RESEARCH ON INNOVATION OF SHIPBUILDING SUPPLY CHAIN MANAGEMENT BASED ON COMPLEXITY ADAPTIVE SYSTEM

Gen Li, Chunlei Lv and Yifei Cheng
School of Economics and Mnanagement, Harbin Engineering University, Nantong Street, Harbin, China

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Abstract: Because of the change of the whole operational environment, traditional methods could not reasonably be used to settle the complicated problems which occur in shipbuilding supply chain management. Based on complexity adaptive system theory, the paper first interprets the whole operational mode of shipbuilding supply chain, then it establishes simulation model of shipbuilding supply chain according to Multi-Agent, finally it puts forward some innovation directions in order to resolve complicated problems which emerge from current shipbuilding supply chain management.

1 INTRODUCTION

Shipbuilding supply chain is a series of value-increasing activities including original material purchasing, conveyance, process, manufacturing and productions arriving in ship owners, in fact it is a function net chain structure which is filled with logistics flow, fund flow, service flow, knowledge flow and information flow thoroughly. Shipbuilding supply chain management is a whole management style which integrates supplier, manufacturers, medium-sellers and buyers through logistics and information flow (Ren and Zhao, 2008).

Under the premise that it quickly satisfies the need of final users, shipbuilding supply chain must have the ability to respond to the change of market quickly and run perfectly from the whole supply chain (Li, 2006). In the market environment which is full of dynamic competition and cooperation nowadays, the enterprises could belong to different supply chains in the meantime. The competition among enterprises actually has already converted into the competition among different supply chains. Under the competition situation above, the operation environment of shipbuilding enterprises becomes more complicated (Zhang, 2003). Enterprises should re-examine their own operational modes from a new aspect. They also should allocate resources and make strategic decisions from the greater thinking space and the area space. The paper explains the complicated phenomenon and resolves complicated problems of shipbuilding supply chain management basically with the help of complexity adaptive system theory.

2 CHARACTERISTICS AND RELATED MODELS OF CAS

Complex adaptive system was put forward by John Holland (USA) when the institute of Santa Fe was 10 years old in 1994. The fundamental thought of CAS is that: because the agents will interact with themselves and environment, they will change themselves and also change the environment.

2.1 Fundamental Characteristics of CAS

The core thought of CAS is “adaption creating complexity”, it can say that it is a leap in understanding system motion and evolving regulation. Its characteristics will be discussed as follows (Chen, 2001).

First, the agent is an active and live agent. This is the key differentiation of CAS from other systems. This characteristic makes it able to effectively be applicable to economic, social, ecological complicated system etc. But other methods are more difficult to deal with these areas.

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Second, the mutual influence and interaction between the agent and environment (including among the agents) is the main motive for the evolution of the system. The former systems usually put the internal attribute of agent into the initial position, and they don't emphasize on the interaction between agent and environment (including among agents). This makes CAS able to be used into different areas where the characteristics of agents are absolutely different, but there are many commons in the correlation.

Third, it introduces the random factor, so it has a stronger ability to describe and express.

Fourth, it contacts the macro view and the micro view organically. It makes the change of agents become the foundation of the change of the whole system through the interaction between the agent and environment (Tan and Dong, 2001).

Because of the above characteristics, CAS has different functions and values compared with other system methods

2.2 Main Models and Simulated Tool of CAS

There are many methods to study CAS, but it has more guiding significance from models and simulated tool (Dong, 2006).

2.2.1 Stimulating-reaction Model

From the micro view level, it expresses the most basic behaviour pattern of agent in each system with the way of unity. The performance system of each agent is composed of three parts such as a detector, an effecter, a set of IF/THEN rule.

The detector is been used to accept external incitement, the effecter is been used to make a reaction, IF|THEN rule stipulates how to respond towards different incitements, but it differs from common sense which is 1 to 1 correspondence. In order to simulate real world, this rule sets up many kinds of choices and it contains contradiction, conflict and disagreement. Based on genetic algorithm, the agent can successfully compare and choose rules, and it even yields new rules through the procession of evolution. Figure 1 is stimulating-reaction model as follows.

2.2.2 Echo Model

Based on micro stimulating-reaction model, it can establish echo model which is macro mode of the whole system. In this model, the agent has three elementary parts: offensive label, defense label and resource pool.

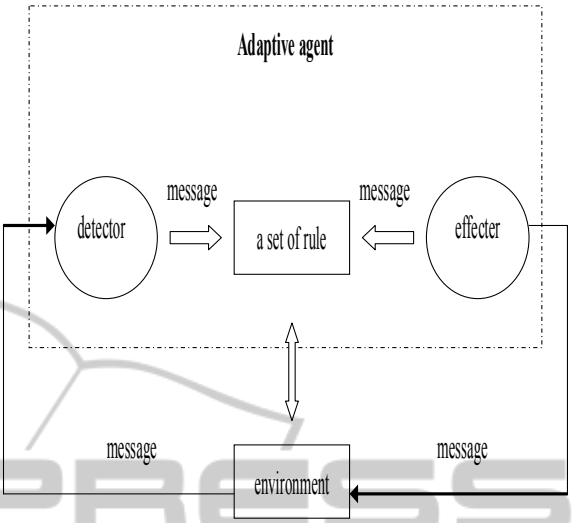

Figure 1: Stimulating-reaction model.

The basic function of echo mode includes the performance that an agent actively contacts with other agents. In the meantime, it gives answers to other agents towards their contacts, if they match successfully, then they will exchange resources. They will save and process resources in their inner bodies; if the resources are enough and then they will breed new agents. Under the control of echo model, the system will be like figure 2 as follows.

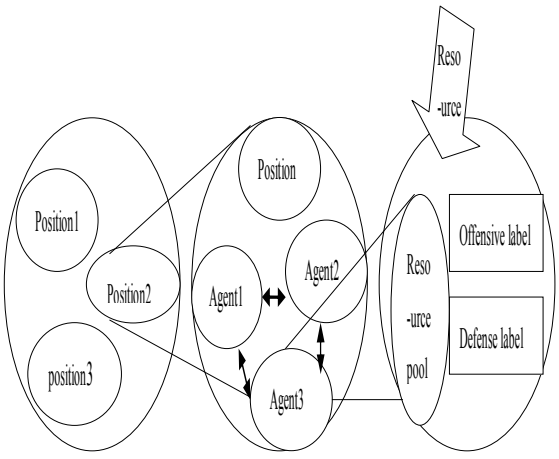

Figure 2: Echo model.

2.2.3 Simulation Tool

Swarm is a simulated terrace. It is an experiment tool to study CAS (Qiu, 2003). This simulated terrace is used to carry out discrete event simulation. It has the same characteristics as the general affairs simulation.

It adopts realizing method which is facing to object, so in this terrace, it provides a whole set of database which is the basic work what the researcher completes in some simulated experiments. The customer can realize many functions on the foundation of these databases.

The majority of simulation procedures of Swarm contain four types of objects: Model Swarm, Observer Swarm, simulation agent and environment. Model Swarm and Observer Swarm are subcategory of Swarm category. Swarm category is the basic structure piece of Swarm simulation. A Swarm is the combination between a series of objects and behaviour timetable that are caused by the objects. Simulation agent usually inherits methods from Swarm Object to provide support for memory and management of speculation control. The different simulation systems have different environment, figure 3 is Swarm structure.

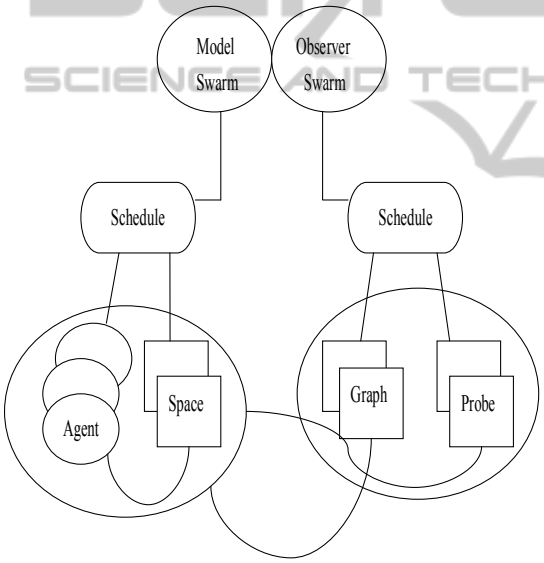

Figure 3: The structure of Swarm.

3 ANALYSIS OF COMPLEXITY AND ADAPTABILITY ON SHIPBUILDING SUPPLY CHAIN

3.1 The Source of Complexity of Shipbuilding Supply Chain System

3.1.1 The INDEPENDENCE of Entities

Shipbuilding supply chain is network system that is constituted by many comparatively independent entities. Overall supply chain model and optimization target don not exist. The management of overall supply chain will be realized through coordination among these comparatively independent entities. Each enterprise in supply chain has its own benefit and management mode and there is no core place among these members. The change of one enterprise will be affected by other enterprises and this change will affect the change of other enterprises. The whole shipbuilding supply chain can constantly study, reorganize and perfect its layer structure and functional structure (Choi and Dooley, 2003).

3.1.2 Turbulence and Indetermination of Environment

Shipbuilding supply chain faces inside and external environment that is full of turbulence and indetermination. Ally and rival will change all the time, and itself of shipbuilding supply chain also adjusts in order to adapt to environment. Under this circumstance, it is very important for the members in shipbuilding supply chain to choose suitable suppliers and dealers, join in the suitable supply chain and valuate the efficiency and effect of supply chain. But among the current researches and applications towards shipbuilding supply chain, the authors just see the supply chain and its environment as a static state or very slowly changing object. They usually adopt serial plan or control mode and over-emphasize the stability of the colleague relationship, so it lacks of enough adaptability and is very difficult to adapt to the operation environment which is changing rapidly.

3.1.3 Difference of Internal Structure

The pursuit of shipbuilding supply chain is unobstruction and agility of logistics, information flow, knowledge flow and capital flow. Because of the different internal structure of shipbuilding supply chain enterprise, the corresponding information systems are not compatible. Shipbuilding supply chain management is to integrate these distributed and heterogeneous systems as a whole or information sharing system, which is urgent problem that needs to be resolved. But the current system is mainly based on the traditional organization management mode and do not really realize business process integration from the scope of the entire supply chain.

3.2 Mechanism of Complexity of Shipbuilding Supply Chain

3.2.1 Interaction and the Occurrence of Emerging of Shipbuilding Enterprises in the Supply Chain

The essence of emerging is the process from small to big and from simple to complex. It is a kind of interaction of before and after association. These interactions and the system coming from the interaction are nonlinear. The interaction is its center and is more complex than the simple sum of individual behaviour. The stable mergence phenomenon could be an integral part of more complex emergence phenomena.

3.2.2 Mutual Adaptation between the Agents and Environment

The agents in the supply chain are the economic entities which are those independent or half independent. These agents have the supply and demand relation that is full of competition, cooperation and dynamic state etc. Operation unit, business process, member's enterprise, supply chain system, the whole action environment constitute agents in different layers. And each agent has its own target, conduct strategy, internal structure and existence motive.

These agents interact through gathering to expect to continuously adapt to environment. Towards the whole supply chain, there is no concentrated control centre to guide the behavior of each agent, but the whole supply chain is still in good order. Because this activity and the repeated and mutual gathering function with environment, which are basic move for development and evolution of the whole supply chain system.

3.2.3 Dynamic State and Non-line of Shipbuilding Supply Chain

Modern enterprises exist in the environment which is full of severe competition and indetermination. Under CAS, although a shipbuilding enterprise makes very small decision, it will largely influence on related enterprises (Forrester, 1961). In the meantime, environment also influences on modes, various rules or standards of enterprises. The agent will change its standard which indicates its ability to adapt to environment because of the change of mode, target appearance, basic function standard and the ability to adapt to the environment etc.

3.2.4 Complexity of Shipbuilding Supply Chain

The intertexture of positive and negative feedback results in the complexity of supply chain and the positive feedback exerts a great influence on the system. Shipbuilding supply chain faces an environment that is full of complexity, the random in agent, which plays an important role in process that system looks for various possibilities. Some important whole characteristics come out in the mentally dense and the random process.

3.2.5 Coordination of Shipbuilding Supply Chain

On the one hand, how to manage and control the logistics flow, information flow, knowledge flow, the funds flow between suppliers and demanders and availably lower inventory, accelerate turnover of logistics and information flow, raise the efficiency of circulates in enterprise production and commodity, quickly respond to market opportunity, which become urgently problems needing to be worked out; On the other hand, because of market competition which is turning worse, the pursue of enterprises in the whole supply chain will result in some antinomies. Enterprises should know that the whole supply chain can achieve the state which is called Pareto Optimality, but it can not achieve the state of the optimization of every enterprise. Therefore, an enterprise should understand how to cooperate with the enterprises which are in upper and lower class. This can make sure that the efficiency of the whole logistics chain is the biggest and the efficiency of the enterprise reaches the best state (Chandra and Kumar, 2001).

4 SIMULATION MODEL FRAME OF SHIPBUILDING SUPPLY CHAIN ACCORDING TO MULTI-AGENT

According to CAS, the paper adopts the software terrace-SWARM which was developed by SFI in order to establish the model for CAS. The Swarm model defines the frame of model. With the help of this frame, we can build simulation model based on Multi-agent.

4.1 Introduction of Swarm Model

Swarm model can make the customer build up his/her own application according to this frame; at the same time, it considers factors such as the characteristics of different agents, and the details of space distribution, the characteristics of network connections and so on. It mainly carry out interaction towards a series of independent individuals through independent affairs carry on handing over to with each other, it will help study behavior of the complicated system which is composed of many agents.

Lin, FuRen and others have studied the process restructuring strategies towards different orders under the application of Swarm, the strategies have affected on the performance of the whole supply chain. They obtained ideal results (Lin and Shaw, 1998).

4.2 Simulation Model of Supply Chain based on Multi-agent

Table 1 shows mapping relationship between supply chain model and Swarm model. We can see the four similarities between them. These similarities are very important for supply chain management. According to this kind of corresponding relation, it calls Swarm 21.1 class library in Jbuilder3.0 platform to build simulation model of supply chain based on Multi-Agent (figure 4) shown. The individual details are omitted for the limited length of the paper.

Table 1: Mapping relationship between supply chain model and Swarm model.

Supply chain model	Swarm model
Different role agents in different levels	A series of agents which have different inner states and behavior rules
Information interaction among different agents	Information transmission among different agents
Logistics flow and machining process	The agent under discrete event simulation and time debugging triggering
The agents get the whole supply chain performance through gathering and interaction	The performance of all agents decides the whole performance of system

In this simple model, system includes supplier agent, manufacturer agent, customer agent, order class and credit standing class, they are all autonomic agents. Logistics, information, fund and knowledge flows of the whole system will run under demand pull. First, Model Swarm produces orders and distributes orders for customers and the customers consult price and delivery time from manufacturers. Then manufacturers will inquire supplier and supplier will quote in response. After getting quotation, manufacturers will tell the customers quotation and then the customers will choose the best manufacturers. Similarly, the manufacturers will also choose the best customers. Finally, it will evaluate the credit of manufacturers (suppliers) and update the prestige historical data.

5 RELATED STRATEGIES OF SHIPBUILDING SUPPLY CHAIN MANAGEMENT BASED ON CAS

Supply chain is a CAS. Shipbuilding supply chain management should fully consider the characteristics of CAS and adjust management mode and theory. We can put forward suggestions as follows (Wu, 2006).

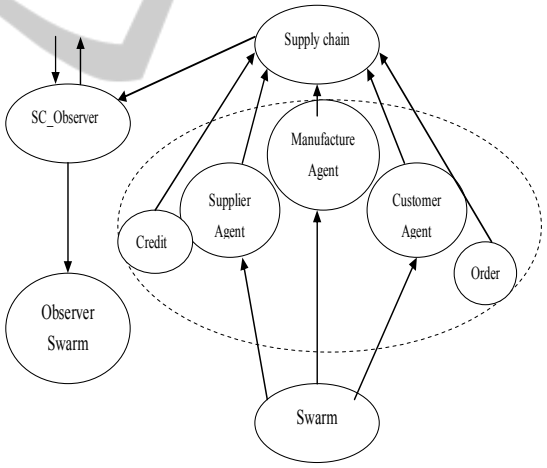

Figure 4: Simulation model of shipbuilding supply chain management.

5.1 Self-management towards Adaptability

Supply chain is a self-adaptive system, if one enterprise wants to develop in the market; it need set up a self-management thought. On the one hand, it should coordinate with other enterprises in supply chain; on the other hand it should pay attention to itself-management. The kind of self expresses the choices of "internal mode".

When the inner and outer environment is changed, the shipbuilding enterprises should rapidly readjust their goal and fundamental structure and establish a rapid reaction mechanism for them to change and optimize their own product characteristics, management process, production method, enterprise culture, even employee career development. Meanwhile, supply chain network is self-organization. Shipbuilding enterprises should actively adjust their position in the supply chain and reorganize themselves quickly according to the dynamic change of the environment.

5.2 Paying Special Attention to Adjustment of the Internal Model

Shipbuilding supply chain pursues the condition of Pareto Optimality, this shows that enterprises in the whole supply chain are unable to maximize their own goals and interests. Based on this, the enterprises need to establish their own characteristics, such as product and service, management, technology, enterprise culture and so on, in order to meet diverse and dynamic market demand. Under the optimization of the whole supply chain, the enterprise realizes the target and maximized benefit.

5.3 Strengthening the Management of "Flow"

Towards supply chain management, we should do well in managing logistics, information, knowledge and fund flows among enterprises or between enterprise and external environment. First, the enterprises should realize that only they transmit "flow" completely among themselves, it will be possible for them to enhance their adaptive and anti-risk ability. Enterprises should closely cooperate in functional layer, operational layer and flow layer etc, then eliminate the bottleneck of whole supply chain, and raise the whole operation performance of supply chain; Secondly, the enterprise shall establish information system and strengthen the ability to exchange information with external environment in order to make enterprises effectively complete the production plan and in or out goods scheduling. Through this process, the enterprises can avoid unnecessary waste.

5.4 Paying More Attention to Micro Management

The good or bad operation performance of the enterprise depends largely on the national or social policies and laws. The enterprise must recognize the supply chain type which it is located in and determine its strategic position in the shipbuilding supply chain reasonably. Through the research, the paper finds that the evolution and development of the supply chain system is a collective dynamic process. This can change strategic errors of some enterprises that they blindly position themselves in "core position" of supply chain. Only they clearly establish strategic concept, they can reasonably allocate resources and realize the target.

5.5 Establishing the Concept of Continuous Learning

Shipbuilding supply chain system is the complex adaptive system that has the ability to learn, which means that supply chain is in change every minute, including the change of external environment and internal management pattern of the enterprise. Only enterprises have the ability to learn fast, they can deal with business environment which is changed fast. Therefore, enterprises in shipbuilding supply chain must establish the concept of learning successively and make themselves become learning organizations.

6 CONCLUSIONS

Shipbuilding supply chain is a CAS, so we need to convert thinking mode and use the methods provided by complexity science. Based on shipbuilding supply chain operational mode of CAS, it can be more objective to describe the behavior of complexity system and provide more scientific operational strategies of shipbuilding supply chain for policy makers; Meanwhile, the paper puts forward the corresponding innovation strategies of shipbuilding supply chain management, such as self-management toward adaptability; paying special attention to adjustment of the internal model; strengthening the management of "flow"; paying more attention to micro management and establishing the concept of continuous learning, which can reasonably interpret complex phenomenon and resolve problems in current shipbuilding supply chain. For the limited time, simulation model of shipbuilding supply chain hasn't been simulated through the computer, which will be the research direction in the future.

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