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A Decision Support System for Agricultural Product Supply Chain

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Agricultural product supply chain assist decision support system is an important component of agricultural informatization and has great significance for the promotion of agricultural sustainable development and realization of agricultural modernization. The establishment of the assist decision support system can solve some long-standing problems that exist in agricultural product supply chain with scientific means. An agricultural product supply chain assist decision support system was proposed in this paper. The design of the system aims at designing an agricultural products supply chain assist decision support system which conforms to China's actual condition and solving some of the problems that exist in the demand, supply, production, processing and circulation sectors in current agricultural product supply chain.
Keywords: Decision support system, Agricultural Product Supply Chain, decision making model

1. Introduction

Agricultural product supply chain assist decision support system [Abramson 2014] is an important component of agricultural informatization and intelligentization, it changes the blindness and subjectivity of decision-making of grass-roots leaders in past agricultural production, supply, marketing and other aspects, reduces the decision-making mistakes, which has great significance for the promotion of agricultural sustainable development and realization of agricultural modernization [Giusti 2015].
Agricultural product supply chain generally consists of the sector of demand, supply, production, processing, distribution and retail [Chen 2003]. By integrating agricultural product supply chain, every aspect of supply chain activities can maintain a coordination for a common goal, it effectively improves the efficiency and service level of agricultural production and processing, and ensures a good operation of agricultural product safety quality system. Throughout the history of agricultural development, the agricultural modernization construction in China must build the agricultural product logistics and supply chain management system in line with contemporary social demands and market rules as soon as possible. Making full use of agricultural demand, supply, production, processing, distribution and other sectors as a breakthrough, fully excavate the resources, scientifically and rationally develop and utilize the potential, enliven professional agricultural product supply chain services organization, rely on comprehensive supply chain information networks to drive the industrialization of agriculture, thus improve the rural economic take-off.
The establishment of the assist decision support system can solve some long-standing problems that exist in agricultural product supply chain with scientific means, and its implementation can provide intelligent, personalized decision support for agricultural supply chain [Segura 2014]. It translates some abstract, qualitative textual problems into a number of specific, digital, quantitative schemes by means of solving mathematical models, thus the demand, supply, production, processing, marketing and other aspects for agricultural products are no longer restricted in policy and seeming regulations, consequently provides a favourable technical support for the normal and efficient operation of supply, demand, production, processing, distribution and other aspects of agricultural products [Fountas 2004].
The research of agricultural product logistics supply chain in China starts relatively late [Wang 2014]. There is an obvious progress in agricultural product supply chain at present in China, which plays a positive role in promoting the circulation of agricultural products, adjusting agricultural structure, and increasing the income of

peasants. This mainly displays in the following aspects: the gradual improvement of the market system of agricultural products; the diversification of agricultural product supply chain; the steadily establishment of agricultural product supply chain information network. But overall, China's agricultural decision support system and supply chain system both exist some problems:

Being unable to effectively acquire and collect data is the primary problem in agricultural product decision support system in China currently. Data problems cause decision deviation, which affects the promotion and application of agricultural product decision support system. Focusing too much on the "system" and ignoring the "decision support system", results in system being incapable to put forward the scientific basis for decision maker, which is contrary to the aim and purpose of DSS.

The lack of coordinated cooperation between developers and policy-makers results in separation between developed agricultural decision support system and the actual decision process. Supply chain information service system is relatively weak, the information lags behind and lacks timely market dynamics, which is not able to provide comprehensive, sustained and interactive information for agricultural production, circulation, and processing.

As for the supply chain, there are too much policies in all aspects, and the practical problems are not translated into mathematical models, it still lacks quantitative solution and specific instructive work; some advanced technology haven’t been applied to the realization of supply chain yet, there still exists many gaps and insufficient in construction of assist decision support system for decision makers.

To accomplish those problems, an agricultural product supply chain assist decision support system was proposed in this paper, which integrates the operations research, data warehouse, data mining and other various methods and technology, it aims at designing an agricultural products supply chain assist decision support system which conforms to China’s actual condition and solving some of the problems that exist in the demand, supply, production, processing and circulation sectors in current agricultural product supply chain, thus the agricultural product supply chain can provide faster and more efficient service.

2. The decision-making model design of the system

2.1 The limited resource allocation model

There often exists problems in production management and business activities, namely, how to reasonably use the limited manpower, material resources and financial resources, in order to achieve the best economic effects. It is named linear programming, the standard form of linear programming is:

$Maxz = \sum_{j=1}^{n} c_j x_j$ (Objective function)

$\sum a_{ij} x_j = b_i$ i=1,2,…,m (Constraint function)

$x_j >= 0$ j=1,2…n (Nonnegative condition)

The limited resource allocation problem to be solved in the system are described as below:

Assume that a farm has 100 hectares of land and 15000 of the funds can be used for the development of production. The situations of farm labor force are: 3500 man-day in autumn and winter, 4000 man-day in spring and summer, the labor force can go out for work when it is in surplus. Income is 2.1 yuan man- day in spring and summer, 1.8 man-day in autumn and winter. The farm grows three kinds of crops: soybean, corn, wheat, and meanwhile feeding cattle and chickens. Crop does not require special investment, while animals need 400 yuan per cow and 350 yuan per chicken for investment. Cows feeding requires to allocate 1.5 hectares of land for forage, and uses labor force for 100 man-day in autumn and winter, 50 man-day in spring and summer, the annual net income of per dairy cow is 400 yuan. The chicken raising doesn’t occupy the land, and needs labor force 0.6 man-day for each chicken in autumn and winter, 0.3 man-day in spring and summer, the annual net income is 2 yuan per chicken. The henhouse in farm allows to raise 3000 chickens, the bullpen allows to raise 32 cows, the annually man-day and income situation of three crops are shown in Table 1:

Table 1: the required man-day and income situation statement

	Soybean	Corn	Wheat
Man-day in autumn and winter	20	35	10
Man-day in spring and summer	50	75	40
Net income per year (yuan/hectare)	175	300	120

Determine the farm management plan to achieve the largest annual net income. Use x_1,x_2,$x_3$respectively on behalf of planting area (hectare) of soybean, corn and wheat;x_4,$x_5$respectively represent the number of dairy cows and chickens, x_6 represent the surplus labor force(man-day) in autumn and winter, x_7 in spring summer, model:

$Max\ z = 175x_1 + 300x_2 + 120x_3 + 400x_4 + 2x_5 + 1.8x_6 + 2.1x_7$

$x_1 + x_2 + x_3 + 1.5x_4$<=100 *(land restrictions)*

$400x_4 + 3x_5$<=15000 *(fund restrictions)*

$20x_1 + 35x_2 + 10x_3 + 100x_4 + 0.6x_5 + x_6 = 3500$

$50x_1 + 175x_2 + 40x_3 + 50x_4 + 0.3x_5 + x_7 = 4000$ *(labor force restrictions)*

x_4<=32 *(bullpen restrictions)*

x_5<=3000 *(henhouse restrictions)*

After solving above problems, the processed soybean, corn and wheat can be machined by equipment A, B, C, to produce three kinds of products: soy milk, bread and steamed bread. It is known that the required equipment (set-hour), the current processing capacity and each product's expected profit of an agricultural product processing enterprise are shown in table 2:

Table 2: the expected profit of each product

	Soy milk	Bread	Steamed bread	Equipment capacity (set-hour)
A	1	1	1	100
B	10	4	5	600
C	2	6	5	300
Single profit	10	6	4	

Then, how to make the processing scheme to reach the maximum profit.
Respectively set x_1,x_2,x_3 as the number of production of soy milk, bread, steamed bread, then set up a linear model:

$Max\ z = 10x_1 + 6x_2 + 4x_3$

$x_1 + x_2 + x_3$<=100

$10x_1 + 4x_2 + 5x_3$<=600

$2x_1 + 6x_2 + 5x_3$<=300

x_1, x_2, x_3>=0

This problem to be solved in this system is making use of known historical data to establish a database, and then conduct the trend prediction or regression analysis according to the historical data, so as to realize the function of the data mining. In a circulation system of agricultural products, these data include the price data, agricultural products demand and output data.
For example: the system collected daily price of tomatoes and cucumbers from the end of 2011 to March 2013 in Qilibao market, Jinan. These historical data are stored in the database, using the method of regression analysis for data analysis, tomato and cucumber price trend chart can be respectively obtained. But the assist decision support system and can not determine the final decision for policymakers, the decision makers make use of these charts combined with his experience and specific situation to forecast the price of the agricultural products. Compared with the previous method of predicting only based on experience, this method is more intuitive, efficient and scientific.

2.2 Transportation problem model
Transportation problem is a special problem in linear programming and often used to solve the practical problems such as transport plan formulation, material transportation and freight optimization problems. When solving such problems, in order to meet the cost of linear superposition principle, transportation problem model in linear programming can be known as cost optimization model of transportation problem.
The mathematical model of cost optimization transportation problem:

$Maxz = \sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij}x_{ij}$ *(Objective function)*

$\sum_{i=1}^{m} x_{ij} = b_j$ *j=1,2,…,n* *(Constraint function)*

$\sum_{j=1}^{n} x_{ij} \leq a_i$ *i=1,2,…,n (Constraint function)*

$x_{ij} >= 0$ *(Nonnegative condition)*

In the formula: z -the objective function of cost optimization transportation problem model;
x_{ij} *- the quantity of supply from supply point i to demand point j.*
c_{ij} *- the unit freight from supply point i to demand point j.*
b_j *- the demand quantity of demand point j.*
a_i *- the available supply quantity of supply point i.*
When the available supply quantity of supply point equals to the sum of the demand quantity of demand point, that is, when $\sum_{j=1}^{n} b_j = \sum_{i=1}^{m} a_i$ is established, it is the transportation problem of co-ordination of supply and marketing, it can be solved with the method of table working method. For incoordination of supply and marketing transport problem, it can be solved by adding virtual supply point or virtual collection point, and translate the problem into the problem of co-ordination of supply and marketing.
The vehicle scheduling problems to be solved of this system is described as follows: the following materials need to be transported between six locations $A_1, A_2, A_3, A_4, A_5, A_6$. As shown in table 3:

Table 3: transportation table

Cargo	Starting point	Arrival point	Volume (vehicle number)
Soy bean			11
Soy bean			2
Soy bean			6
Corn			14
Corn			3
Corn			3
Wheat			9
Tomato			7
Tomato			5
Cucumber			4
Garlic			8
Garlic			3
Onion			2
Celery			4

The distance between the locations are shown in table 4: Try to determine an optimal vehicle scheduling scheme.

Table 4: distance table

	2	11	9	13	15
		2	10	14	10
			4	5	9
				4	16
					6

The optimal scheduling of the automobile minimum the mileage of empty run in essence. Firstly make a list of car balance sheet in each point, shown in table 5, "+" on behalf of empty trip at the point, "-" on behalf of the need to dispatch an empty car.

Table 5: transportation balancing table

	Dispatch number	Coming number	Balanced result
	19	27	+8
	20	10	-10
	19	14	-5
	15	11	-4
	2	5	+3
	4	14	+10

The balanced results show that in addition to shipping their own goods,A_1,A_5, A_6 are able to have 21 empty trips, ,A_2, A_3, A_4 have a lack of 19 trips. In addition to 2 trips directly transferred back to the garage, the rest are allocated according to the minimum empty trip principle, accordingly the production and marketing balance sheet can be listed.

2.3 Location problem model

The optimal location problem is that some existing facilities address are known, determine one or several new facilities. Here the meaning of the facilities can be generalized, the service providing facilities and service demanding facilities are all included. The typical examples of optimal location problem are: the location of the factory and user are known, determining the optimal addresses of new warehouses; power supply area is known, selecting the optimal address of power supply factory; reader service area is known, choosing the optimal address of the library. Actually location problem is a 0-1 integer programming, it is characterized by variable value can only be 0 or 1, under normal circumstances we can assume that if the address is selected, the corresponding variable value is 1, otherwise the value is 0.

In this system, the location problem is described as follows:

An agricultural enterprise intends to stablish a salesroom in the east, west, south areas, seven positions are proposed (according to the amount of investment, it can be divided into three grades: large wholesale market, small and medium-sized wholesale market and retail market), A_i (i=1,2…7) can be chosen from, the rules are:

In the east area, choose at least two positions in A_1, A_2, A_3 (at least 2 the retail markets);

In the west area, choose at least one position in A_4, A_5 (at least one small and medium-sized wholesale market);

In the south area, choose at least one position in A_6, A_7 (at least one large wholesale market);

Total investment can not exceed 2 million yuan.

The input and profit of the alternative addresses are shown in table 6:

Table 6: investment and profit table

Investment	10	11	12	50	60	100	100
Profit	20	25	24	70	80	153	152

Introduce 0-1 variable$x_i (i = 1,2, \dots 7)$, when A_i was selected, $x_i$is 1, otherwise is 0. The following model can be established:

$\text{Max z} = 20x_1 + 25x_2 + 24x_3 + 70x_4 + 80x_5 + 153x_6 + 152x_7$

$10x_1 + 11x_2 + 12x_3 + 50x_4 + 60x_5 + 100x_6 + 100x_7 <= 200$

$x_1 + x_2 + x_3 <= 2$

$x_4 + x_5 >= 1$

$x_6 + x_7 >= 1$

$x_i = 0 \text{ or } 1$ (i=1,2,…7)

2.4 Network maximum flow problem model

Flow problem is very common in our daily life, such as the vehicle flow in the highway system, information flow in the control system, water flow in the water supply system so on.

The maximum flow problem in this system is described as follows:

A factory products a kind of commodity, thorough the network shown in figure 2.3 (the figure beside the arc in the graph is (c_{ij}, f_{ij}) and c_{ij} is the maximum capacity of each arc andf_{ij} is a feasible flow of each arc, if the feasible flow is not given, then default the feasible flow as 0.) when the commodity is transported to a market, the maximum shipping amount from factory to market can be determined with the labeling method:

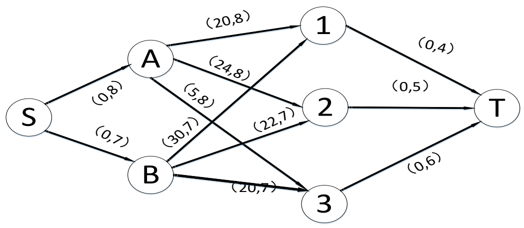

Figure 1: Network graph

2.5 Minimum cost and maximum flow problem model

In real life, when it relates to the "flow", people consider not only flow, but also "cost" factors. Problems such as traffic, every section from origin to destination, in addition to the arrangements of the flow (such as vehicle),

it should also consider the different costs due to various reasons, so each arc reflects the its cost, this kind of problem is called the minimum cost and maximum flow problem.
The minimum cost and maximum flow problem of the system is described as follows:
Table 7 shows the production and marketing balance sheet and unit freight list of a transportation problem. Transformed this problem into the minimum cost and maximum flow problem, draw network diagram and find out solution.

Table7: production and marketing balance sheet and unit freight list

	1	2	3	Output
A	20	24	5	8
B	30	22	20	7
Sales	4	5	6	

Translate table 7 into network figure 2, due to the imbalance of production and marketing, so set two nominal points S and T, where S and T are nominal origin and destination, the number next to each arc in the graph is (b_{ij}, c_{ij}), in which b_{ij} represents the unit cost of each arc,c_{ij}represents the maximum capacity of each arc.

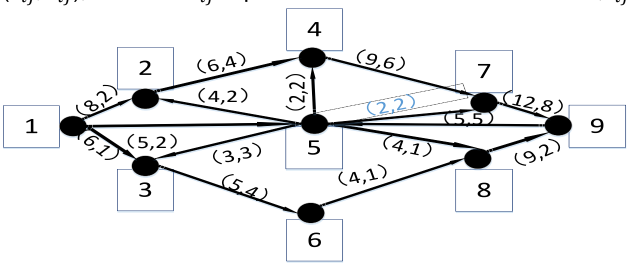

Figure 2: The transformed network graph

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