Advanced in Control Engineering and Information Science

Analysis of Bullwhip Effect Based on ABMS

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Abstract

With the globalization and the development of information technology, supply chain has become a complex system. In this paper, ABMS(Agent-based model and simulation), as one of the scientific and dynamic research methods for complex system, is applied to establish a supply chain model and determine its abundant bullwhip effect phenomenon under swarm platform. Based on analysis of certain conditions obtained in the paper, it proves the ABMS is the effective way to study the bullwhip effect in complex supply chain.

Keywords: Supply chain; Bullwhip effect; Agent; Swarm; Modeling; Simulation;

1. Introduction

With the globalization and the development of information technology, supply chain has become a complex system. Supply chain is the supply network involving suppliers, manufacturers, wholesalers, retailers and customers in the process of production[1]. In this complex supply chain system, there are various forms of uncertainty, particularly, uncertainty of customer demand is the most fundamental uncertainty [2].

Bullwhip effect is the distorted and fluctuated information caused by customer demand, referring to the orders placed by the retailer to the supplier which have inconsistence with the actual sales[3].

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Specifically variance of the orders sent to the vendors is greater than ones received from the buyer (that is Demand-Distorting)[4]. Such distortions in the supply chain are gradually magnified to the upstream. It is a serious impact on modern logistics, supply chain operations and the economic efficiency of the supply chain system.

However, with the development of economic, the supply chain system has shown the larger, more complex nature of nonlinear[5]. In this complex system, the traditional theory of quantification and control system is unable to fully meet the analysis. Therefore, it will be an inevitable trend of utilizing a new theory to study the bullwhip effect. Unlike traditional statistics, in this paper , ABMS(Agent-based modeling and simulation) as one of the new technologies has been adopted to build supply chain model, and with the powerful corresponding simulation platform-Swarm, the abundant experimental results have been observed to verify and analyze the bullwhip effect under different conditions. Therefore it can be referred by supply chain management for how to weaken bullwhip effect and provide appropriate improvement strategy.

2. The ABMS technology

ABMS is the multi-agent modeling and simulation tool based on bottom-up thinking. The whole modeling steps of ABMS are as follows[6]:

1)The division of individual agent: Firstly, determine the objectives and functions of the total system; Secondly, set out various sub-goals for completing the overall goal, and analyze the relationship among sub-goals, then get the hierarchy diagram of the goal; Lastly, determine the functions of individual Agent in the system, that is, set role differentiation of agent.

2) Modeling on static structure: Agent modeling on the static structure is mainly to describe the organizational structure reflected by the Agent relations. This relationship decide the possible patterns of behavior in the process of interaction with each Agent.

3) Design of dynamic behavior: On one hand, the process focuses on the dynamic behavior of the interactions Agent, on the other hand, it focuses on the internal mental state features of each Agent. Both are uniform in nature.

4)Buildup of system: In principle, decentralized autonomous Agent is defined firstly, and then, study how to complete a task with a number of entities. The MAS modeling process can be seen as bottom-up design approach.

3. Model and simulation

Condition: There are five members included by one supply chain: manufacturer, distributor, wholesaler, retailer and customer. It is assumed that there is only one member of each level, such as one manufacturer, one distributor, one wholesaler, one retailer and one customer. Every week, according to the needs demand of downstream firms , the delivery cycle, the inventory of their own enterprises and the production and supply capacity, the enterprise place orders to the upstream firm. Then upstream enterprises make supply decision to meet the needs of downstream businesses according to its own inventory tactics. There is one delay (just one week) between order received and order filled up in the supply chain. Initially, the supply chain is in complete equilibrium in terms of demand, orders, supplies, and inventory.

The target of modeling: 1)to establish the behaviour of single member in supply chain; 2)to affirm interaction between members in the supply chain;3)to build up whole supply chain.