Computer information technology and agricultural logistics management system

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Abstract

At present, there are kinds of problems on circulation pattern of agricultural products' supply chain, leading to high cost of agricultural logistics system and unreasonable planning. In order to solve the problem of agricultural product circulation pattern, we need to put forward a circulation pattern of agricultural products' supply chain, which takes the agricultural product logistics as a core enterprise. This thesis introduces the idea of combination between computer information technology and logistics management system. It also analyses how to better complete the modules of logistics management system and key points of them, based on the technology of computer, automation, bar code, etc., which focus on analysing the module of farm, customer relations and decision.

Keywords: supply chain; logistics management; circulation pattern; information technology; module

1 Introduction

IT application in agricultural logistics management is a new content of agricultural modernization and inexorable trend of world agricultural development. With a background of rapid expansion of economic globalization, agricultural products market at home and abroad needs to be integrated, which demands us to improve the level of agricultural informatization construction. From the view of agricultural producer, operator, or government sector, there is vitally important significance on agricultural logistics management information system construction. It is the need of optimizing allocation of resources of agricultural producer and expanding the market of agricultural products, the need of reducing the agricultural risk (including the market risk and natural risk), the need of increasing the agricultural products international competitiveness (including the price competitiveness, quality competitiveness and brand credibility competitiveness), the need of government support and agriculture protection [1].

In recent years, with the rapid expansion of computer networks and communication technology, agricultural products logistics management system evolved from an easy mode into automated management whose main feature automatic logistics equipment, such as automatic guided vehicle automatic storage and extraction system, sky-rav-rail automated vehicles, stockers, etc., as well as the appearing of logistics computer management and control system. They change people's life-style, work-style and thinking method with leap-type to bring immeasurable social profit and economical profit to the whole society.

2 Summary on computer information technology and logistics management

Analysing the present stage of circulation pattern of agricultural products' supply chain, we discovered that there are many defects [2]. In order to solve the disadvantages and deficiency, we put forward a circulation pattern that takes the agricultural product logistics as a core enterprise, focusing on the profit of agricultural products factory and customer. Take the measure of combination with computer technology to improve the supply chain pattern, which makes the logistics and information stream circulate more smoothly.

The chief application of computer information technology in logistics information technology includes device collecting and transporting, storage equipment automation, as well as information collecting, transmitting, and processing based on bar codes technique, EDI technique and network technique. With the social development and the approaching of e-commerce, computer technology makes the logistics informationized, automated, networked, intelligentized and flexible [3]. Multifunctional modern logistics highly depends on some demand, which contains mass of data and information collecting, analysing, processing and immediate updating. That's why logistics informatization is the inevitably demand of society imformatization. The application of these modern techniques and equipment highly improves the efficiency of logistics activities and enlarges the field of logistics activities, forming into supply chain.

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3 Logistics management system

There is an idea, which refers to system integration and the total cost controlling in modern logistics. Economic activity includes supply, production, market, transportation, inventory and other relevant information flow. Modern logistics see all these as a dynamic system master, concerning the operation efficiency and costs in this system [4]. The whole system specifically includes these modules: purchasing management, farm, customer relation and decision, inventory management and supply chain management system [5].

3.1 PURCHASING MANAGEMENT

With the system providing the correct and immediate purchasing information, we help business manager make a scientific acquisition strategy, provide them purchasing management in a good time, defined amount and price and know the performance of suppliers in time. System provides the function from purchasing requisition to cargo checkups and acceptance, data quality monitoring, etc., realizing the general management of purchasing business.

3.2 FARM, CUSTOMER RELATION AND DECISION

The agricultural buying and selling system does not run smoothly means it does not obey the marketing rule to make the production-supply-marketing into a dragon (a mode of agricultural products supply chain). Therefore, the agriculture cannot be developed rapidly, usually leading to a situation of ‘hard to buy or selling’. The market of agricultural products becomes the main part of the whole supply chain. For this reason, we came up with the bi-le module programming module of agricultural logistics system, to optimize the supply chain.

3.2.1 The basic idea of Bi-level programming module of supply chain

From the supply chain integration’s perspective, it uses bi-level programming module [6] to describe the optimization problem of bi-level distribution network, which takes a full consideration on the both profit of agricultural products factory and customers and design a heuristic solution algorithm to solve as well.

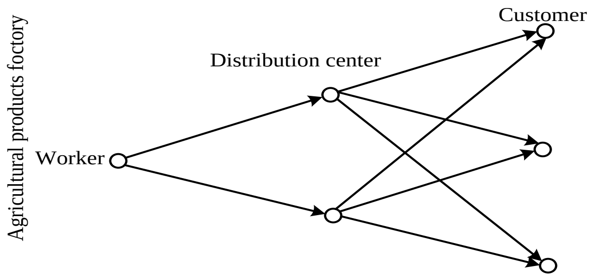

FIGURE 1 Agricultural products distribution framework

We could regard the optimization problem on distribution network as a mentor (henchman) problem. Therein to, the decision-making section of manufacturing concern is the mentor, and customer’s choice behaviour to distribution centre or his need on allocation of distribution centres is the henchman. Decision-making section could change the position and distribution costs of a distribution centre through policy and management, affecting the customer’s choice to distribution centre, but not controlling. Customers could make a comparison between available distribution centres and make the choice based on their need and behavioural habits. This kind of relationship can be described by bi-level programming, whose basic idea are two submodels of following mathematic model bi-level programming model:

$$\min_{x} F(x,y)$$
$$s.t. G(x,y) \le 0$$

Among them: $y = y(x)$ can be got from following project (L_0):

$$\min_{y} f(x,y)$$
$$s.t. g(x,y) \le 0$$

Bi-level programming model is consist of two submodel of (U_0) and (L_0). (U_0) is called superstratum project. (L_0) is called substratum project. *F*Is the objective function decided by superstratum. *x* is the decision variable of superstratum. *G* is constraint of variable. *f* is the objective function decided by substratum project. *y* is the decision variable of substratum. *g* is constraint of variable *y*. The superstratum decision maker affects the substratum decision maker by setting *x*, so it limits the feasible constraint set of substratum decision maker. On the contrary, the activity of substratum decision maker will affect superstratum decision by *y*. Therefore, the variable y is the function of *x*, which means $y = y(x)$. It is usually called reaction function. The optimization problem of supply chain’s distribution network relates to 2 decision makers (the agricultural products factory and customers) of obviously different objective function, so it is proper to describe this relation by bi-level programming module [7].

3.2.2 The optimization of agricultural products supply chain’s distribution Bi-level module

Considering the superstratum decision maker is the owner of agricultural products factory (the peasant households), the problem they are concerning about involves 2 aspects, costs and profits. It means the costs can be less, while the profit can be more. Taking this as an objective, we could set a project of superstratum decision maker. Due to the distribution centre built by investment of peasant households, the costs they are concerning about are not only production costs, but also costs of delivery centre. The substratum decision maker is the customers. Their objective to distribute the quantity demanded among the distribution centres to chasing the least total costs. The module can be set by (U):

$$\min F = \sum_{i=1}\sum_{j=1} C_{ij} x_{ij} + \sum_{j=1} f_j u_j + \sum_j \left(t_j \sum_i x_{ij} \right) - \theta \sum_i \sum_j x_{ij}, \quad (1)$$

$$s.t. \sum_{j=1}^{n} u_j \geq 1, \quad (2)$$

$$u_j \in \{0,1\}. \quad (3)$$

The first item in this objective function is the generalized unit cost of the i-th customer served by the distribution centre of j place, which mainly means the transportation expanses. It can be estimated in practical application with the increase of quantity demanded. x_{ij} is the quantity demanded of i customer satisfied by distribution centre of j place. θ is a harmonic coefficient. As it mentioned before, the peasant households ask for the best profit while taking the least costs. In many works, the optimization objective is the least costs but ignoring the factor of profit. Taking these factors into consideration, the author takes a way to make the module better. Due to the unfinished distribution centre, how can we judge the profit? There are many unpredictable factors in the market which we don't take into account. Under this circumstance, if the total demanded customers are large, it reflects that the market share of this distribution is large. The market share is an important indicator to measure the profit. Therefore, we use this indictor to measure the profit expected. The first 3 items of this objective function is the cost objective. In order to balance the disunity between costs and profit indicator, we bring in harmonic coefficient θ. f_j makes the fixed investment on building the distribution centre at j place. t_j is the transportation costs from agricultural products factory to the j distribution centre. X is the constant. The transportation costs could be got according to the data of local transportation and carriage former years. Formula (2) ensures to set at least one distribution centre. 0 and 1in formula (3) is variable. You should set it to 1 when building distribution centre at j place, otherwise you should choose 0.

$$\text{(L)} \quad \min T = \sum_i \sum_j \int_0^{x_{ij}} D^{-1}(w)\, dw, \quad (4)$$

$$s.t. \sum_{j=1}^{n} x_{ij} = w_i, \qquad i = 1,\dots,m; \quad (5)$$

$$D^{-1}(x_{ij}) \geq 0 \qquad i = 1,\dots,m; \quad j = 1,\dots,n; \quad (6)$$

$$\sum_{i=1}^{m} x_{ij} \leq s_j \qquad j = 1,\dots,n; \quad (7)$$

$$x_{ij} \leq s_j u_j \qquad i = 1,\dots,m; \quad j = 1,\dots,n; \quad (8)$$

$$x_{ij} \geq 0 \qquad i = 1,\dots,m; \; j = 1,\dots,n. \quad (9)$$

$D_{ij}^{-1}(.)$ in the formula is the inverse function of demand function, which means cost function. The expression of quantity demanded is $x_{ij} = D_{ij}^{-1}(f_{ij})$. In this formula, x_{ij} is the quantity demanded of i customer satisfied by distribution centre at j place. f_{ij} is the generalized cost function. It is the demand of i customer that the least cost should be provided by the contribution centre at j place, which usually use power function or log function to express. w_i is the quantity demanded of i customer spot. s_j is the best supply ability of the distribution centre at j place.

The substratum programming is the customer's distributed quantity demanded of each distribution centres to make least to the total costs. Formula (5) ensures customer's quantity demanded could be satisfied by distribution centres. Formula (6) is nonnegativity restrictions of cost function. Formula (7) ensures the quantity demanded will not be beyond the best supply ability. Formula (8) ensures the quantity demanded could be distributed only at built distribution centre. The quantity demanded will be 0 if the distribution centre is not built. Formula (9) is nonnegativity restrictions of variable. Using the centre quantity u given by substratum programming could figure out that hessian matrix of objective function is positive definite. Therefore, there is the only solution to module (L).

By analysing the formula (8), we could see if u_j=0, x_{ij}=0 is correct. If u_j=1, $x_{ij} \leq s_j$ of formula (7) is obviously correct. It is to say, if u is fixed, formula is useless which could be omitted.

3.2.3 The solution method for the model

Through analysis, the superstratum of this module is a normal module of location problem, and the substratum is a module of nonlinear programming. It is hard to get the solution. Therefore, as the bi-level programming module mentioned in this thesis, the scholars like Sun Huijun came up the heuristic algorithm: Take the Formula (8) as a heuristic method to get the solution. In the meanwhile, we could make following assumption: The production-supply-marketing situation of agricultural products factory in a given period conforms to the module condition; Presumed inventory and extra lost is little; optimize one kind agricultural products logistics system at one time.

From the module (L), we could see formula (8) expresses the relation between the distributed quantity demanded of customers and address selection planning of each distribution centres. But from the formulas mentioned, formula (8) could be omitted. However, in order to get the reaction function, we should keep it but not in the module, to simplify it into the following form:

$$x_{ij} = s_j u_j - y_{ij}, \qquad i = 1,...,m; j = 1,...,n. \tag{10}$$

In this formula, y_{ij} is a slack variable. When u_j=0, we could get x_{ij} and y_{ij} directly. When u_j=1, we could use available way to solve the substratum module (L) to get the quantity demanded at each distribution centres x_{ij}^* when in a balanced stage. Then use formula (10) to get y_{ij}^*, and the relations of all reaction function could be expressed:

Bring that relation into superstratum objective function and solve by an available way, like branch and bound method. For the solution solved from superstratum problem, we could solve the substratum problem and get the distribution of customers' demanded quantity. And repeat that, we could get another new address selection planning. Finally, it is possible to get a best solution though bi-level programming. The solution algorithm is in fact a heuristic algorithm based on formula (11). Here are the steps:

Step 1: Set a initial solution u_j^0, make the iteration k =0.

Step 2: For the given u_j^k, get the substratum problem solution x_{ij}^k .

Step 3: Base on formula (10), calculate y_{ij}^k, and bring $x_{ij}^k = s_j u_j - y_{ij}^k$ into superstratum objective function. Get the solution of superstratum problem and get a new u_j^{k+1}.

Step 4: Stop if $\left|F^{k+1} - F^k\right| \le \varepsilon$; otherwise, make $k=k+1$ and back to step 2: ε is iteration accuracy.

This method is heuristic algorithm which is hard to prove the stypticity, but the calculation improves the method is convergent. Those modules are basic agricultural products logistics bi-level programming module, which is appropriate for the agricultural products that won't go bad in a short time, like wheat, corns, beans, peanuts and so on. As for the vegetables and fruit which go bad easily, it is only to add the timing constraint into the original module. This constraint is substratum constraint, which is not appropriate to add into available module. We could make the judgment before calculating the substratum programming in following way.

In the following formula, $e_{ij} \le E_{ij}$ is the delivery time which is asked not to surpass the given time by I customer at j distribution centre. e_{ij} means the delivery time. E_{ij} is the given time.

For i=1 to m
For j=1 to n
If $e_{ij} \le E_{ij}$ then
$x_{ij} > 0$
Else
$x_{ij} = 0.$

3.3 INVENTORY MANAGEMENT

Modern storage, instead of static storage, is a process of logistics which operate through the application of buffer stand, accumulation area, and some related operations. Storage is a process that materials have not only a short stay. Using this system, managers can obtain real-time dynamic material inventory information. In order to better control inventory, improve efficiency and timeliness of delivery and improve customer service levels, we could finally reduce inventory costs, production costs, feedback logistics information timely, and accelerate capital operation through the intelligent analysis [8].

3.4 SUPPLY CHAIN MANAGEMENT SYSTEM

1) Take advanced data encryption technique to ensure the security when transferring the data.
2) On the basis of satisfying the market needs, the excellent architectural design has good scalability to satisfy the enterprise on business development in the future.
3) Support a variety of business models and integrated supply chain; support the ports of original background of enterprise ERP or MIS system interface; support the integration of CRM, OA, e-commerce, quality management system and so on, forming a powerful enterprise information centre.
4) Gathering the total quality management theory, the thought of ISO quality management system and so on, we will promote the development of the enterprise quality management and provide powerful tools for continuous improvement in quality. Quality management system regulates the quality management process to effectively monitor quality, improving product percent of pass, and eventually reducing the production cost, improving the economical benefits of enterprises [9].
5) B/S structure reduces the workload of maintenance, and supports telecommuting. This system totally adopts B/S structure. Customers completely don't need to install the software or configurate. Only through the IE can we realize all functions [10].

4 Conclusions

This paper shows the bi-level optimization module for agricultural logistics system. Take the whole agricultural supply chain as the research object on the purpose of obtaining the perfect effect of the whole supply chain. It involves the purchase of agricultural products supply chain, distribution, final agricultural products for customers, inventory management, supply chain management system and other aspects. Emphatically analysing the distribution model, it sets the bi-level optimization module, which takes farmers as superstratum, customers as substratum. It plays a reference role on optimization decision problems of agricultural logistics system. The next research direction is to further explore the optimization method of supply chain, and get real data to argue.

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