Research Article

Analysis on Optimization of Agricultural Products Supply Chain Based on Dynamic System

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To thoroughly implement the spirit of the Fifth Plenary Session of the 19th CPC Central Committee, this paper optimizes the supply chain of agricultural products based on dynamic system. In the complex supply chain of agricultural products, they are scattered upstream and downstream. It is difficult to form agglomeration scale effect, information asymmetry between supply chain nodes, and poor hardware environment of supply chain. Logistics operation is difficult. By analyzing the supply chain of agricultural products, optimize the supply chain by using the push-pull supply chain. According to the change of market demand, the push mode and the pull mode are properly allocated and the government’s attention to the supply chain is increased, intentionally the Internet is combined with the supply chain, the stability of the supply chain is increased, and there is a certain adaptability to market demand fluctuations. Problems can be fed back to the suppliers and final buyers of agricultural products in time, and the delivery rate of the whole supply chain should be improved.

1. Introduction

Food security has increasingly become a concern at home and abroad [1]. In order to thoroughly implement the spirit of the Fifth Plenary Session of the 19th CPC Central Committee, speed up the construction of modern circulation system of agricultural products in China, improve the circulation efficiency of domestic agricultural products, and further strengthen the self-system construction in the supply chain of agricultural products. The key supply chain of agriculture is becoming more and more important [2]. Supply chain has existed since ancient times and is constantly changing. Based on modern logistics, using the principle of system dynamics and optimizing the operation mode is more suitable for the needs of modern society for economic development [3]. However, although many models of supply chain optimization work have been developed, when encountering very complex systems, some existing supply chain work models may not meet the needs of the work and cannot analyze the scheme and solve it [4].

In this study, in order to optimize the supply chain of agricultural products to solve the actual food supply problem, using system dynamics, combined with the overall operation mode, connecting the supply of various parts, and formulating a more close to and more in line with the needs of Chinese society, first of all, we should analyze the present situation of agricultural products in China and then learn from the experience of other countries in the development of agricultural products supply chain and further put forward the optimization scheme [5]. Agricultural products supply chain finance has achieved capital increase to credit enhancement, mainly through the construction of segmented credit financing model and system dynamics simulation and analysis of agricultural products supply chain financing performance and influencing factors [6].

All along, China is a big agricultural country, the demand for agricultural products is extremely large, and food is essential in our daily life. It is necessary to optimize the supply chain by putting complex and diverse agricultural products into people’s daily life through layers of processes. Although
logistics has existed since ancient times, the ancient logistics technology can no longer be satisfied with modern life, and we need to come up with a supply chain management mode that is more in line with the development of modern society on the basis of modern logistics [7]. It can save energy, efficiently and scientifically utilize modern system dynamics theory and feedback of actual implementation, and optimize a brand-new management mode of agricultural products supply chain. Drawing up a more stable supply chain of agricultural products is conducive to the sustainable development proposed by President Xi and avoids the short-comings of the traditional industrial chain [8].

Our country’s agricultural product supply market in today’s society overall demand is balanced, but its price dynamic fluctuation range is large, the transportation process produced in the cost in high situation is widespread, and the national government has been paying great attention to the “three rural” issues [9, 10]. However, it is often difficult to sell and expensive to buy in the market. For example, “fish is expensive” and “it is difficult to eat pork”; it reduces consumers’ trust in the Chinese market and hurts the interests of our consumers. On the one hand, the existence of these problems indicates that the demand for agricultural products in China is expanding, people’s consumption level is improving day by day, and living standards are gradually rising; on the other hand, it also indicates that the supply chain of agricultural products in China is not closely related to the market demand. This study is to optimize the supply chain of agricultural products through dynamic system, have a stronger grasp of the flow of logistics, capital chain, and information flow in the process of transporting agricultural products, and coordinate well with suppliers, producers, distributors, and consumers of means of production in China’s agricultural production. The process relationship starts from the data of agricultural production and completes the reasonable arrangement of cultivation, planting, acquisition, processing, transportation, logistics, and distribution of agricultural products. It makes a series of processes run more smoothly, links are closer and more reliable, and feedback information is timely, improves the trust in the supply chain of agricultural products, and increases the sales channels, which plays a positive role in promoting its sustainable development and provides a more scientific guidance scheme [11, 12]. Aiming at the problems of asymmetric product information, poor supply chain environment, and difficult logistics operation in the supply chain, this paper puts forward a supply chain optimization method based on dynamic model to solve the supply problem of agricultural products.

Although China has been a big agricultural country since ancient times, compared with other developed countries, the development is late, but in recent years, the country has paid close attention to the problem of agricultural supply. The research on solving the problem of agricultural products supply chain by using dynamic system is still less in China, the basic theoretical knowledge is insufficient, the research on each link is weak, and the published journals are relatively few compared with other explorations. In the theoretical sense, we hope it can help the research on the completion of agricultural products supply chain and provide enlightenment for a series of links such as logistics and sales of characteristic agricultural products supply chain. The second part of the article analyzes the research on supply chain optimization at home and abroad, the third part discusses the technical problems of supply chain, and the fourth part designs the application model of dynamic model in supply chain; the fifth part analyzes and compares the optimization experiments of agricultural products under the dynamic model. The scientific significance of this paper lies in the realization of optimization problems in the supply chain, optimization, and distribution of product logistics process.

2. Research Status

2.1. Domestic Research Status. Agricultural supply chain is still developing in our current environment, the ongoing business model is not mature enough, and more analysis and research are needed to improve the modern information exchange in the agricultural supply chain, so that the circulation is smoother. In recent years, the construction of Internet of Things in China has been continuously improved. With the research and development achievements of Huawei 5G, the modern agricultural products market with network informationization will gradually enter the commercial market and integrate with the modern business model [13, 14]. It can be seen from the graph that there are few studies on agricultural products supply chain in China, and the analysis of agricultural products supply chain optimization based on dynamic system is even less. In the past five years, there are 7558 documents related to agricultural industrialization in Chinese periodicals, but there are only 853 reports on agricultural products supply chain, and only one report on agricultural products supply chain optimization based on system dynamics. Industrialization development accounts for the bulk of agricultural product industrialization research. In the research of supply chain, agricultural products only account for less than one fifteenth of the whole research, and the development of agricultural products is of great significance to our country, which needs our great attention. See Table 1 and Figures 1–3 for details, from which it can be seen that the research on industrialization of agricultural products has reached a certain demand, and further related research can be needed.

2.2. Research on Supply Chain Theory. In China, there are many scholars studying supply chain. Supply chain refers to the network chain structure formed by upstream and downstream enterprises involved in providing products or services to end users in the process of production and circulation [15]. Fu [16], a Chinese scholar, investigated and studied the supply of agricultural products in Hong Kong’s foreign trade as early as 1981 in the journal World Agriculture and compared and evaluated the supply of Hong Kong’s import and export in Chinese mainland, which was an initial exploration of supply chain. Huang [17] put forward logistics supply chain and agricultural industrialization as early as 2002. At that time, shortly after China
joined the World Trade Organization, he believed that modern logistics made logistics and capital flow by changing the traditional circulation mode of agricultural products and the economic hierarchy mode. The speed of information flow is accelerated, the competition among enterprises is promoted, the industrial structure is optimized, and the utilization rate of resources can be improved by integrating external resources and redistributing resources through cooperation. Xu and Xu [18] regard sharing of agricultural products supply chain as a key link according to the overall

<table>
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<th>Reference</th>
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<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
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<td>0</td>
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**Figure 1:** Bar statistical chart of literature quantity.

**Figure 2:** Sector statistical chart of literature quantity.
framework of sharing mechanism, improving supply efficiency and saving resources. Gao and Leng [19] look at the supply chain of agricultural products from the perspective of circular economy and have evaluated whether the supply chain meets the indicators, comprehensively evaluated the ability to promote the economy, and provided basis and guidance for government investment and economic promotion. Gong [20] pointed out that the supply chain needs to be familiar with the region and diversify its demand through the market.

2.3. Research Status Abroad. Because of lean production, Toyota in Japan regards the supplier’s work as an organic component of production, is ready to produce at any time, and welcomes every production project in a positive way. Becker and Murphy put forward “spillover effects” in their book Division of Labor, Coordinating Costs and Knowledge. None of them agree with Smith. It is believed that division of labor can benefit the world and promote its economic development, but it also brings coordination costs. In recent years, there are economies of scale in specialization of division of labor, technological creation and knowledge spillover, and institutional innovation. It proves that agricultural division of labor and specialization are increasing with the return on scale, so it emphasizes the importance of specialized human capital for agricultural production.

3. Research Contents and Methods

Aiming at the development status and existing problems of agricultural industry chain, this paper analyzes several modes of agricultural products supply chain and expounds the development status. According to the practical experience of agricultural products supply chain optimization at home and abroad and the development of systematic dynamics theory, this paper discusses how to further optimize agricultural products supply chain by using dynamics system, constructs the process of related experimental design, and puts forward corresponding countermeasures to support the implementation of optimization scheme. The technical route is shown in Figure 4.

3.1. Research Methodology. This paper combines theory with practice, looking for relevance in domestic and foreign literature, understanding their research progress, obtaining reliable information, and then using systematic analysis and comparative analysis, combining domestic and foreign to complete this research.

Using the system dynamics model method, according to the needs of the research process, VenSim software and Visio software are used to build the object model, so that it can measure the validity of the model from multiple angles and carry out model simulation for different countermeasures.

Consult data: collect relevant historical data and reference materials for the construction of the system to provide realistic basis and design ideas.

This paper consults the relevant literature at home and abroad, collates and analyzes the data, compares the research status at home and abroad, analyzes the development and optimization direction of agricultural products industry chain in China, and provides the data background and ideas for optimization.
3.2. Innovations and Shortcomings. In this paper, the system dynamics model is combined with the theory, but the experimental data is small, so it needs to be practiced. The innovation point of this paper is now more attention to the optimization of agricultural products supply chain in China. With the crazy rise of pork in recent years, there is little research on each enterprise link. This paper grasps the optimization problem and puts forward the shortcomings of the optimization paper on agricultural products supply chain by using dynamic system theory.

For modeling analysis, in the actual agricultural product supply chain, the degree of integration is average, and too detailed problems may be missing. There are few statistics on agricultural product industrialization collected online, and relevant industrial data are lacking. Most farmers do not participate in the agricultural product supply chain or even understand this concept, and there are loopholes in optimization. It needs further analysis and research to study the implementation scheme of supply chain optimization by using systematic dynamics in each link.

4. Dynamic System Model

In a system, behavior patterns and characteristics depend on its internal dynamic structure and feedback mechanism; the system develops according to certain natural laws under the interaction of its internal and external dynamic changes and causal characteristics. It mainly emphasizes the integrity of the system and the nonlinear characteristics of complex systems. Under the qualitative and quantitative conditions, it solves a series of complex problems by overall thinking and analysis.

4.1. Systematic Causality Analysis. Dynamic system analyzes the qualitative relationship between the whole systems through causal feedback. Macroscopically, the factors of external environment act on the system, which is mainly reflected by the influence of economic level on the interior of the system and in the system, mainly through the logistics integration and logistics supply between the role of the whole system and the external environment for information exchange or sharing. Agricultural products supply chain logistics obstruction, logistics integration income, logistics integration income demand, and agricultural products logistics industry investment are the media among the system elements. Through the analysis of system causality, the diagram shown in Figure 5 is obtained.

The causal diagram of the whole system includes three subsystems, which is Figure 6.

The feedback system is a negative feedback system, mainly used to analyze the economic level of agricultural products with the change of logistics demand and logistics capacity. This cycle reflects the relationship between the economic level (economic benefit or value) of agricultural products and the supply chain of agricultural products. As can be seen from the figures, the rising economic level of agricultural products contributes to the increase of supply chain logistics demand, but the increase of supply chain logistics demand will also bring various obstacles and inhibit the economic level of agricultural products.

Feedback system is a positive feedback system, which mainly analyzes the impact of external environment on the internal of the system. With higher economic level of agricultural products, the government will increase the investment in the supply chain logistics of agricultural products, which leads to the increase of integrated supply capacity of logistics. However, because the logistics system of the whole supply chain is too large, the integrated supply cannot meet the requirements of the whole system, which will cause a series of impacts, such as local logistics backlog and delay, which in turn inhibits the improvement of the economic level of agricultural products.

Feedback system is a positive feedback system, which mainly analyzes the external environment on the internal effects of the system. The improvement of agricultural economic level accelerates the growth of logistics demand, which leads to the rise of logistics integration demand, which in turn leads to the rise of logistics integration income, thus better realizing logistics integration supply. However, this series of effects is not comprehensive for the whole system, and the rise of integrated supply will lead to a series of supply chain logistics obstacles and inhibit the development of agricultural products economic level.

4.2. Establishment of Flow Rate and Level System. Based on the above causal analysis of the internal and external environment of agricultural products supply chain, the dynamic system flow diagram of related factors in agricultural products supply chain and the mathematical expression to realize the working relationship among various elements are established.

Flow rate and flow level are important variables in dynamic system, in which flow level $LEV(t)$ is a cumulative variable, which changes with time, and its change speed is affected by the change of variable flow rate $RAT(t)$, and flow rate variable is the speed that causes the change of flow level variable. To put it simply, we set the flow rate variable that can increase the flow level variable as the inflow rate $R_1(t)$ and the flow rate variable that can decrease the flow level variable as the outflow rate $R_2(t)$; then we can get the relational equation as follows:

$$RAT(t) = R_1(t) - R_2(t).$$

(1)

At the same time, we can also obtain the differential equations satisfied by $LEV(t)$ and $RAT(t)$:

$$\frac{dLEV(t)}{dt} = RAT(t).$$

(2)

If you want the above differential equation to have a special solution, you need initial conditions, namely:

$$LEV(t)|t = t_0 = LEV(t_0).$$

(3)

In the substructure of performance evaluation, our key indicators are total cost of agricultural products producers
$MTC$, profit of agricultural products producers $MPR$, and sales revenue of agricultural products producers and so on. $MPR$ is a flow level variable because it increases with time and there is a speed of change. Furthermore, the inflow rate is the sales income $CUC$ of agricultural products, and the outflow rate is the cost of this period. Therefore, we can get such a flow bit flow rate:

$$< MPR(t), MPR(t) + MSR(t) - CUC(t) >.$$  \hspace{1cm} (4)

The total cost $MTC$ of agricultural producers is also a variable accumulated with time, so we can take it as a flow variable, so the cost increase $MCA$ of agricultural producers is the inflow rate, and the outflow rate is the total cost decrease $TCD$. Therefore, we can get the following flow rate system:

$$< MTC(t), MTC(t) + MCA(t) - TCD(t) >.$$  \hspace{1cm} (5)

In the market index substructure of core producers of agricultural products supply chain, the market share of agricultural product $MOP$ is a flow variable, because it is a variable accumulated with time. Furthermore, the increase of market share of agricultural products $MPI$ is the index of inflow rate. Because, under normal circumstances, the market share should develop in an upward trend, it is no longer necessary to use the outflow rate index. Therefore, we can define the following flow rate system:
In the substructure of internal operation and management of producers, the inventory management of agricultural products is the key index. We can take the inventory of agricultural products MSQ as the flow variable, which accumulates with time. Productivity MMR of producers’ agricultural products will lead to an increase in the inventory MSQ, which can be used as an inflow rate variable. The producer’s delivery rate of agricultural products MDR will lead to an increase in MSQ, which can be used as an indicator of outflow rate. Therefore, we can define the following flow rate system:

\[ < MOP(t), MPI(t) >. \] (6)

Finally, we get four stream bit rate subsystems, as follows:
4.3. Agricultural Products Supply Chain

4.3.1. Basic Definition of Agricultural Product Supply Chain. Agricultural products supply chain refers to the network structure connected by various departments involved in the process of agricultural products production and circulation, such as raw material providers, agricultural products producers, agricultural products sellers and consumers, etc. The working relationship between each node of agricultural product supply chain is similar to that of food chain in nature biosphere, and the relationship diagram is shown in Figure 7.

It can be seen from the figure that, in the food chain of nature, if all sheep disappear, grass will grow wildly, while wolves will die if they cannot find food sources in the food chain, resulting in the destruction of ecological balance. In analogy to the following simple supply chain, if the producer produces too many agricultural products and the seller cannot sell them, it will lead to excessive waste of raw materials.

4.3.2. Basic Characteristics of Agricultural Products Supply Chain. In most cases, supply chain is a complex network structure model, each node of which is usually composed of multiple, multitype, and even multinational enterprises, so the supply chain structure model is more complex.

Due to the change of enterprise management and market demand, each node should update information at any time, and the management strategy should change at any time, which leads to obvious dynamic changes in the supply chain of agricultural products.

The structure change and management policy of supply chain are all around the change of market demand. In the whole supply chain operation, the driving source of information flow, service flow, and capital flow between each node is the user demand. Simply put, once the market demand changes, the whole supply chain will respond and make corresponding changes to meet the needs of users.

Node enterprises on each node can be responsible for the services of multiple agricultural product supply chains on the node, forming a network structure formed by the intersection of many supply chains, which increases the difficulty of coordinated management.

4.3.3. Classification of Agricultural Products Supply Chain. (1) Classification according to Scope of Work. Agricultural products supply chain can be divided into internal supply chain and external supply chain according to the scope of work. There are many departments in an enterprise, such as purchasing department, production department, warehousing department, sales department, and so on. The internal supply chain is usually composed of purchasing department, production department, warehousing department, and other departments working within the enterprise; external supply chain is often composed of sales and publicity departments, as well as some external enterprises such as raw material suppliers and logistics companies that have reached cooperation with enterprises. See Figure 8.

External supply chain and internal supply chain together constitute the supply chain from raw materials to finished products and then to consumers. They complement each other and are indispensable. The main difference between the two is that the internal supply chain has a small scope of work and is easy to manage; external supply chain has a large scope of work, involving many departments, and it is difficult to manage and coordinate.

(2). Classification according to Stability. According to the strong and weak relationship of stability, it can be divided into dynamic supply chain and stable supply chain. Stable supply chain has single market demand and strong stability; however, the market demand of dynamic supply chain changes frequently, with high complexity, strong dynamics, and weak stability.

(3) Classification according to Different Functions. Supply chain can be divided into effective supply chain and reactive supply chain according to its physical function, market intermediary function, and market demand function.

4.4. Development Status and Existing Problems of Agricultural Industrial Chain

4.4.1. Supply Chain Management Mode of Agricultural Products with Wholesale Market as the Core. This is a more traditional supply chain management mode of agricultural products, which originated in China, and China has always been a big agricultural country. According to the survey, as early as the Tang Dynasty, the supply chain model of agricultural products with wholesale market as the core was used by people. According to the survey conducted by the Federation of Agricultural Trade Centers, 70% of China’s agricultural products circulate through wholesale markets, and the participants are mainly agricultural product producers, wholesalers, and retailers. At present, this model still occupies a dominant position in the Chinese market, as shown in Figure 9.

4.4.2. "Agricultural Superdocking" Mode. With the gradual development of the market, supermarkets have gradually become an important channel for urban families to purchase goods. "Combination of agriculture and supermarket" can avoid blindness in agricultural production and help stabilize the price and sales volume of agricultural products. At the same time, supermarkets have strict control over agricultural products. For example, every agricultural product purchased needs to be tested for its freshness, safety, and quality.

At present, the “agricultural superdocking” mode, as shown in Figure 10, is the most important agricultural
product sales mode abroad. Data show that the proportion of agricultural products sold by supermarkets in the Asia-Pacific region is as high as 70% and that in the United States is as high as 80%, but only about 15% in China. Nowadays, with the rise of "e-commerce" in rural areas, many online orders have been born, laying a solid foundation for the system of "tracing back to the source" of agricultural products.
4.4.3. Direct Selling Model. This model refers to the all-inclusive form of agricultural products producers. Producers of agricultural products sell their agricultural products to consumers without middlemen. It is mainly achieved through online direct sales and on-site sales. At present, “direct selling mode of agricultural products” can be seen in many tourist bases, which not only drives the development of surrounding tourism, but also helps most agricultural products producers get rich. However, there are still some deficiencies, such as difficult management, lax price control, and so on.

4.5. Optimization Method and Scheme of Agricultural Product Supply Chain Based on Dynamic System

4.5.1. Problem Analysis on Logistics Supply Chain. At present, in China, most of the supply chain structure of agricultural products makes a single linear relationship; there are at least 4–6 circulation links in the supply chain. According to rough statistics, in real daily life, the phenomenon of complicated logistics may be more serious. Under the vast landform in China, the uneven distribution of combined land resources makes the supply chain in China unable to form a scale. However, the terrain of our country is various, complex, and changeable, which makes the distribution of agricultural products uneven, resulting in long or short transportation distance, which makes it difficult to form a unified mode, and the operation cost increases, which affects the overall economic development of agricultural products.

4.5.2. Optimization and Upgrading of Production Links in Agricultural Products Supply Chain. The promotion of agricultural products supply chain is reflected in the high level, high informationization, and high capital content of all nodes. Agriculture, as the most important basic industry in China’s economic system, also has its own special industrial curve. The smile curve of agricultural product supply chain is shown in Figure 11. The upstream and downstream ends are R&D and brand marketing, while the midstream and the parts between the midstream ends are production, agricultural materials, and deep processing, respectively. It can be seen that R&D and brand marketing have the highest profits, while production has the lowest profits.

4.5.3. Push-Pull Supply Chain Operation Mode. Using the combination of push and pull in the supply chain operation management mode, the agricultural product supply chain needs to run in the form of push in some specific links, and the other links adopt pull mode. The push-pull boundary is the boundary of push and pull. In the operation mode of combining the two, the push-pull boundary is located at the beginning of supply.

For the supply chain of agricultural products, we need not only to carry out the promotion strategy when the demand of agricultural products is determined, but also to carry out the promotion strategy when the demand of agricultural products is uncertain. In this way, the push-pull combined supply chain can be operated in agricultural products, so that all kinds of agricultural products can be sold with activity and enhance the firmness of the supply chain.

5. Comparative Analysis of Simulation Results

In order to facilitate the analysis and comparison of simulation results, the parameters are set to the same value. The simulation results of the three modes are shown in Figures 12 and 13.

In order to study its sensitivity, the disturbance function STEP (8, 40) is added in the experiment, and the demand function is changed to Random * Normal (0, 10, 5, 5, 0) + Step (80, 40), which optimizes the mode of policy change.
Figure 11: Smile curve of agricultural products supply chain.

Figure 12: Simulation results.
From the above experiments, it can be seen that \( f \) (manufacturer’s qualified total) ≤ \( g \) (usual inventory reserve). In the figure, the manufacturer’s qualified curve has shifted, which shows that it cannot achieve the expected delivery; it is very important to change the distribution inventory, and the change is very small, which shows that the delivery rate of distributors is closely related to it. The experimental part focuses on the related requirements of suppliers, manufacturers, and distributors and analyzes them from the time dimension. Therefore, the supply and demand changes among suppliers, manufacturers, and distributors are analyzed from the dynamic model.

### 6. Conclusion

Push supply chain is extremely unstable, so push-pull combination is needed to stabilize logistics supply chain. To improve the delivery rate of the whole supply chain, it is necessary to change the ordering cycle of suppliers. In the process of logistics network informationization logistics, it is necessary to closely contact the production side and the buyer, so as to solve problems in time and feedback information in time, which can improve the supply chain.

### Data Availability

The experimental data used to support the findings of this study are available from the corresponding author upon request.

### Conflicts of Interest

The authors declare that they have no conflicts of interest regarding this work.

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