Performance Comparison Between the Globalization and the Localization of A Supply Chain

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Abstract

The ideal in supply chain management is the fully integration of business process from end consumers through original suppliers that provides products, services and information. And we know that it is very difficult to coordinate and to integrate all members of the supply chain, especially the global supply chain that the members are dispersed in a number of countries. It is obvious that we can get some benefits from the globalization. However, because of the higher uncertainty of the globalization itself, we also get some trouble and losses. So we have the reason to doubt that whether the globalization of a supply chain can really improve its performance or not.

The multi-agent modeling technique is a very useful approach to model the complicated structure of a supply chain network. In this paper, we will propose a multi-agent based simulation model for evaluating the performance of a supply chain to help us in decision-making. Since each member of a supply chain is an independent entity, an agent is used to represent a member of the chain. We can build each agent's functions based on each corresponding member's characteristics. And also in this research, we will use simulation approach to do the performance comparison between the globalization and localization of a supply chain to study what are the gains and the losses caused by the effects of the globalization.

1. Introduction

In the past, enterprises used mass production to cut down cost for getting competition advantages. Traditional management focused on centralization and control. Today, manufacturers suffer more difficult pressures and problems than the ones in the past. The examples include rising consumer expectation, growth in product variety, quick response expectations, increased competition and global economics. Therefore, in order to overcome the highly uncertainty, enterprises increasingly stress the importance on supply chain management and attempt to improve the business process from end consumers through original suppliers in an uncertain environment.

A supply chain is generally viewed as a network of facilities that procures raw materials, transforms them into intermediate subassemblies and final products and then delivers the products to customers through a distribution system [12]. With the explosive growth in global markets and global sourcing, the global supply chain has become more and more important. As we take notice of the benefits from globalization, the potential effect and unpredictable fluctuations are necessary to be taken in consideration.

Lee and Billington [11] identify 14 pitfalls in supply chain management based on their knowledge and experiments from various industries. What are found relevant to this paper consists of (1) no supply chain metrics, (2) Inadequate definition of customer service, (3) inaccurate delivery status data and (4) ignoring the impact of uncertainties. This paper first proposes a performance evaluation model to assist in making decision and to depict the operations, processes and environment of the global supply chain, which takes these pitfalls into consideration. Next, the study evaluates the performance between globalization and localization of a supply chain by simulation.

The paper is organized in the following way. The literature review of supply chain management and agents is given in Section 2. The detail description of model framework using multi-agent approach is provided in Section 3. Finally, we implement a supply chain to understand the operation of globalization and localization in Section 4.

2. Literature Overview

2.1 Supply Chain Management

There are various definitions of supply chain management. And in this research, we adopt the definition of Lambert et al.[10], "supply chain management is the integration of key business process from end user through originals suppliers that provides products, and information that add value for customers and other stakeholders." The framework of supply chain management contains three inter-related elements: the supply chain business process, the supply chain network structure, and the supply chain management components [4].

Because of the complexity of supply chain, researchers attempt to generalize different types of supply chain from a collection of instances. Fisher[7] has found that if we consider the nature of the demand for the products one's company supplies, products could be classified two categories: primarily functional or primarily innovative. We also could recognize that a supply chain performs two distinct types of functions: physically efficient or responsive to the market. And each category of product requires a distinctly different kind of supply chain. Lin and Shaw[14] identify three typical types of supply chain, called Type I, II, and III SCNs. Table 1 illustrates the properties of these three types of SCN. In this paper, we adopt the classification of supply chain that Lin and Shaw[14] provide.

Table 1 Three types of supply chain network (source: Strader, Lin and Shaw [18])

Attributes	Type I SCN	Type II SCN	Type III SCN
Manufacturing Process	Convergent Assembly	Divergent Assembly	Divergent Differentiation
Primary business objectives	Lean production	Customization	Responsiveness
Product differentiation	Early	Late	Late
Range of product variation	Small	Medium	Large
Assembly process	Concentrating at the manufacturing stage	Distributed to the distribution stage	Concentrating at the manufacturing stage
Product life cycle	Years	Months to years	Weeks to months
Main inventory type	End Products	Semi-products	Raw materials
Example industries	Automobile and aerospace	Appliance, electronics and computers	Apparel/fashion

There are three sources of uncertainty that plague supply chains: suppliers, manufacturing, and customers [5]. The first source of variability that leads to holding safety stocks is supplier delivery performance because of the lateness. The second source of variability comes in the manufacturing process itself. Customer demand marks the third and final major source of uncertainty in the supply chain [5].

As activities of a global supply chain locate over the world and product flows start crossing national boundaries, managers face the uncertainties and complexities much more complicated. Dornier[6] provides several characteristics differentiate global from local supply chains as below:

(1) Substantial geographic distances.
(2) Adding forecasting difficulties and inaccuracies
(3) Exchange rates and other macroeconomic uncertainties
(4) Inadequacies in infrastructure.
(5) Explosive dimensions of product variety in global markets.

Levy[13] considers the influence of distance depends on location-specific and relational factors. Location-specific factors are related to the attractiveness of particular locations, such as wages and resource availability. Relational factors place emphasis on the relationship and linkage. In this paper, we focus on relational factors in the supply chain.

2.2 Intelligent Agent

The agent architecture provides an ability to solve complex problems and improve the efficiency of system development. There is no clear, unanimous definition of what an agent is until now. However, most researchers are in agreement on following definition [20].

An agent is a computer system situated in some environment, and that is capable of autonomous action in this environment in order to meet its design objectives. Autonomy is a difficult concept to pin down precisely, but we mean it simply in the sense that the system should be able to act without the direct intervention of humans.

An agent-based system may contain more than one agent, and the multi-agent case means that a system is designed as several agents interact with each other. One of the major advantages of the multi-agent approach is to help us understand the conceptualization of a system easily and completely. The issue of multi-agent approach is addressed and has been widely applied in different domains, including air traffic control, information management, electronic commerce, games, etc. A lot of researches have been done considering multi-agent approach in supply chain [8][15][19][14][17][3]. The supply chain of a manufacturing enterprise may be widely distributed over world and formed an international network involves heterogeneous environments. Multi-agent approach provides a natural way to design and implement manufacturing enterprise integration and supply chain management within such environment [16].

Shen and Norrie[16] simultaneously proposed that multi-agent based approaches have the following advantages for enterprise integration and supply chain management.

- increasing the responsiveness of the enterprise to the market requirements;
- involving customers in total supply chain optimization;
- realizing supply chain optimization through effective resource allocation;
- achieving dynamic optimization of materials and inventory management;
- realizing total supply chain optimization including all linked enterprises;
- increasing the effectiveness of the information exchange and feedback.

Fox et al.[8] originally applied multi-agent based approach in supply chain modeling. Agents perform one or more supply chain functions, and coordinate their actions with other agents. Swaminathan[19] developed a flexible and reusable multi-agent based framework to model supply chain dynamics. The similar concept of multi-agent approach is presented by Teigen[15]. Lin and Shaw[14] simulate the operations of supply chain by means of multi-agent based system to reengineer the order fulfillment process.

Thus it can be seen that multi-agents based approach provides a useful tool to model the complicated structure of a supply chain network.

3. Design

3.1 Simulation Model

The paper seeks to provide a perspective of supply chain performance as a whole, which can help to understand how the members of supply chain interact with each other. In order to study how complex systems operate, we need a powerful tool. And of all analytic methods, simulation is a widely used and increasingly popular method for studying complex system [9]. Some of possible advantages of simulation were identified following: (1) to evaluate real world systems that are too complex to be accurately described by mathematical models; (2) to estimate the performance of existing systems under operation; (3) to compare alternative proposed system design; (4) to maintain better control over experimental conditions; (5) to study the detailed operations of a system with a long time frame.

The purpose of this paper is to begin to construct a simulation model for performance evaluation as is shown in Fig. 1. Three categories of input data are distinguished: the network structure, the planned data and the random variates.

First, this paper develops a flexible and reusable simulation model to depict the operations of a generic supply chain network without lots of assumptions and restrictions as previous studies. The complicated structure of a supply chain network could be repeatedly constructed by different input data including number of members, attributes of each member, and relationships between members. The number of members signifies the quantity of entities from raw suppliers to retailer in a supply chain.

Secondly, the model treats uncertainty of supply chain using probability concepts to generate random variates. There are three distinct sources of uncertainty that needs simulation this system: customer demand, manufacture process variance, and delivery delay. We use the "uncertainty cycle" that Davis[5] states to describe operations of unstable supply chain. Unpredictable fluctuations in customer demand start things rolling. According to market forecast or experiments, materials are purchased, but suppliers do not always delivery right products on time. Then manufacturers start to produce finished products, but problems of manufacturing process happened. Finally, the products are shipped to customers.

Customer demand is modeled as an expected value of amount ordered plus a random variate distributed uniformly. The standard deviation of this variable stands for demand instability. Manufacturing process variance is generated the same as customer demand in accordance with the quantity of daily production less a random variate represented the level of manufacturing instability. Finally, delivery delay is modeled as delivery time plus a random variate from uniform distribution. The degree of inconsistency is measured by the standard deviation of lateness.

Finally, planned data corresponding to each entity is necessary for simulation. The data including bill of materials, lead time, initial inventory, holding and order cost for inventory, and safe stock level could be read into simulation system from a binary formatted file and altered with graphic user interface provided by system.

Output variables were reported to evaluate performance of supply chain. A supply chain management places emphasis on three separates types of performance measures: resource measure, output measure, and flexibility measures [2]. Resources are generally measured in terms of the minimum quantity such as inventory level, transportation costs, manufacturing costs, etc. Outputs measure customer services including the ability to fulfill orders within due date (fill rate), to delivery products to customers within the time quoted (on-time deliveries) [15]. Flexibility is used to measure the ability to respond to changes in the uncertain environment.

In other words, by inputting different value of parameters, the simulation system could represent different types of supply chain. The configuration of the supply chain can be modified by setting different network architecture, changing planned data, or adjusted the level of variation for the realistic situation.

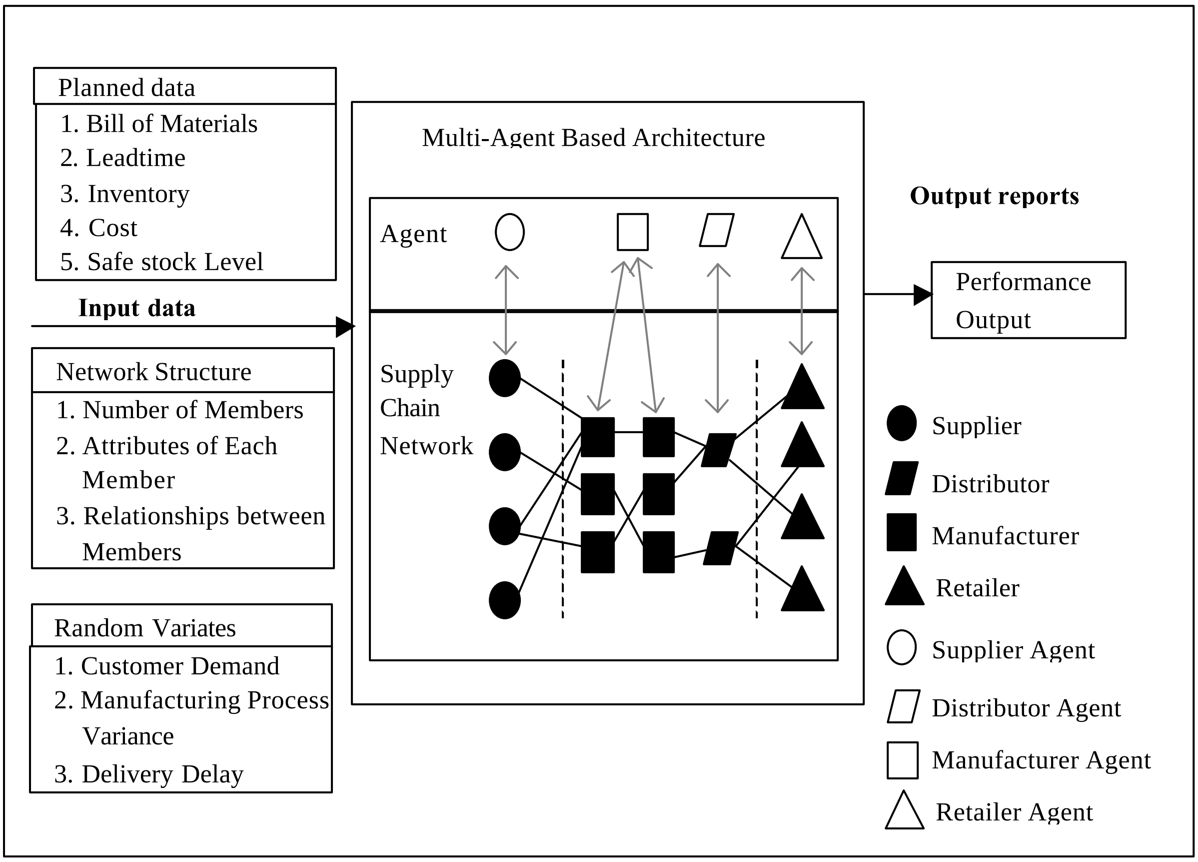

Fig. 1 Supply chain simulation model

3.2 Agents

Teigen[15] considered that a supply chain can be visualized as a set of entities and process. Entities (modeled as agents) may be suppliers, plants, distribution centers, customers, etc or it many be internal departments such as sales, planning, purchasing, materials, or research and development. The supply chain library proposed by Swaminathan[19] identifies two categories – structure elements and control elements. Structure elements (modeled as agents) correspond to which actually involve in production and transportation process of supply chain including retailer, distributor, manufacturer, supplier and vehicles. Control elements are policies aimed to coordinate the flow of products and information.

As indicted early, an agent can be performed a specific independent entity and used to represent a member of the chain. Each agent owns its functions for operations and can interact with other agents.

(1) Retailer Agent

A retailer is where customers buy products. The interarrival and the amount ordered are generated by retailer agents and modeled as random variates from uniform distributions, which can represent the situation of demand uncertainty.

(2) Distribution Center Agent

Traditionally, a distribution center is responsible for receiving products from a manufacturing plant, storing them and shipping them to retailers. But now distribution center agents have the capability of simply assembling process for customized products. As orders come from retailer agents, distribution center agents assemble the finished products using parts that manufacturer or supplier agents turn out and then the products are shipped to customers.

(3) Manufacturer Agent

A Manufacturer is where components are assembled and products are manufactured. Orders come from distribution center or other manufacturers. Production can be simulated as either a make-to-order (MTO), make-to-stock (MTS) or assembly-to-order (ATO) strategy on a basis of characteristics of supply chain. After receiving orders, manufacturer agents assign the due date according to the status of inventory and manufacturing and delivery time. Manufacturer agents have an associated bill of materials(BOM). If materials are insufficient for production, materials are purchased from other manufacturing plants and external suppliers.

(4) Supplier Agent

A Supplier supplies raw parts to the manufacturing plant. The difference between a manufacturing plant and a supplier is whether a company has direct control on their internal operation or not.

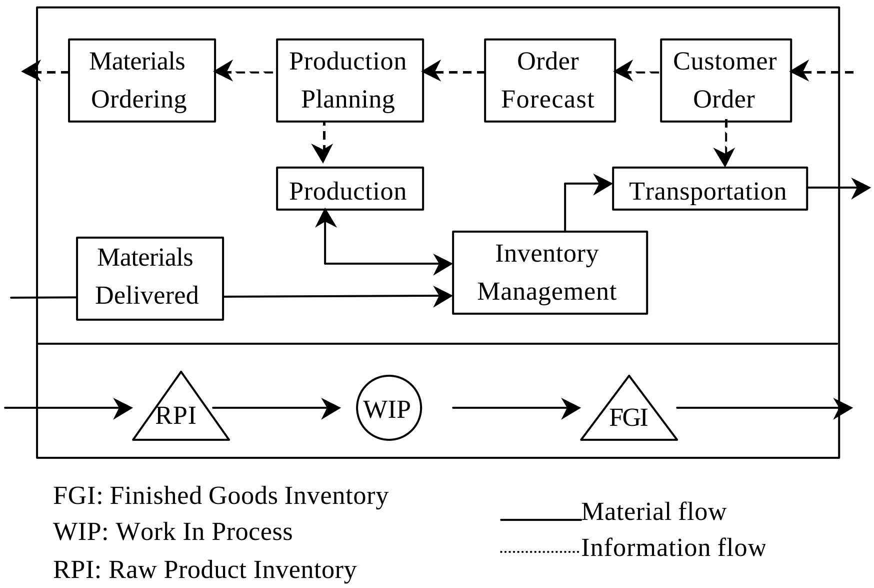

Fig. 2 Internal operation and external interaction processes of an agent

In addition, we describe the internal operation of an agent and external interaction with other agents shown in Fig. 2. If an agent receives orders from its customers, it assigns a due date to the order based on the information of inventory status, production plan and manufacturing capacity. At due date, if inventory is available, the ordered products are delivered and shipped to customer.

At the beginning of a week, the agent starts to forecast demand. According to production strategy of enterprise, a make-to-order or make-to-stock strategy works for production planning. An agent inspects the rolling projected availability of inventory to decide the production schedule in next eight weeks. On the basis of master production schedule, inventory status, and a bill of material, an agent continues planning the required amount of materials and offsetting lead time informed by upstream supplier. Then, materials are purchased at order release date. If the order is fulfilled, the inventory level of raw parts is adjusted accordingly and the reached date is recorded.

4. Simulation

4.1 Simulation Environment

It is interesting to challenge whether the performance of distinct types of SCN between the globalization and the localization of a supply chain will be the same or not. In this paper, we implement the supply chain of a company in the computer industry designed to simulation Type II SCN categorized by Strade, Lin and Shaw[14]. The distinguishing characteristic of Type II SCN is the final assembly process at distribution centers for the goal of mass customization. The computer industry involves Type II SCN using an assembled-to-order strategy to meet the demands. But, the longer lead time would result in worse forecast error, more terrible demand unfulfillment and higher inventory level. The main issue of this SCN is to reduce the lead time of the assembled-to-order process.

A typical global supply chain for the fabrication of a personal computer (PC) is shown as Fig. 3 below [1][15]. The complex assembly processes for motherboards and PC boxes are executed at manufacturing site. The suppliers are responsible to provide raw parts such as CPU chips, power supplies, disks, etc for manufacturers and distributors. As orders come from customers, the finished products (computers) are simply assembled at distribution center using assemble-to-order approach.

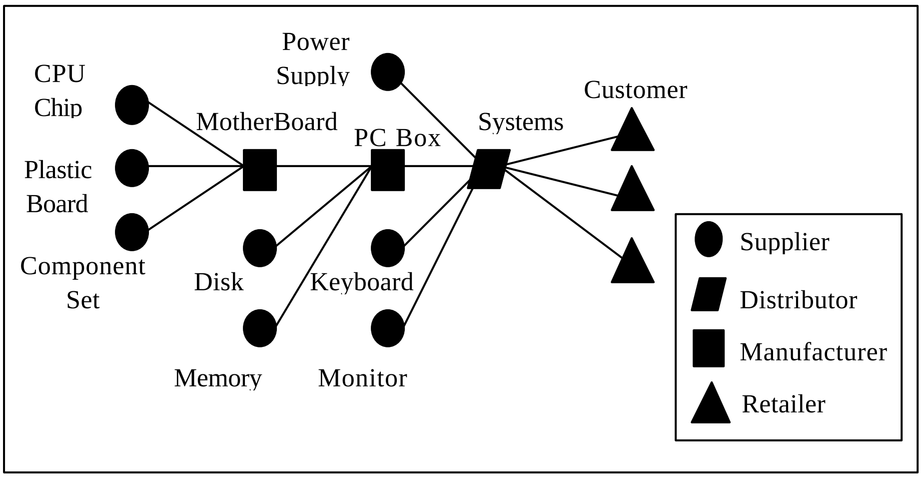

Fig. 3 A supply chain model for the PC industry

The global supply chain represents the fabrication stages, locations (See Table 2), and recipes as a global bill of materials (See Table 3) [1][15]. Suppliers according to Table 2 listing where is located consist of two types, responsive and slow suppliers. The former takes three weeks shipment to customers, and the latter takes one week to ship orders.

Table 2 Location of suppliers

Supplier	Product	Location
Intel Inc	CPU Chips	USA
Hard Plastics Inc	Plastic Board	Canada
Motorola Inc	Component Set	Japan
Yoshi Disk Inc	Disk	Japan
Fuji Memory Inc	Memory	Japan
Honshu Digital Inc	Monitor	Japan
Super Power Inc	Power Supply	Canada
Keyboard Inc	Keyboard	Canada

Table 3 Bill of materials

Manufacturer	Product	Quantity
MB Plant	Mother Board	
	CPU Chips	2
	Plastic Board	1
	Component Set	1
Cbox Plant	PC Box	
	Mother Board	1
	Disk	2
	Memory	1
SYS DC	Computer	
	Computer Box	1
	Monitor	1
	Power Supply	1
	Keyboard	1

4.2 Simulation Results

The simulation results from performance evaluation between globalization and localization of a Type II supply chain are shown in Fig. 4 through Fig. 6 below. The main performance indicators are (1) fill rate, (2) average amount of backorders, (3) cycle time. The variations of delivery delay are distinguishing, including x1, x2 and x3 (a multiple of standard deviation). The x1 represents the slight variations and the x3 is the most serious of them. The level of production and demand instability are held constant. Fig. 4 illustrates backorders of globalization using various variations of delivery delay in a Type II SCN. Fig. 5 and 6 illustrate fill rate and cycle time in a Type II supply chain using various variations of delivery delay with globalization and localization polices.

Fig. 4 shows the influence of delivery performance on the average amount of backorders (Y-axis) during a finite time period (X-axis). We see that the greater variance of delivery delay results in the greater variance of the amount of backorders in a global supply chain. It is interesting that the changes of variations, x1 and x2, do not differ a lot, but x3 shows itself in the form of an apparent ripple for the variance of backorders. As for the localization of the supply chain, the impact of delivery delay on backorder is quite slight.

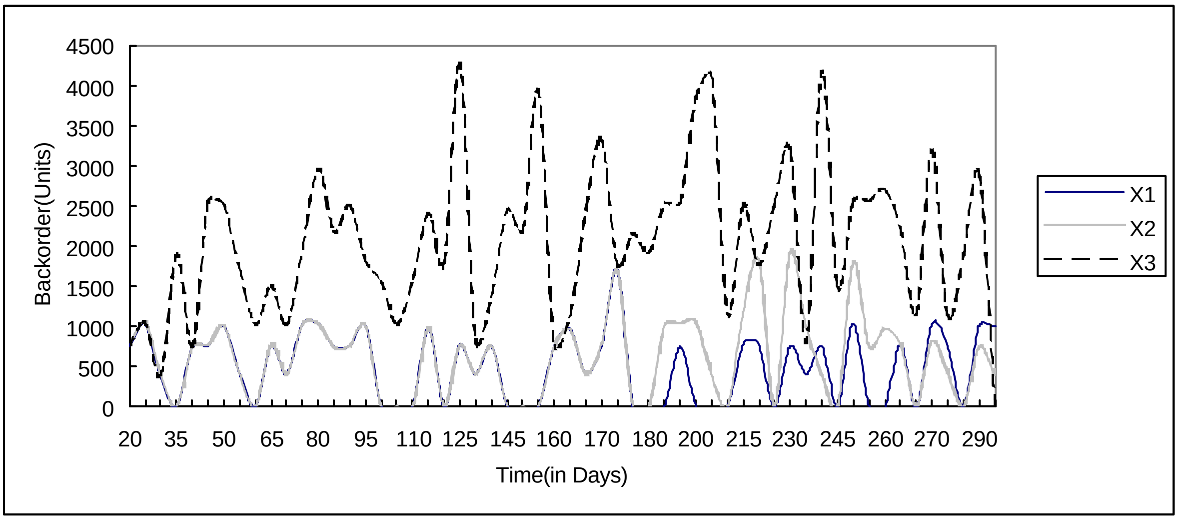

Fig. 4 Backorder of globalization using various variations of delivery delay in a Type II SCN

In Fig. 5 the simulation model is used to look at the impact of delivery performance on fill rates. Each point on the graph represents the percentage of the demand filled from the stock on hand. We see that if the supply chain is stable, the fill rate would reach 100% either globalization or localization of a supply chain. As the delivery delay happens, the fill rate of localization is more stable and greater than that of globalization. That means the fill rate of localization has very little influenced by variances of delivery delay.

Fig. 6 shows the cycle time between globalization and localization policy. The expected result is given that the cycle time performance of a global supply chain is worse because of long shipping and lead times. The steeper slope on the graph means that the variance of delivery delay makes a great impact on a global supply chain.

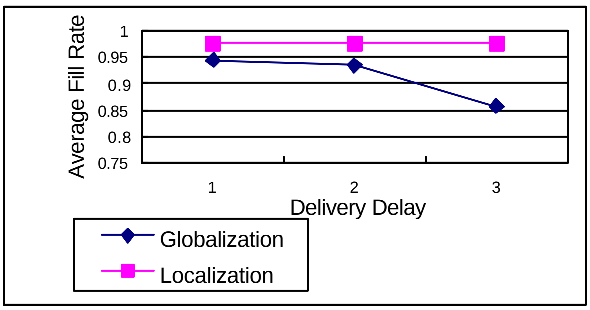

Fig. 5 Fill rate of globalization and localization using various variations of delivery delayin a Type II supply chain

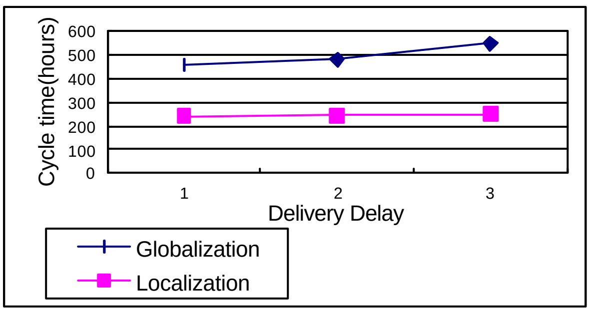

Fig. 6 Cycle time of globalization and localization using various variations of delivery delay in a Type II supply chain

5. Conclusion

Based on the literature and prior knowledge, we use multi-agent approach to provide a flexible model framework described above. Entity and process of a supply chain are identified in this paper. In order to understand the impact of delivery performance between globalization and localization of a Type II supply chain, this model is used to simulation for several situations. Results from the simulation of globalization, show that the problem of longer lead time and shipping time is inevitable. As the variances in delivery lateness increase, the influence on performance is more obvious. The effective approach to overcome this problem is to coordinate the activities of supply chain in order to reduce the level of uncertainty.

Further researches are being undertaken:

(1) The influence on other types of supply chain, Type I and II SCN, should be understood whether the performance of distinct types of SCN between the globalization and the localization will be the same or not.

(2) Besides the variances in delivery performance, demand and manufacturing instability should be taken into consideration.

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