Optimization Models and Educational Teaching Research in Agricultural Logistics System

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Abstract. Logistics science is a new comprehensive discipline. It plays a very important role in the development of national economy and the improvement of production and management level. The task of cultivating new agricultural business entities is an important measure to build a strong agricultural industry. This paper studies and expounds the significance of the connection between the new agricultural management subject and the agricultural logistics system; Analyze the problems of coordination between the logistics system and the fresh characteristics of agricultural products, the docking between the main bodies of agricultural circulation channels and the control of production, supply and marketing costs in the docking process between new agricultural business entities and agricultural logistics; How to effectively optimize and allocate logistics operation and reduce logistics cost is of great significance not only to enhance the international competitiveness of enterprises, but also to promote the rapid development of the whole national economy.

Keywords: Agricultural logistics system · Optimization model · Research on Logistics algorithm

1 Introduction

Cultivating new agricultural business entities and strengthening their organic connection with agricultural logistics system are powerful measures to implement the strategy of strengthening agriculture. At this stage, it is increasingly urgent to achieve the strategic goal of building a well-off society in an all-round way. Comprehensively promoting agricultural modernization and fundamentally resolving the "three rural issues" restricting China's economic and social development are the basis to ensure the realization of this strategic goal.

Supply chain is a functional network chain structure mode that connects suppliers, manufacturers, distributors, retailers and end users into a whole by focusing on core enterprises and controlling information flow, logistics and capital flow, starting from purchasing raw materials, making intermediate products and final products, and finally sending products to consumers through the sales network.Agricultural supply chain is an advanced management model of modern agriculture based on the study of modern

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agricultural logistics. It not only studies the logistics allocation of agricultural production itself, but also studies the scientific flow of agricultural pre production and post production logistics, so as to achieve the organic connection of supply, production, transportation, processing and marketing, so as to connect the pre production, production, post production and market into a satisfactory system optimization operation state [1]. The model of agricultural supply chain management is a network composed of various entities and information, on which agricultural logistics, capital flow and information flow. These entities include some agricultural companies, subsidiaries, farms, processing plants, manufacturing plants, warehouses, external suppliers, transportation companies, distribution centers, retailers and farmers- A complete agricultural supply chain starts from the suppliers of agricultural means of production and ends at the end users of agricultural products (including processed finished products).The agricultural supply chain consists of three basic links: pre production, in production and post production. Pre production mainly refers to the supply of seeds, feed, fertilizer and other means of production for the production of agricultural products. In production refers to the planting and production of agricultural products, and post production refers to the grading, packaging, processing, transportation, storage and sales of agricultural products.

With the development of the national economy, the development of agriculture, as the basis of the national economy, has been paid more and more attention by the government. In addition to technological progress and policy guidance, a very important factor in the prosperity of agricultural economy is the circulation of agricultural materials and agricultural products, that is, agricultural logistics. To do a good job of agricultural logistics in a region, we must first have a better understanding of the existing logistics situation, and the selection of evaluation methods has become an indispensable step. By evaluating the advantages and disadvantages of agricultural logistics system, we can find out the shortcomings of the current situation of local agricultural logistics, so as to make reasonable decisions. How to evaluate agricultural logistics system? How to optimize the agricultural logistics system in a region? The research on these problems has certain application value.

Optimization theory and method is an important branch of mathematics. The problem it studies is how to find the optimal scheme and calculate the optimal solution among many schemes. Evaluation is indispensable for decision optimization, and its result is the basis of decision. Some of the traditional evaluation methods are subjective and lack of quantitative analysis in actual decision-making. Although some evaluation methods are based on quantitative analysis, due to the complexity and fuzziness of practical problems, the effect of these methods directly used in decision-making is not ideal. How to quantify qualitative problems better? How to apply optimization method in large-scale system modeling? The research on these problems has certain theoretical significance.

At present, there are few systematic studies on agricultural logistics system in China. This paper provides an optimization model and algorithm. Through systematic evaluation and optimization, taking the agricultural logistics system as the research object, this paper discusses the regional agricultural logistics problems.

2 Related Work

2.1 Agricultural Logistics System Control

Both producers and consumers of agricultural products are dissatisfied with the price of domestic agricultural products. Producers think the purchase price is too low, consumers think the retail price is too high, and the profit space of bulk circulation of agricultural products is very large. For example, in the first half of 2002, the lowest purchase price of banana producing areas in Hainan fell to about 0.09–0.1 yuan/kg, while the retail price of bananas in major cities in North China is about 1.5–2 yuan. In addition to reasonable transportation and marketing costs, there is a huge profit space for wholesale and retail sales. But on the other hand, the bulk logistics of agricultural products is actually risky, and there is a problem of uneven distribution of logistics profits and risks in all links of the supply chain. Shortening circulation channels is an effective way to solve this problem.

(1) Circulation channels. The bulk logistics of agricultural products generally goes through the following main links: suppliers - producers - wholesalers - land markets - retailers - consumers. In the whole logistics chain, because the unprocessed fresh selling products of agricultural products account for the vast majority, and such a multi link circulation chain, whether in terms of time and circulation efficiency, or the existing fresh-keeping means, cannot adapt to the fresh selling form of agricultural products, so a considerable number of new fresh products suffer huge losses due to freight rates, transportation capacity, basic traffic conditions and product fresh-keeping technology. When agricultural products are centrally listed, logistics is not smooth, The processing capacity is insufficient, the production and marketing are seriously disconnected, and the loss is more prominent. According to the statistics of relevant departments, the annual losses caused by the decay of fresh commodities such as fruits and vegetables in Guangdong reach 750million yuan. At present, the circulation channels of agricultural products are relatively single, and there is no multi-channel marketing system.

(2) Logistics cost. In the supply chain of agricultural products, the combination of production and marketing is one of the bottlenecks of current procurement and operation, and it is also the hot spot of future market investment. The current circulation cost is still high and unstable, and the transportation and marketing cost fluctuates greatly; In addition, the time cost of poor road conditions, card fees and other issues have virtually increased the circulation cost and increased the operational risk of bulk logistics of agricultural products.

(3) Logistics technology. Transportation and marketing fresh-keeping technology is one of the prominent problems affecting the fresh management of supermarkets at present. “Fresh” is the life and value of fresh agricultural products. However, due to the high water content, short fresh-keeping period and extremely perishable deterioration of fresh agricultural products, it will greatly limit the transportation radius and transaction time, so it puts forward high requirements for transportation efficiency and circulation fresh-keeping conditions.

At present, the logistics of agricultural products in China is mainly in the form of normal temperature logistics or natural logistics, and the losses of agricultural products in the logistics process are great. According to statistics, the loss rate of agricultural and sideline products such as fruits and vegetables in the logistics links such as picking, transportation and storage is about 25–30%, that is to say, more than 1/4 of agricultural products are consumed in the logistics links. While the loss rate of fruits and vegetables in developed countries is controlled below 5%, and the logistics of vegetables and fruits in the United States is more typical. Products can always be in the low temperature state of post harvest physiological needs and form a cold chain: pre cooling after harvest in the field – cold storage – refrigerated truck transportation – cold storage in wholesale stations – supermarket freezers – consumer refrigerators. The loss rate of fruits and vegetables in the logistics link is only 1–2%, which is shocking in comparison.

Agricultural logistics system is a limited resource temporarily stored to meet future needs. The agricultural logistics system is divided into two types according to the state. One is the static agricultural logistics system stored in the warehouse and the other is the dynamic agricultural logistics system during transportation.

Traditionally, agricultural logistics system plays a long-term storage place for raw materials, semi-finished products, products in process and finished products. The manufacturer produces for the agricultural logistics system and tries to sell out the agricultural logistics system in the warehouse. With the advent of real-time supply (Zero agricultural logistics system), partnership and supply chain, in order to achieve the logistics objectives of faster and shorter agricultural logistics system turnover time and lower cost, the position of warehouse in material flow system has been unprecedentedly increased and attracted the full attention of logistics experts. The warehouse is no longer regarded as a long-term goods storage facility, and its logistics activity level has made great progress. For many international logistics companies, the storage time of products in the warehouse is usually only a few days or only a few hours. In the macro-economic sense, warehouse plays an essential role and creates the time utility of products. Warehousing improves the utility value of goods by increasing the supply time of goods to customers. In short, by using the warehouse to store goods, enterprises can meet the needs of users anytime and anywhere. The value-added role of warehousing in the logistics system is reflected in: integrated transportation, mixed products, customer service, prevention of uncertain factors, stable supply and demand, etc. As shown in Fig. 1.

The purpose of agricultural logistics system control system is to decide when to order and how much to order [2]. The controlled ordering decision depends on the current situation, expected demand and different cost factors of agricultural logistics system. The current situation of the agricultural logistics system here is not only the so-called existing agricultural logistics system, but also includes the order quantity ordered from the outside but not yet arrived, the unfinished order and the backorders ordered by customers. It is described by the location of the agricultural logistics system.

The decision-making depends on the location of the agricultural logistics system, but the storage cost and shortage cost all depend on the level of the agricultural logistics system: the level of the agricultural logistics system = the existing agricultural logistics system - delayed delivery.

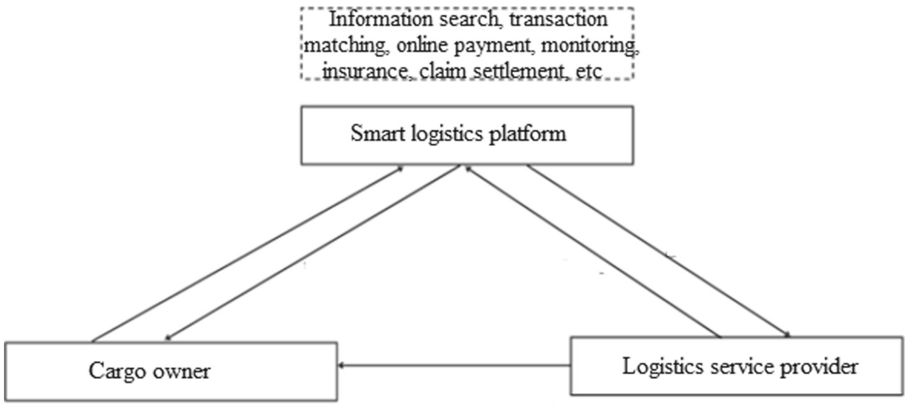

Fig. 1. Agricultural logistics system

2.2 Periodic Inspection Strategy

Periodic inspection of agricultural logistics system is to detect the quantity of agricultural logistics system at the beginning of each cycle. The decision of the whole cycle also depends on the value of agricultural logistics system detected this time. When the cycle is very small, the cycle detection can be approximated by continuous detection.

Assuming that the time unit is the inspection cycle of the agricultural logistics system and the order lead time l is an integer cycle, the agricultural logistics system level used to calculate the agricultural logistics system cost, shortage cost or service level is the IL at the end of each cycle, that is, the L after the demand of each cycle occurs, so it is not necessary to specify the time of the cycle when the demand occurs.

If the demand of a cycle is distributed at any position of the cycle, the level of agricultural logistics system can be considered at the end of the cycle or in the middle of the cycle. The assumptions here are the standard methods for modeling this problem, which is equivalent to that the demand occurs at the beginning of the cycle and after the replenishment decision is made. In this case, the level of agricultural logistics system is constant in the whole cycle [3].

Now consider that the position of the agricultural logistics system at the beginning of any cycle T and after replenishment is IP. At the end of cycle $T + L$, all replenishments occurring before cycle T and before cycle t have arrived, and the replenishment after cycle T has not arrived. There are $L + 1$ cycles from the beginning of cycle T to the end of cycle $T + L$, The level of agricultural logistics system at the end of cycle $T + L$ is as follows (discuss the (R, q) strategy and (s, s) strategy respectively):

(R, 2) strategy: the transition condition of agricultural logistics system state is the beginning of each cycle, not the trigger of customer arrival in continuous inspection. If the periodic demand is used to replace the demand of each customer in the continuous state, the relevant Markov chain is the same as the continuous inspection state.

(s, s) strategy: suppose that the periodic demand is a discrete probability distribution, g = the probability that the periodic demand is *J (J = 0, 1,…),* M is the average number of cycles with *IP* = *J* in a ordering cycle. The periodic demand is similar to the single customer demand of continuous inspection. It is assumed that the single customer demand is at least 1. Here, it is assumed that the periodic demand is greater than or equal to 0, so:

$$\begin{aligned}(E(t) - M_2C)\Delta\dot{x}_{k+1}(t) &= f(t, x_d(t)) - f(t, x_{k+1}(t)) \\ &+ B\Delta u_k(t) - (\Gamma_{p1}C + M_1C + M_2C)\dot{x}_d(t) + \Gamma_{p1}C\dot{x}_{k-1}(t)\end{aligned} \tag{1}$$

So:

$$\begin{aligned}\Delta x_{k+1}(t) &= \int_0^t Q^{-1}(f(t, x_d(\tau)) - Q^{-1}f(t, x_{k+1}(\tau)))d\tau \\ &+ \int_0^t Q^{-1}B\Delta u_k(\tau)d\tau - \int_0^t Q^{-1}Z\dot{x}_d(\tau)d\tau + \int_0^t Q^{-1}F\dot{x}_{k-1}(\tau)d\tau\end{aligned} \tag{2}$$

3 Research on Some Optimization Models and Algorithms in Agricultural Logistics System

The current logistics system is designed for the storage and transportation characteristics of a chemical industrial product. Compared with industrial logistics, agricultural products show different characteristics because of their unique natural attributes and supply and demand characteristics [4]. The key point of realizing the value of agricultural products lies in “preservation”, but most agricultural products have the characteristics of high water content, easy decay, easy deterioration and high requirements for storage and transportation environment, which puts forward the requirements for a large number of agricultural logistics enterprises to innovate the storage and transportation technology of agricultural products, so as to solve the problem of high “cargo damage rate” of agricultural products in storage, packaging, transportation and other links. Moreover, the production activities of agricultural products have significant seasonal characteristics, which determines that the operation of the logistics system of agricultural products should also have obvious seasonality. However, there is a lack of effective matching between the logistics capacity allocation of existing agricultural product logistics enterprises and the seasonal storage and transportation demand of agricultural products, which increases the logistics cost of agricultural products.

Set up agricultural logistics system processing station *j* the use and operation expenses during the planning period are $C_j; j \in S \cup K$. It has nothing to do with the processing quantity, but only with whether to use the station. The construction cost of the new agricultural logistics system processing station is apportioned to the planning period according to the depreciation method. If the new agricultural logistics system processing station is added, In addition to the transportation cost, the new cost also includes the construction and operation cost of the new agricultural logistics system processing station. Suppose that the agricultural logistics system processing station s is the closest to the new recycling station h in the original agricultural logistics system processing station, the unit freight rate from the recycling station h to the agricultural logistics system processing station s is k, and the unit freight rate from the recycling station h to the alternative agricultural logistics system processing station J is $k_j; j \in K$. If the recycling quantity of recycle bin h in the planning period is labor, the transportation cost borne by agricultural logistics system processing station s of recycle bin h is KGZ, and the cost borne by alternative agricultural logistics system processing station J is KGZ $C_j + k_j x$; $j \in K$. The 1-bit improved model is shown in the Fig. 2 below.

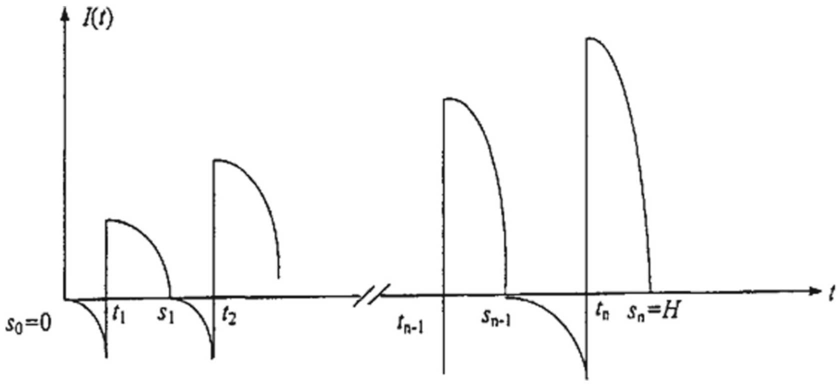

Fig. 2. Periodic improvement model of logistics system

Comparing the smallest of these costs is the optimal adjustment scheme:

$$F_j(x) = \begin{cases} k_j x, j \in S \\ k_j x, j \in K \end{cases} \tag{3}$$

There are problems in the connection between cost management and control of agricultural product circulation channels [5]. The channel structure among traditional agricultural product suppliers, logistics enterprises, chain supermarkets and consumers is too complex, usually including multiple contracts between farmers and agricultural product collection and storage enterprises, agricultural product collection and storage enterprises and logistics enterprises, chain supermarkets and distribution companies, which lengthens the circulation chain of agricultural products and increases the residence time of agricultural products in the circulation channel, It reduces the "freshness" of agricultural products, and then increases the cargo damage rate and logistics cost of agricultural products. Specifically, there are the following problems in the cost control of agricultural production, supply and marketing. First, the information search cost of agricultural product logistics business. The cost of agricultural product producers searching for terminal market demand is high, and the supply and marketing sides of agricultural products are unable to negotiate directly with the counterparty, which makes it impossible for each party to grasp the supply and demand information of the other party, thus lacking the necessary market bargaining power. Second, the long chain of agricultural product channels [6, 7]. It is difficult for shippers and distributors of agricultural products to reach a transportation contract with short channel chain, economies of scale and high cost performance price ratio. It is difficult for farmers and consumers to bear the problem of high circulation price and sales price of agricultural products caused by the problem of long channel chain of agricultural products. Third, the cost of agricultural product distribution business. The distribution channels of distribution channels in the terminal market are not smooth, the distribution cost remains high, and the problem of "the last kilometer" of agricultural products is difficult to solve. Because the producers of agricultural products and the logistics carriers of agricultural products belong to different legal entities, they all have relatively independent standard interests. The lack of necessary communication leads to the disconnection between the cost management and control of agricultural product logistics in each stage of logistics business.

4 Agricultural Logistics Channels

It can be seen from the analysis that the upper layer of the model is a general location problem model, and the lower layer is a nonlinear programming model, which is difficult to solve. Berr ayed and Blair pointed out that even the simplest bilevel programming problem is NP hard, and there is no polynomial algorithm. Generally speaking, the non convexity of bilevel programming is an important reason for the complexity of Solving Bilevel Programming problems. Even if the upper level problem and the lower level problem are convex, the whole problem is still very likely to be non convex. Because of its non convexity, the local optimal solution is usually obtained instead of the global optimal solution. Some scholars have discussed the relationship between multi-level planning and multi-objective planning, which is still inconclusive in academia. Therefore, for the bilevel programming model obtained in this paper, the heuristic algorithm proposed by sun Huijun and other scholars is called method one, which uses the algorithm as a heuristic to solve. Sun et al. Verified the feasibility of this method.

It should be noted that considering the seasonal characteristics of agricultural products, this model assumes that agricultural products The production, supply and sales of the factory in a certain period of time meet the conditions of the model. In addition, without considering the inventory factor, it is assumed that the inventory and additional losses are very small. Only one agricultural product logistics system is optimized at a time.

The key to solve the bilevel programming problem is to find the specific form of the response function, which is obviously difficult. For the case of continuous variables, the derivative relationship between variables can be obtained through the sensitivity analysis method. In this way, the Taylor expansion can be used to approximate the response function, so as to simplify the response function to solve the bilevel programming problem. This is the heuristic algorithm SAB (sensitivity analysis basedalgorithm) based on the sensitivity analysis method. Yang and yagar applied the sensitivity analysis method to solve the traffic control problem, and Gao Ziyou and others used the sensitivity analysis method to solve the bilevel programming model of traffic continuous balance network design. However, because some variables in this paper are discrete variables, the sensitivity analysis method of continuous variables cannot be applied.

First, eliminate the information asymmetry in the circulation channels of agricultural products. Cultivate a number of information intermediaries for the circulation of agricultural products to reduce the asymmetry in the collection of agricultural products. Local governments should vigorously support information intermediaries in the circulation of agricultural products [8].

Support the development of logistics information intermediary organizations and reduce the transaction costs paid by new agricultural business entities in the agricultural logistics market. Different from the general agricultural products circulation subjects, the new agricultural management subjects have strong price influence in the agricultural products market. It realizes the business goal of optimizing its profits by buying out specific categories of agricultural products in specific areas, and feeds back ordinary farmers through mechanisms such as agricultural cooperatives and agricultural land circulation, So as to realize the cross integration of the interests of new agricultural management subjects and ordinary farmers.

Second, establish a "tripartite contract" to optimize the channel structure. The value of agricultural products is reflected in the word "fresh", which is the key to ensure the value of agricultural products at the channel terminal. Therefore, the new agricultural management subject needs to strengthen the cooperation with the agricultural logistics subject to shorten the logistics time of agricultural products "from agricultural land to dining table" [9]. The traditional single door and single family discrete planting and breeding model usually lacks the necessary price negotiation ability in the face of large terminal retailers. In view of the complex channel structure among traditional agricultural product suppliers, logistics enterprises, chain supermarkets and consumers, new agricultural business entities such as farmers' professional cooperatives and large planting and breeding households need to establish strategic cooperative relations and sign "tripartite contracts" with third-party logistics and chain supermarkets, Integrate the interests of the business entities involved in the production, supply and marketing of agricultural products into a unified contract structure [10]. This can shorten the circulation chain of agricultural products from the level of system design, effectively reduce the retention time of agricultural products in the circulation channels, strictly control the damage rate and logistics cost of agricultural products from agricultural land to consumption, effectively ensure the "freshness" of agricultural products on consumers' tables, and then increase the income level of various stakeholders.

The operation process of agricultural logistics system is shown in Fig. 3.

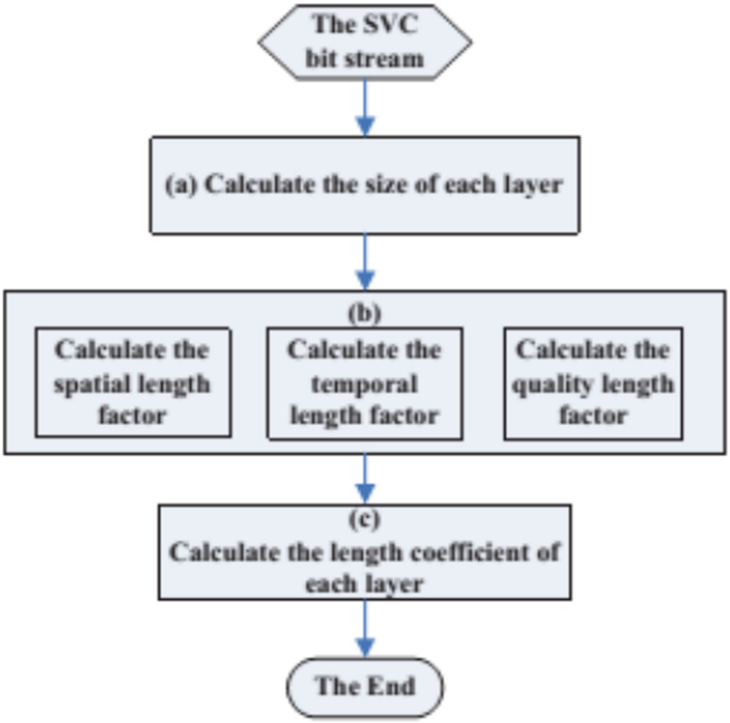

Fig. 3. Logistics system operation flow chart

5 Conclusion

This paper studies several optimization models and their algorithms in the agricultural logistics system, makes a detailed analysis on several problems of the logistics of the agricultural products agricultural logistics system in the agricultural logistics system, and improves the traditional logistics model to make it more suitable for solving the actual agricultural products logistics problems. The specific performance is as follows:

The classification criteria of supply chain structure are given. The corresponding classification methods are proposed from four aspects: the complexity of supply chain, the concentration of supply chain node enterprises, the reliability of supply chain and different optimization objectives. The seasonality of agricultural products, its demand rate and agricultural logistics system will also change periodically. Therefore, this paper improves the classical EOQ problem.

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