Research on the Framework of Supply Chain Logistics Storage Base Location Based on Stochastic Demand Algorithm

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Abstract

In the background of market economy, with the continuous development of social economy, people's quality of life and their consumption capacity are also increasing; especially with the rapid development of electronic commerce, the competition among enterprises is fiercer and the uncertainty of the whole market demand is greatly enhanced. Therefore, enterprises must maximize the utilization of their resources so as to effectively enhance their own economic benefits, reduce the operating risk of market economy, and improve the competitiveness of enterprises. As a new operation mode of enterprises, supply chain management model is a more scientific and effective competitive strategy for enterprises; it is conductive to give full play to the overall efficiency to conduct in-depth exploration and implementation of the supply chain management theory as well as the combination with the practice of enterprise management. As an important part of supply chain system, especially in the background of the high development of e-commerce, logistics network can play an irreplaceable role in the combination of the supply side and the demand side, and has become one of the key industries with the fastest development level in China at present; the establishment of a perfect supply chain logistics storage base is of great significance to enhance the competitiveness and influence of enterprises. Therefore, this paper studied the address selection of supply chain logistics storage base based on the hybrid genetic algorithm, providing reference for the level of selection of supply chain logistics storage base.

Keywords: Hybrid Genetic Algorithm, Supply Chain Logistics, Storage Base.

1. INTRODUCTION

1.1 Research Background

The concept of logistics originated in 1918, when the Instant Delivery Co., Ltd., established by Lord Hamm, undertook the nationwide delivery of goods. During World War II, in order to secure the front-line arms demand, for the first time, the concept of "logistics management" was put forward, and the comprehensive management of the warehousing, transporting and dispensing of arms was carried out; because of its superior characteristics, it was widely valued by the Americans and applied to the enterprise construction after the end of the World War II. In the late 1950's, Japan formed a delegation to study the advanced experience of American logistics, followed by the PD Enlightenment; until 1964, PD had aroused the attention of Japanese Government and relevant experts and scholars, and the construction of enterprise logistics system was carried out, which played an important role in the development of enterprise supply chain. This is one of the main reasons for the rapid economic development in Japan after the war. Supply chain is a more extensive enterprise structure model, which includes suppliers, manufacturers, distributors, third-party platforms and customers, and many other subjects; as a form of logistics to carry out economic and trade activities smoothly, supply chain logistics mainly undertakes to coordinate the operation of production, supply activities, sales activities and logistics activities, and has the comprehensive strategic management obligations.

1.2 Literature Review

The supply chain system has the characteristics of high complexity, and the adopted management method should take into account each individual in the supply chain and adopt a coordinated management method. Supply chain management means that under the constraints of a complete supply chain framework, it is possible to give full play to the organization, planning, coordination and incentive functions of supply chain management by analyzing
and mastering the general law of the inner part of supply chain and the connection between its individuals, conduct scientific management for all important aspects of the product logistics process, and achieve the maximum effect of supply chain logistics management, so as to effectively improve the management ability of supply chain logistics and provide customers with greater added value (Yang and He, 2016). The basic objectives of supply chain logistics management are as follows: first, the minimization of total costs, ensuring not only that the cost of transportation and warehousing is minimized, but also that the total cost in the whole supply chain logistics is minimized; second, customer service optimization, as customer is the key to supply chain development, providing customers with better supply chain logistics services and having a direct impact on the promotion of the development of supply chain; third, the minimization of the total inventory, as the most ideal state of logistics is zero inventory, and how to ensure the minimization of total inventory is the key problem of supply chain logistics research; last, the minimization of the total cycle time, as the competition between supply chains is in a certain degree a time competition, and reducing the supply chain logistics cycle time can effectively promote the supply chain development (Ma and Shen, 2016). Supply chain logistics mainly involves four components: supplier, intermediary business, third-party service platform and customer; based on their different functions, supply chain logistics can be divided into three modes: first, bulk logistics, that is, to forecast according to the needs of customers so that bulk operation, procurement, production and sales work can be carried out; second, order logistics, which is implemented mainly in accordance with customer orders. Order logistics is divided into two modes, one is the Dell Model driven by the final consumer order, and the other is the Haier mode driven by the channel customer order; last, the punctual logistics, which means after accurately determining the efficiency of each process in the production line, eliminate all invalid operation and waste mode according to the accurate plan of the order (Li, 2015).

2. LOCATION MODEL OF SUPPLY CHAIN LOGISTICS STORAGE BASE BASED ON STOCHASTIC ALGORITHM

2.1 Main Model of Supply Chain Logistics Storage Base Location

The main factors to be considered in the location of supply chain logistics storage base are freight rate, regional cargo throughput, transportation average distance, and so on. The model is shown below:

\[ \min TC = \sum_i V_i R_i d_i \]  

(1)

Where, TC represents the total cost of transportation, minTC represents the lowest cost of transportation, \( V_i \) represents the freight volume from the storage base to point i, \( R_i \) represents the transport rate from the storage base to point i, and \( d_i \) represents the distance from the storage base to point i (Li, 2015). The following two sets of equations can be used to determine the address of the storage base:

\[ \bar{X} = \frac{\sum_i (V_i R_i X_i / d_i)}{\sum_i (V_i R_i / d_i)} \]  

(2)

\[ \bar{Y} = \frac{\sum_i (V_i R_i Y_i / d_i)}{\sum_i (V_i R_i / d_i)} \]  

(3)

where both X and Y represent the coordinates for the location of the goods to be delivered, and \( \bar{X}, \bar{Y} \) represents the pending coordinates of the logistics distribution facility (Xie and Gao, 2011). In the above formula, distance d is a key variable (Zhang et al., 2015), and the value of d can be derived from the following formula:

\[ d_i = K \sqrt{(X_i - \bar{X})^2 + (Y_i - \bar{Y})^2} \]  

(4)

In the above formula, K is a measure factor whose main function is to convert the axes of X and Y into a unit of
distance measurement commonly used in logistics (Fu et al., 2011). Therefore, when solving this kind of model, the iterative method can be used to solve the value of $d$, loop network in an iterative way, in which $\bar{x}, \bar{y}$ will eventually shrink in the process of iterative calculation until the goods have reached a small numerical bit (Chen and Yue, 2011). Since this method usually takes the centroid point of the distribution demand points as the initial point, it is generally called the centroid method.

2.2 Supply Chain Distribution Network Model

In the supply chain, in order to effectively improve the reaction speed, there will be a large number of retailers; while in order to reduce logistics costs and production costs, a company will establish a number of production plants (Dong, 2014). In order to meet the logistics demand of retailers and production plants and to solve the complexity of cost and management of supply chain logistics, it is necessary to optimize the location of storage base. The supply chain distribution network is shown in Figure 1:

![Figure 1. Supply Chain Distribution Network](image)

In Figure 1, F represents a factory location, W represents a warehousing base or distribution center, and D represents a retailer. Among them, the factory is the source to provide goods; logistics transports the goods provided by the factory to the warehouse center, and delivers the goods according to the retailer's order demand in a targeted way, thus constituting a complete supply chain logistics network.

2.3 Supply Chain Logistics Service Level Evaluation

For enterprises, its service level is mainly embodied in the ability of meeting the needs of customers or suppliers when there is a lack of inventory of a commodity and there is an order demand. When an enterprise receives an order but there is a lack of inventory, it generates an out-of-stock problem, in which case the service level of the enterprise can be measured. In the same way, the service level of supply chain logistics can be evaluated by this method, and the main measurement methods are as follows:

First, the supply rate of a product refers to the proportion an enterprise uses the inventory products to meet the total demand in a market environment. Suppose that an electronic product company provides 85% of its customers with goods from its inventory, while the remaining 15% of its customers will be lost and be acquired by other electronic products companies, mainly because of insufficient inventory to meet the customers' demands (Liu et al., 2014).

Second, the order completion rate refers to the proportion an enterprise uses the inventory products to meet the all the order demands of a certain goods. Generally speaking, when there is a variety of products, only when the order can meet all of the products, it will prove that the enterprise can provide high quality service. Suppose that a customer put forward an order for the purchase of TV sets and DVD to an electronic products company, only by meeting the order demand of the customer can the company ensure the service quality.

Third, replenishment cycle supply level refers to the proportion of replenishment cycles that can meet all customer demand in all replenishment cycles. Replenishment cycle refers to the time interval between two continuous replenishing points of delivery; to some degree, the higher the replenishment cycle supply level, the less the shortage of goods will be. Suppose that an electronic products parent company retailer supplies quantitative goods, and if there are 7 replenishment cycles without shortage of goods among the 10 replenishment cycles, the replenishment cycle supply level will be 70% (Lei and Ma, 2016).
3. BASIC ASSUMPTIONS AND SYMBOLIC MEANINGS OF THE LOCATION OF SUPPLY CHAIN LOGISTICS STORAGE BASE

3.1 Model Assumption of Supply Chain Logistics Storage Base Location

In the supply chain logistics system, each factory can provide products to distribution center through the logistics storage base. Distribution centers will sell goods to retailers all over the world, so as to form a complete supply chain. Among them, plants and distribution centers have larger scales and relatively fixed geographical position, and their logistics cost and the indicators are known. As far as the demand is concerned, the order tells that each retailer's demand is more or less fixed and known and shows the characteristics of normal distribution, and each retailer's orders are determined by the market in which it is placed; therefore, there are no connections among them. From the perspective of time, most of them are for weeks, months or years, and each link is consistent (Guo and Lu, 2016).

3.2 Symbolic Connotation of Supply Chain Logistics Storage Base Location

In the supply chain logistics storage base location, i represents the number of goods factory, i ∈ {1,2, ..., m}; j represents the number of goods distribution center, j ∈ {1,2, ..., m}; k represents the number of goods retailer, k ∈ {1,2, ..., m}; T represents the research interval length; L represents the lead time of goods distribution center; C_i represents the single ordering cost of the goods distribution center; x_{ij} represents the holding cost of the unit time and unit product of the goods distribution center; C_b represents whether it is logistics from goods factory i to goods distribution center; y_j represents whether the j goods distribution center has been put into use; z_{jk} represents whether it is logistics from goods distribution center j to retailer k.

3.3 Data Collection of Supply Chain Logistics Storage Base Location Model

Supply chain logistics storage base location needs to consider multiple projects and data, including plants, distribution centers, retailers, customers, product information, product demand, etc. In addition, in the logistics cost, it is reflected in the mode of transportation, transportation fees, warehouse cost, labor cost, storage cost, logistics enterprises operating costs, etc. Therefore, in order to collect the data of the model, it is necessary to forecast the demand information of the retailer. As mentioned above, different retailers are independent of each other and do not have relevance (Guo and Zhao, 2012). Therefore, the following conclusion can be drawn:

For a retailer k, the unit time demand is in normal distribution, that is:

$$D_k \sim N(\mu_k, \sigma_k^2)$$  \hspace{1cm} (5)

For a retailer k, the research interval demand is in normal distribution, that is:

$$D_{ki} \sim N(\mu_{ki}, \sigma_{ki}^2)$$  \hspace{1cm} (6)

$$\mu_{ki} = T \mu_k$$  \hspace{1cm} (7)

$$\sigma_{ki}^2 = t \sigma_k^2$$  \hspace{1cm} (8)

For a distribution center j, the unit time demand is in normal distribution, that is:

$$D_j \sim N(\mu_j, \sigma_j^2)$$  \hspace{1cm} (9)

$$\mu_j = \sum_{k=1}^{s} z_{jk} \mu_{kj}$$  \hspace{1cm} (10)
\[ \sigma_{jt}^2 = \sum_{k=1}^{s} z_{jk} \sigma_k^2 \]  

(11)

For a distribution center \( j \), the research interval demand is in normal distribution, that is:

\[ D_{jt} \sim N(\mu_{jt}, \sigma_{jt}^2) \]  

(12)

\[ \mu_{jt} = \sum_{k=1}^{s} z_{jk} \mu_{kt} \]  

(13)

\[ \sigma_{jt}^2 = \sum_{k=1}^{s} z_{jk} \sigma_k^2 \]  

(14)

Order lead time demand distribution is as follows:

\[ D_{jl} \sim N(\mu_{jl}, \sigma_{jl}^2) \]  

(15)

\[ \mu_{jl} = L \mu_j \]  

(16)

\[ \sigma_{jl}^2 = t \sigma_k^2 \]  

(17)

### 3.4 Distance estimation

Logistics cost is the cost incurred in the process of transport of goods from one point to another point; it can be expressed in a function. The most critical step is to estimate the distance between the two points. Assume that two points are represented in coordinates, where point A’s coordinates are \((x_A, y_A)\), and point B’s coordinates are \((x_B, y_B)\), then the linear distance between them can be obtained, as shown below:

\[ D_{AB} = \sqrt{(x_A - x_B)^2 + (y_A - y_B)^2} \]  

(18)

The above formula is mainly based on map distance, where \( k \) refers to the zoom distance of the map. This formula can effectively and accurately judge the linear distance between two points, but in actual use, is limited by factors such as road, and cannot judge the distance between the two points in accordance with the linear distance; at the same time, the road distance value is not emphasized. Therefore, in general there are two ways to optimize the formula above: The first is to add an indirect coefficient in \( D_{AB} \), which is set to \( \rho \); according to the road level in different regions, the indirect coefficient \( \rho \) has different values. In cities, for example, \( \rho = 1.3 \) generally, and in rural areas, it can be set to 1.15. This method is relatively simple, but easy to produce certain error values. The second method is to calculate the error between two points by the geographic information system; the accuracy of this method is higher, but it is more complex and relatively more expensive compared with the first method (Long and Xu, 2012).

### 3.5 Storage Cost Composition

In the supply chain logistics system, there are two main kinds of storage costs: The first is the handling cost, or the amount of human and material costs incurred in the process of loading and unloading, handling, and storage. Handling cost has a direct correlation with the flow level of the storage base. The higher the flow level is, the higher the handling cost will be. The second is the fixed cost, which is an inevitable cost of the warehouse base regardless of its flow rate, such as site cost, staff wage, equipment maintenance and update, etc. Fixed cost is generally related to the construction scale of the logistics warehouse. The larger the construction scale of the
warehouse is, the greater the logistics costs will be generated (Wang and Zhang, 2012).

3.6 Construction Location of the Distribution Center

The location of distribution center directly affects the supply chain logistics and warehousing costs, while the choice of distribution center is restricted by various conditions. The first is geographical conditions. Distribution center should be established in a flat and well-traffic-environment location to ensure that retailers in all directions can provide the best logistics services. The second is the richness of the local labor force; although the current logistics industry has started the informationization construction, and the degree of application of artificial intelligence is higher and higher and much work can be done by intelligent processing, the delivery of goods is mostly completed by manpower. The abundance of local labor force directly affects the service and development level of distribution center. The third is the local tax system. Different areas have certain differences in the tax system, and tax may give a heavy burden to enterprises; therefore, how to choose an ideal location with relatively low taxes and other excellent conditions has become a key problem of the selection of distribution center location. These are the key issues to be considered in the construction of distribution center, and solving them can effectively reduce the cost of supply chain logistics.

ACKNOWLEDGMENTS

Funded by: The Science and Technology Research Project of Hubei Provincial Department of Education: Research of fourth party logistics routing optimization problem considering behavior of decision makers. (Q20171104).

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