Equilibrium Control Method of Logistics Supply Chain of E-commerce Platform Based on Big Data

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ABSTRACT
In order to better manage the massive logistics information, this paper puts forward the balanced control method of logistics supply chain of e-commerce platform based on big data, constructs the e-commerce logistics supply management system combined with the big data plan, optimizes the evaluation index and algorithm of logistics supply chain evenness of e-commerce platform, and simplifies the balanced control steps of logistics supply chain of e-commerce platform. Finally, experiments show that the logistics supply chain equilibrium control method of e-commerce platform based on big data can effectively improve the effectiveness of logistics control management and fully meet the research requirements.

Keywords: *big data, electronic commerce, logistics supply chain, equilibrium control.*

1. INTRODUCTION

The logistics supply chain of e-commerce platform is composed of logistics routes and warehouses in various cities. With the accelerating pace of urbanization, it is more necessary to balance the multi-level supply chain of logistics and warehousing[1]. However, in the actual process of Multi-level Supply Chain equilibrium control of logistics warehousing, the implementation of Multi-level Supply Chain equilibrium control of logistics warehousing has fallen into a bottleneck because it is unable to grasp the evolution process of competition among multi-level supply chains[2]. The organization of logistics equilibrium control directly affects the performance of e-commerce platform, and then affects the operation efficiency of the whole supply chain. In all operations of e-commerce platform, logistics operation plays a role equivalent to the heart of human body and the compressor of air conditioning system. Logistics operation is the most labor-intensive operation, while in the automatic warehouse system, it is the most capital intensive operation[3]. Any error in logistics operation may lead to customer dissatisfaction and high operation cost, and even affect the whole supply chain. It can be seen that the optimal design of logistics operations and the balanced control of logistics supply chain of e-commerce platform have a decisive impact on the operation efficiency of e-commerce platform[4]. Traditional methods carry out static feedback control on the state of logistics warehousing supply chain, so that the dynamic system of supply chain can restrain the interference of uncertain factors, but it ignores to obtain the fitness function of supply chain equilibrium control, resulting in low control accuracy. In order to reduce the logistics operation cost of sub business platform and improve the competitiveness of the whole supply chain, which has positive theoretical and practical guiding significance, a balanced control method of logistics supply chain of e-commerce platform based on big data is proposed[5]. According to the defects of traditional methods, this paper improves the layout of logistics warehousing, controls the multi-level supply chain equilibrium of logistics warehousing, gives the constraints of equilibrium control, and obtains the fitness function of Multi-level Supply Chain equilibrium control.

2. E-COMMERCE PLATFORM LOGISTICS SUPPLY CHAIN EQUILIBRIUM CONTROL

2.1. Construction of E-commerce Logistics Supply Management System

E-commerce logistics supply management is a structural concept produced with the development of regional economy[6]. It is not only a thinking mode of e-commerce platform with global optimization, but also a regional logistics control thought with instrumental characteristics. Generally speaking, the regional logistics system must be developed in combination with the specific regional location conditions, regional economic level, regional industrial and social development needs, especially the development of manufacturing industry to provide a complete logistics function with integrated and public attributes. Therefore, on the basis of previous research, the characteristics of regional logistics system are summarized, as shown in the table 1:

Table 1. Characteristics of regional logistics management system

Features	Interpretative statement
Entirety	It shows that the district logistics system is composed of multi-objective attributes. Multiple influencing factors. The organic whole of coordinated development composed of multiple subjects, each node. There is a relatively stable close relationship between the elements.
Regionality	It shows that the district logistics system is established within the regional boundaries of specific regions and has the attribute of matching with specific regions.
Openness	It shows that the district logistics system and its constituent elements are not closed cycle, and the logistics nodes or lines belong to multiple logistics systems at the same time.
Hierarchy	The elements of district logistics system will show different structures, usually a multi-level circular system
Complexity	The operation of district logistics system actually includes logistics and information flow The pole transportation grid formed by capital flow will involve manufacturing enterprises, energy supply, logistics, etc.
Equilibrium	The operation of regional logistics system shows the quantity of logistics. The equilibrium characteristics of structure and time.

In a specific region, the regional logistics system has the above characteristics, and corresponding to the characteristics, the regional logistics system plays many functions in the regional economic development, as shown in the table 2.

Table 2. Functional description of regional logistics management system

Function	Interpretative statement
Foundation support	It shows that the district logistics system is the infrastructure to provide logistics services for manufacturing and other industries.
Information interaction	The first is the information interaction with the manufacturing industry, and the second is the information interaction among multiple subjects in the regional logistics system. Delivery includes logistics information, capital and other related information.
Resource integration	Provide timely and accurate logistics resources for multiple logistics entities
Multi-Agent Coordination	It refers to the goal of coordinating multiple subjects in the district urban logistics system. Operation connection to ensure the orderly operation of district and city logistics
Benefit balance	It refers to the distribution of benefits according to a certain established contract in the process of coordinating multiple entities to jointly provide logistics services
Shared risk	It refers to that multiple entities of the district logistics system jointly bear the logistics services and related risks, so as to ensure the orderly operation of the district logistics services and service objects.

The functional areas of logistics management of e-commerce platform are basically divided according to logistics units, which can be divided into pallets, boxes and single products. The logistics supply chain balance control unit is determined according to the results of order analysis. If the smallest unit of order is box, the box is the logistics unit; if the smallest unit of order is single product, the single product is the logistics unit: if the ordering unit has both box and single product, there must also be two kinds of logistics units in the e-commerce platform, In the design, zoning must be considered for each case.

Reducing the handling times and minimizing the cost are the important objectives of the balanced control of the logistics supply chain of the e-commerce platform. Moreover, material handling and walking are the main operations in the logistics operation, and occupy most of the funds of the balanced control cost of the logistics supply chain of the e-commerce platform. Take this as the goal as the main factor to measure the quality of the scheme. Suppose that the product of the weight of the goods and the distance the goods are transported is D, and the logistics strength E increases with the increase of the transportation volume and the transportation distance, which is consistent with the relationship between the logistics transportation cost, the transportation volume and the transportation distance. Therefore, the logistics handling cost can be simply described by logistics intensity. Let $\left[D_c\right]$ represent the flow of the c-th process, and $\left[D_{\mathrm{a}}^{\mathrm{X}}\right]$ represent the operation distance between area J and area K. According to the total length of different shelves, the layout model is used to determine the best layout structure of the logistics area. When the total shelf length is certain, the roadway length will gradually decrease with the increase of the number of lanes. In this way, the length y of the shelf in each roadway is equal to 1 / 2 of the ratio of the total length L of the shelf to the number of lanes. Considering the number of roadways under the minimum path length, the optimal layout of logistics area related to walking distance can be obtained. As the minimum path length is related to storage strategy and path strategy, taking the crossing strategy under random storage strategy as an example, the logistics area with a total length of shelf l of 300m and a distance of roadway Center w = 4m is optimized. When the entrance and exit are located in the middle, $d=\left(n+1\right)/2$. For simplicity, the approximate calculation formula of formula is adopted for the travel distance in the logistics roadway. According to the above assumptions, the logistics travel distance can be simplified as:

$$D_m^{\mathrm{X}}(n,y,d)=E\left[D_{\mathrm{a}}^{\mathrm{X}}\right]+E\left[D_c\right] \quad (1)$$

The equilibrium control model of logistics supply chain is a nonlinear function. In addition to rounding the number of lanes n, the absolute value calculation related to variables also appears in the objective function, and variables also appear in the upper limit of summation. At present, such models are difficult to solve by using authoritative software such as MATALAB and lingo. However, after careful analysis, it is not difficult to see that the nth constraint is an integer, and the dependent variable y can be directly substituted into the objective function with variable n. at this time, the objective function becomes a univariate function with only one variable. The second constraint condition shows that when l = 300, the value of n is an integer between 1 and 150, the solution space of the model is very small, and there are only 150 possibilities for the layout structure, that is, from one roadway 150 meters long to 150 roadway 1 meters long. In the case of a small number of solutions, the exhaustive algorithm is a very competitive algorithm, which can get the exact optimal solution. In the logistics area layout model in this paper, the number of lanes in the shelf layout is not a large number, and takes an integer, which belongs to a discrete problem, and its solution space is very small. After inputting relevant data, in order to ensure the correctness and effectiveness of the calculation results, the exhaustive algorithm first does not consider the rounding requirements of N, and rounds the upper bound variables in the summation. First, the model is regarded as a real number programming, Call the bounded scalar nonlinear minimization program in metnable to obtain the real solution, and then search the integer solution near the real solution. The obtained result is consistent with the result of big data method.

2.2. Equilibrium evaluation algorithm of logistics supply chain

Equilibrium degree is usually a concept in economics. It is used to reflect the development differences between regions in a country or region, including economy and capital. It generally involves the following indicators: standard deviation, static imbalance difference, variation coefficient, Lorentz curve, Gini coefficient, etc. Specifically, in this paper, the concept of regional logistics system equilibrium degree is evolved from the concept of logistics equilibrium. In this paper, the concept derived from logistics equilibrium refers to that, with the support of a certain level of logistics technology, the logistics supply and logistics demand of each industrial link upstream and downstream of the industrial chain or supply chain reach a relatively stable and balanced state in terms of quantity, structure and time, so that a certain input can obtain the maximum output. According to the overall model of logistics automatic allocation control shown in the figure, firstly, physical information collection is carried out to obtain that the control parameter set of information collection of logistics supply chain by logistics sensor node a meets the requirements:

$$\begin{cases} v - D_m^{X}(n,y,d) = 0 \\ v - A_1 = \delta \cdot \left[D_a^{X} \right] + \left[D_c \right] A_2 \end{cases} \tag{2}$$

$$U = \begin{cases} v - 1 = p_1 \rho_1 A_1, \\ v = \dfrac{p_1 - p_2 + \rho_2 A_2 - \rho_1 A_1}{1 - \delta} \end{cases} \tag{3}$$

Based on the optimization design of the control objective function of logistics automatic allocation by using the big data method, the optimization design of logistics automatic allocation control under the big data environment is carried out. This paper proposes a logistics automatic allocation control method under the big data environment based on the logistics flow load balance distribution control. The tag identification technology $C(e,i)$ is used to identify the big data networking of automatic logistics allocation. The control objective function optimization of automatic logistics allocation is obtained, and the optimization control law is as follows:

$$\begin{cases} \min U \sum\limits_{1 \S i \square ke_e \in (e)} \dfrac{v - D_m^{X}(n,y,d))}{C(e,i)} \\ v - D^{X}(n,y,d) C(e,i) \\ F = \ln U - 1 \\ \sum\limits_{1 \S i \notin k, e \subseteq k(e)} \dfrac{1}{C(e,i)} + \sum\limits_{e \subseteq k(e)} \dfrac{1}{C\left(e^{'},i\right)} - 1 \end{cases} \tag{4}$$

The big data method is used for logistics allocation control, and the automatic logistics allocation information mining is carried out in combination with the information sensing and identification method. For the logistics network node B, the output logistics supply chain data meets the requirements

$$\delta \cdot v - \frac{v - D_m^{X}(n,y,d))}{C(e,i)} = 0 \tag{5}$$

In the process of Multi-level Supply Chain equilibrium control of logistics warehousing, firstly, the relationship between logistics warehousing and multi-level supply chain is given, the demand state of logistics warehousing for each level of supply chain is calculated, the robustness index of Multi-level Supply Chain equilibrium of logistics warehousing is obtained, the multi-level supply chain equilibrium mechanism $s_{gth}^{'}$ is given, and the equilibrium control of multi-level supply chain of logistics warehousing is completed by using this mechanism. The specific steps are detailed. Assuming that $s_{fg}^{'}$ represents the node set of logistics warehousing, s represents the node set of transportation, warehousing and manufacturing, B represents the multi-level supply chain system of logistics warehousing composed of core suppliers, and s represents the uncertain factors in the supply of logistics warehousing resources, the relationship between logistics warehousing and multi-level supply chain is given by using the formula

$$r_{kop}^{'} = \frac{s_{gth}^{'} \pm b_{poi}^{'}}{s_{fg}^{'}} \mp \delta \cdot v - \frac{v - D_m^{X}(n,y,d))}{\xi C(e,i)} \tag{6}$$

Where, $b_{poi}^{'}$ represents the logistics storage demand issued by the supplier according to the production progress, and δ represents the inventory time of material d at storage node ξ and K represents the inventory area of material d at storage node v, then the demand state of logistics warehousing for each layer of supply chain is calculated by Equation (2)

$$u_{dkp}^{'} = \frac{k_{dph}^{'} \times e_{dph}^{'}}{r_{kop}^{'} \mp c_{xbn}^{'}} \mp r_{kop}^{'} \tag{7}$$

Where, $k_{dph}^{'}$ represents the transportation cost of logistics storage, $e_{dph}^{'}$ for storage resources $c_{xbn}^{'}$ Consumed state vector. In order to improve the balance between logistics warehousing multi-level supply chains, first integrate the big data model to form a logistics warehousing multi-level supply chain competition network, give the direct competition relationship $r_{kop}^{'}$ among the members of each node, get the non cooperative competition relationship between the supply chain nodes of the same layer, give the storage cycle of each circulating commodity, and obtain the logistics warehousing Operating costs. The specific steps are detailed as follows. Assuming that / represents the set of logistics warehouses, J represents the set of suppliers, k = represents middlemen, represents the supply and demand relationship of goods, and e represents the service relationship of logistics, a multi-level supply chain competition network of logistics warehousing is formed by using formula

$$G_K^{'} = \frac{E_{'} \mp K_{kw}^{'}}{\mu_{se}^{'}} \times \left\{ J^{'} \times I^{'} \right\} - u_{dkp}^{'} \tag{8}$$

Let $J^{'}$ represent the circulation state of goods, $I^{'}$ represents the service state of the warehouse, $\mu_{se}^{'}$ represents the sales state of the middleman, the middleman puts the market demand goods $K_{kw}^{'}$ in the logistics warehouse, and $E_{'}$ represents the type of goods required by the market. The direct competition relationship among the members of each node in the network is given in the formula. To sum up, it can be explained that in the process of balanced and optimal control of multi-level supply chain of logistics warehousing, first integrate the big data model to form a multi-level supply chain competition network of logistics warehousing, give the direct competition relationship among members in each node, get the non cooperative competition relationship between supply chain nodes in the same layer, and give the warehousing cycle to be experienced by each circulating commodity, Obtaining the operation cost of logistics warehousing lays a foundation for realizing the balanced and optimal control of multi-level supply chain of logistics warehousing.

The existence of this waiting time, on the one hand, will cause idle waste of personnel and equipment, on the other hand, will delay the logistics operation of the next cycle, and finally affect the overall operation efficiency of the e-commerce platform. The purpose of time equilibrium design is to minimize the waiting time in the logistics process under the established logistics strategy. A brief analysis of logistics strategies in the three main logistics regions is shown in table 3.

Table 3. Logistics equilibrium control strategy of e-commerce platform

Project Partition	Picking area of three-dimensional warehouse	Pallet shelf picking area	Flow shelf picking area
Safekeeping unit	Tray	Tray	Tray
Picking unit	Tray, box	box	Single product
Commodity characteristics	Large volume, large quantity and high frequency	Large volume, medium quantity and low frequency	Small size and high frequency
Picking strategy	Order segmentation, batch picking and classification after picking	Order segmentation and order picking	Order segmentation and order picking
Picking information	Electronic information + picking list	Picking list	Picking list
Picking equipment	Roadway stacker, conveyor	Hydraulic pallet forklift	Conveyor

In the optimization of network plan, it is usually used to change series work into parallel work or cross work Take advantage of the time difference on the non critical route to slow down the progress of non critical work, reasonably allocate limited resources and reduce the cost schedule, so as to obtain the best effect. In view of the particularity of logistics operation, two new indexes for evaluating the time balance of logistics operation are proposed. E-commerce platform is a hybrid system composed of n different types of e-commerce platforms. If the logistics time of each subsystem is t, I = 1,2,, N, the waiting time at for completing a batch of logistics tasks can be expressed as:

$$\Delta t = \max\left\{\left|t_i - t_i\right|\right\} \tag{9}$$

In addition, the balance delay value in production and assembly is introduced as a relative evaluation index to measure the time balance of e-commerce platform. Namely

$$d = \frac{t_{\max} - p_{av}}{\Delta t} \times 100\% \tag{10}$$

This result p_{av} is the maximum logistics time in the logistics time of v logistics subsystems and the average logistics time of each logistics subsystem. In the theory and practice of regional logistics operation, the composition of regional logistics system mainly includes three parts: logistics foundation, logistics policy system and operation main body. These three parts cooperate and cooperate with each other to realize the matching with the logistics demander and provide the right logistics services in the right place and in the right way. The level of logistics equilibrium is the key regulating factor for the coordinated development of service-oriented manufacturing and regional logistics system. Therefore, the measurement of logistics equilibrium is the key technical problem for effective operation of service-oriented manufacturing regional logistics system.

3. ANALYSIS OF EXPERIMENTAL RESULTS

In order to test the performance of this method in realizing the automatic logistics allocation control in the big data environment, the simulation experiment is carried out. In the experiment, the number of big data nodes is 100, the load of logistics supply chain is 1000, the sampling time interval of logistics configuration information is 12, and the number of simulation experiments is 50. For the operation state of a regional e-commerce platform, based on the above calculation results, Hierarchical analysis is carried out. Calculate the difference and dispersion of the index values of each layer in the operation state of the regional e-commerce platform, as shown in the table 4.

Table 4. Differences in underlying indicators of the operation status of regional e-commerce platforms

	Quantity equilibrium		Structural equilibrium			Time equilibrium		Facilities and equipment level	
Paper method	0.178	0.121	0.246	0.28	0.185	0.286	0.237	0.288	0.295
Traditional method	0.895	0.834	0.965	0.892	0.912	0.902	0.900	0.895	0.889
	Informatization level		Standardization level		Economic performance		Social results	Environmental benefit	
Paper method	0.255	0.279	0.272	0.288	0.276	0.228	0.288	0.269	0.277
Traditional method	0.922	0.901	0.923	0.942	0.896	0.898	0.911	0.905	0.946

Table 5. Dispersion of middle tier indicators of regional e-commerce platform operation status

	Logistics equilibrium			Logistics foundation			Comprehensive benefits		
Paper method	0.211	0.135	0.118	0.011	0.136	0.065	0.165	0.028	0.086
Traditional method	0.846	0.983	0.935	0.897	0.883	0.814	0.893	0.812	0.901

Based on the comparison of the test results in the above table, it is not difficult to find that compared with the traditional methods, the difference value and dispersion of logistics equilibrium control under the guidance of this method are significantly lower than the traditional methods.

4. CONCLUSIONS

The multi-level supply chain equilibrium control strategy of logistics storage can be an effective measure to solve the uncertainty of logistics service demand, improve customer satisfaction and reduce storage risk. This paper proposes a multi-level supply chain equilibrium control method for logistics warehousing based on big data, analyzes the structure of e-commerce logistics supply chain, takes the realization of equilibrium as the decision-making condition, obtains the fitness function of Multi-level Supply Chain equilibrium control, and completes the multi-level supply chain equilibrium control of logistics warehousing based on this. Simulation results show that the proposed method has good control performance, improves the layout of logistics storage, and greatly improves the economic and social benefits of logistics.

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