs and the overall target respectively or cooperatively.

The design of food supply chain based on fractal theory: At first, we should analyze the industry situation, review enterprise' target, including the profit target and the market target and then combine the detailed target to design the initial structure of the food supply chain.

Then, we take some structural adjustment to determine the systematic target and establish the food supply chain. There is much necessity of designing the corporation regulations among the enterprises, including the profit distribution, cost-sharing and cooperation standards, which ensure the implement of food supply chain self-optimization and self-organization.

Final is the operation and improvement. Here we design the self-controlling mechanism for fractal unit to ensure self-optimizing and self-organizing. The basic principles of food supply chain operation and improvement are to guarantee the transparency of the

workflow and information and allow the enterprise members to perform actively. Only in this manner can we cooperate rather than confront and along with quality awareness and continuous optimization.

CONCLUSION

After analyzing the shortcomings of the traditional food supply chain management, we propose the fractal food supply chain management and introduce and analyze the detailed characteristics, structure and function. Compared with the traditional food supply chain management, we find that the fractal food supply chain possesses both stability and flexibility through the research. Such characteristic ensures the fractal food supply chain to make up for the disadvantages of the traditional food supply chain, therefore we can coordinate various partners much better in the food supply chain network.

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