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Simulation and optimization of agricultural product supply chain system based on Witness

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ABSTRACT: Researches on agricultural product supply chain have important implications for improving the efficiency of agricultural products circulation, strengthening the construction of agricultural market system, promoting agricultural modernization and solving the three rural issues. Agricultural product supply chain system has begun to be optimized through simulation technique. In this paper, agricultural product supply chain system is reasonably simplified and assumed. A simulation model was developed by using the simulation software Witness to study agricultural product supply chain. Through the analysis of the simulation output data, improvement suggestions were also proposed as follows: improving the organization degree of agricultural products, improving the agricultural products processing, establishing strategic partnership and scientifically developing agricultural products logistics.

Keywords: Witness; agricultural product supply chain; optimize

1 INTRODUCTION

Chinese authorities have been issuing No. 1 Central Document underscoring the importance of three rural issues continuously for 13 years from 2004 to 2016. China is a large agricultural country. Since the reform and opening up, China's rural economy has developed rapidly, but China is not an agricultural power, there are many problems in the development of agricultural product supply chain, such as the low organization degree of agricultural producers, low deep processing rate of agricultural products, unstable prices of agricultural products, and safety problems of food.

2 AGRICULTURAL PRODUCT SUPPLY CHAIN

Agricultural product supply chain refers to the network structure formed by all node enterprises providing agricultural products and related services for consumers in the process of agricultural production and circulation [1-2].According to the characteristics of supply chain, such as complexity, dynamic, and using of supply chain integration, the agricultural product supply chain model is constructed, including the model members, the external environment and the network structure.

Members of the model come from the origin to consumption, who directly or indirectly interacted with all the companies, organizations and individuals through suppliers and customers, including agricultural raw materials suppliers, agricultural producers, agricultural products processing enterprises, agricultural products sales enterprises, agricultural consumers. External environment mainly includes the government which carries out macro regulation and conduct supervision and management and the agricultural product logistics service enterprises that provide services. The network structure is the chain structure which each node are composed of members of the model, and the relation between the members is a kind of demand and supply relationship. The connection between the model members is composed of capital flow, logistics and information flow. Agricultural product supply chain model is shown in Figure 1.

3 SIMULATION MODEL

In this paper, the simulation software Witness is used to study agricultural product supply chain. Witness is

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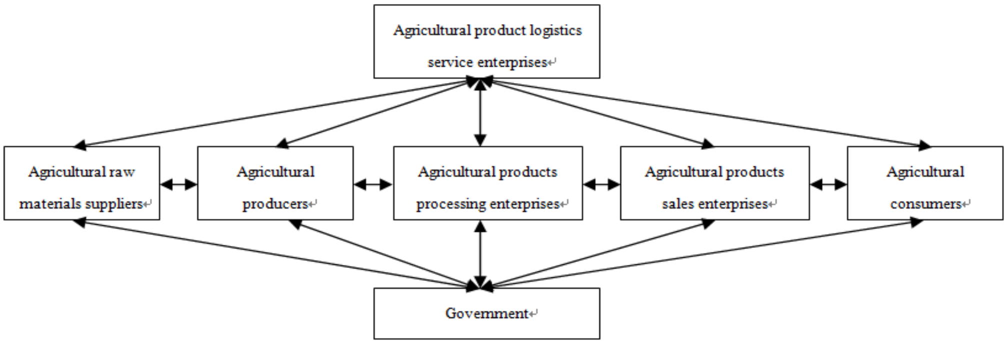

Figure 1. Agricultural product supply chain model

a software platform for dynamic system modeling and simulation, which is developed by the British Lanner, to be geared to the needs of industrial systems, business systems and processes [3-4]. As Witness has a wide range of application areas, a large number of model elements, a powerful simulation engine, a convenient graphical interface operation function and a hierarchical modeling function, it has become one of the main simulation software.

3.1 *Hypothesis and simplification of simulation model*

Reasonable simplification and hypothesis of the model is of great necessity, because the modeling and analysis of complex system could not reflect the whole reality system [5-6].In this paper, the simulation model of agricultural product supply chain system is simplified and assumed.

(1) Model members of agricultural product supply chain are simplified to agricultural producers, agricultural products processing enterprises, agricultural products sales enterprises. External environment is simplified to agricultural product logistics service enterprises.

(2) The time for the production and distribution of agricultural products are in line with the uniform distribution.

(3) In the agricultural product supply chain, the supply of upstream enterprises is based on the inventory of downstream enterprises.

(4) In the agricultural product supply chain, the demand of downstream enterprises can be satisfied, the agricultural products produced by upstream enterprises meet the quality standards.

(5)Agricultural product logistics service enterprises have the ability to meet the logistics needs of agricultural product supply chain nodes.

(6)Do not consider reverse logistics.

3.2 *Defining simulation elements*

In this paper, we mainly choose the parts, machines, buffers in discrete elements and attributes in a logical element in the model. Simulation elements are as defined in Table 1. Agricultural product supply chain simulation model based on Witness is shown in Figure 2.

3.3 *Details of the simulation elements*

In this paper, input parameters in the simulation model of agricultural product supply chain system are based on the enterprise database.

(1) Details of the A1 Machine element set
Input From …:
IF NPARTS （C2）<30
PULL from P out of WORLD
ELSE
Wait
ENDIF
Cycle Time: UNIFORM （6, 8, N）
Output.TO…: PUSH to B1 at Rear

(2) Details of the A2 Machine element set
Input From …:
IF NPARTS（C3）<6
PULL from C2
ELSE
Wait
ENDIF
Cycle Time: UNIFORM （2, 3, N+2）
Output TO…: LEAST PARTS B2 (1) at Rear, B2 (2) at Rear

(3) Details of the A3 Machine element set
Input From …:
IF MIN （NPARTS（B31）, NPARTS（B32）, NPARTS（B33））<2
PULL from C3
ELSE
Wait
ENDIF
Cycle Time: UNIFORM（3, 5, N+2）
Output TO…: LEAST PARTS B31 at Rear, B32 at Rear，B33 at Rear

(4) Details of the A41 Machine element set
Input From …:
PULL from B31 at Front

Table 1. Defining simulation elements

Element name	Type	Quantity	Illustration
P	Part	1	Agricultural products
C2	Buffer	1	The inventory of agricultural products logistics service enterprises
C3	Buffer	1	The inventory of agricultural products processing enterprises
A1	Machine	3	Agricultural producers
A2	Machine	2	Agricultural products logistics service enterprises
A3	Machine	2	Agricultural products processing enterprises
A41	Machine	1	Agricultural products sales enterprises
A42	Machine	1	Agricultural products sales enterprises
A43	Machine	1	Agricultural products sales enterprises
B1	Conveyor	1	The path of agricultural producers to agricultural product logistics service enterprises
B2	Conveyor	2	The path of agricultural products logistics service enterprises to agricultural products processing enterprises
B31	Conveyor	1	The path of agricultural products processing enterprises to agricultural products sales enterprises A41
B32	Conveyor	1	The path of agricultural products processing enterprises to agricultural products sales enterprises A42
B33	Conveyor	1	The path of agricultural products processing enterprises to agricultural products sales enterprises A43
T1	Time series	1	Inventory statistics

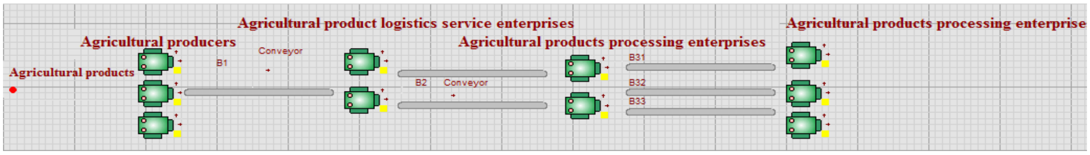

Figure 2. Agricultural product supply chain simulation model based on Witness

Cycle Time: 8.0
Output TO…: PUSH to SHIP
(5) Details of the A42 Machine element set
Input From …:
PULL from B32 at Front
Cycle Time: 8.0
Output TO…: PUSH to SHIP
(6) Details of the A43 Machine element set
Input From …:
PULL from B33 at Front
Cycle Time: 8.0
Output TO…: PUSH to SHIP
(7) Details of the B1 Conveyor element set
Length in Parts: 10
Index Time: 0.2
Output（TO…）: PUSH to C2
(8) Details of the B2 Conveyor element set
Length in Parts: 10
Index Time: 0.2
Output（TO…）: PUSH to C3
(9) Details of the B31, B32, B33 Conveyor element set
Length in Parts: 10
Index Time: 0.2
Output（TO…）: Wait
(10) Details of the T1 Time Series element set
Recording: 2.0
Plot: NPARTS （C2）
Plot: NPARTS （C3）
Plot: NPARTS （B31）
Plot: NPARTS （B32）
Plot: NPARTS （B33）

4 MODEL OPERATION AND DATA ANALYSIS

4.1 *Model operation*

Simulation clock of the model takes 1 as the time unit for 1 day, and the model works a total of 24 x 365=8760 simulation time unit. The utilization rate of production equipment and statistics of transport status are as shown in Table 2 and Table 3.

Table 2. Utilization rate of production equipment (unit: %)

Name	Idle	Busy	Filling	Emptying	Blocked
A1(1)	11.33	88.52	0	0	0.15
A1(2)	11.4	88.45	0	0	0.14
A1(3)	11.2	88.66	0	0	0.14
A2(1)	52.96	47.04	0	0	0
A2(2)	53.2	46.8	0	0	0
A3(1)	24.49	75.51	0	0	0
A3(2)	24.96	75.04	0	0	0
A41	0.23	99.77	0	0	0
A42	0.23	99.77	0	0	0
A43	0.33	99.67	0	0	0

Table 3. Statistics of the transport status (unit: %)

Name	Empty	Move	Blocked	Queue	Broken Down
B1	56.73	43.27	0	0	0
B2(1)	61.51	38.49	0	0	0
B2(2)	63.33	36.67	0	0	0
B31	0.24	0.08	0	99.68	0
B32	0.29	0.14	0	99.57	0
B33	0.43	0.14	0	99.44	0

4.2 *Model operation*

By analyzing the rate of production equipment in Table 2, the transportation time of logistics service enterprises A2 is only 46.8%, and the idle time is as high as 53.2%. Through the analysis of transport status statistics, it can be found that the queuing time (B31, B32, B33) from agricultural products processing enterprises to agricultural products processing enterprises is more than 99%, which greatly reduces the working efficiency.

5 SIMULATION AND OPTIMIZATION OF AGRICULTURAL PRODUCT SUPPLY CHAIN SYSTEM

The waiting time during the transportation of agricultural products from processing enterprises entering into selling procedure can be reduced by improving the logistics service. According to the above optimization strategy, the parameters of the agricultural product supply chain system model can be optimized as following suggestions.

5.1 *Reduce the number of agricultural producers in the model*

The number of agricultural producers in the model is reduced from 3 to 2. Simulation clock of the model takes 1 as the time unit for 1 day, and the model works a total of 24 x 365=8760 simulation time unit. As shown in Table 4, it can be found that the queuing time (B33) for agricultural products from processing enterprises to selling enterprises dropped to 0.27%, greatly improving the working efficiency. The specific optimization strategy is as follows:

The practice of agricultural cooperative organization promotes a good reference. Efforts should be made to change the management mode of scattered agricultural producers, and encourage agricultural producers to develop cooperation, thus leading the agricultural products entering the market more successfully and effectively promoting the development of agricultural product supply chain.

The agricultural producers doing deep and fine processing in China are rare, and this results in low profits for agricultural producers. In suitable cases, agricultural producers can gain more income from the deep processing of agricultural products [7-8].

5.2 *Shorten the order lead time*

The order lead time of each link in the model is reduced to half of the original model. Simulation clock of the model takes 1 as the time unit for 1 day, and the model works a total of 24 x 365=8760 simulation time unit. As shown in Table 5, it can be found that the queuing time for agricultural products from processing enterprises (B32) to selling enterprises dropped to 30.98%, greatly improving the working efficiency. The specific optimization strategy is as follows:

Supply chain of the agricultural products need the cooperation of all strategic partners in upstream and downstream, thus forming a favorable condition of mutual trust, information sharing, clear rights and responsibilities, risk sharing, profit sharing and realizing effective connection, cooperation, design, production and competitive strategy between the nodes[9-10].

Scientifically and rationally make plans of the logistics infrastructure rather than blindly pursue innovation logistics infrastructure and scientifically develop the technology of preservation storage and processing.

Table 4. The statistics of transport status (unit: %)

Name	Empty	Move	Blocked	Queue	Broken Down
B31	27.77	24.82	0	47.42	0
B32	41.78	24.63	0	33.58	0
B33	92.31	7.42	0	0.27	0

Table 5. The statistics of transport status (unit: %)

Name	Empty	Move	Blocked	Queue	Broken Down
B31	3.12	19.28	0	77.6	0
B32	44.07	24.96	0	30.98	0
B33	41.01	24.93	0	34.05	0

6 CONCLUSION

Based on the above research, the author proposed several suggestions for the optimization of agricultural products supply chain system.

6.1 *Improving the organization degree of agricultural producers*

In the process of strengthening the organization degree of agricultural producers, it should be combined with the actual situation in our country, and cannot blindly copy the foreign experience.

6.2 *Developing deep processing of agricultural products*

Logistics service enterprises can carry out professional value-added services, helping agricultural producers gain profits from the producing, processing and selling procedures.

6.3 *Establishing a strategic partnership*

To establish a strategic partnership should be based on trust mechanism and information sharing mechanism between the nodes, thus forming a framework of common value chain.

6.4 *Scientifically developing agricultural products logistics*

It needs to focus on the development of the third party agricultural products logistics, make full use of the industrial, professional, cost, service and social value of the third party agricultural products logistics and appropriately expand the scale of the third party agricultural products logistics enterprises and reduce the proportion of the self-run logistics.

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