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Research on the Human-Computer Interaction Optimization of Supply Chain Management of Agricultural Products Based on AI-Powered CAD

Yuanyan Xia[1*]

[1] School of Finance and Trade, Zhengzhou Business University, Zhengzhou, Henan, 451200, China

Corresponding author: Yuanyan Xia, XY864521@163.com

Abstract. The supply chain management of agricultural products is not just a theoretical concept but a crucial aspect of economic development and social stability. Based on big data technology, this paper conducts a comprehensive system data analysis of the supply chain management of agricultural products. The aim is to enhance the optimization effects of supply chain management of agricultural products and demonstrate the proposed algorithm's practicality and efficiency. By optimizing agriculture's supply chain management system using big data technology, analyzing the farm supply chain management nodes, and constructing the corresponding model system, this paper presents a detailed construction scheme of the Chinese rural supply chain management information system. The practical effects of this system, based on experimental research, are also discussed.

Keywords: AI-Powered CAD; Agricultural Products ; Supply Chain Management ; Optimization; Human-Computer Interaction
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1 INTRODUCTION

The fragility of the supply chain is exposed to severe dysfunctions and disturbances affected by its internal and external risks, which may be destroyed due to internal and external risks. In general, there are two reasons for the formation of supply chain vulnerabilities: one is globalization and the country's opening to the outside world, and the complexity of the supply chain is gradually increasing; the other is when the influence of risk sources and risk drivers is more significant than the risk mitigation strategy, the supply chain will be volatile [19]. Therefore, in most cases, circulation companies will ignore the supply chain's internal and external risks and vulnerabilities. When it comes to the field of agricultural products, the members of the farm product supply chain are closely linked, and its formation is the result of alliances and cooperation in the process of market expansion by agricultural enterprises. When this division of labor and collaboration encounters internal and external disturbance factors, the farm product supply chain often shows a certain degree of alliance vulnerability and even the possibility of chain disconnection, affecting the regular operation of the entire agricultural product supply chain.

Moreover, the agricultural product chain system cannot resist these disturbances or restore the original system. Agricultural product supply chain risks typically include internal and external risks [15]. Internal risks mostly come from the interaction between the supply chain system components, such as conflicts of interest, logistics constraints, information blockages, etc [16]. When the potential optimal interaction elements in each link are mismatched or overlapped, the stability of the supply chain itself will be weakened, and the internal risks of the agricultural product supply chain will be aggravated. The cause of external risks in the agricultural product supply chain is mainly the result of the interaction between the farm product supply chain and its surrounding external environment, which is usually related to policy changes, price fluctuations, and changes in market supply and demand. Therefore, although the sources of internal and external risks in the agricultural product supply chain are different, the concurrent occurrence of these risks will aggravate the economic losses of each member and each link [18]. Integrating big data technology, E-commerce, and Human-Computer Interaction (HCI) offers a transformative strategy for optimizing agricultural supply chain management, addressing market volatility and sustainability challenges. Through big data analytics and machine learning, stakeholders gain insights to streamline operations and enhance decision-making processes. E-commerce platforms enable seamless transactions and data exchange, while HCI principles ensure accessibility through intuitive interfaces and collaborative tools, empowering users to monitor operations and drive improvement. This interdisciplinary approach fosters transparency, efficiency, and innovation across the agricultural value chain, enhancing productivity and sustainability amidst changing market dynamics and environmental pressures.

With the rapid development of the economy, my country's economic model is constantly changing, and all walks of life are adapting to the needs of the times through changes. New retail refers to making full use of network resources, combining the advantages of network resources with the benefits of physical stores, and Allowing the sales model to upgrade and transform; in this way, the economy develops rapidly, and through the integrated economic model, consumers' purchases are more concise and convenient, and sales are also expanded. New retail refers to the integration of this technological environment and actual commodity needs in a highly developed environment, such as artificial intelligence network technology, through logistics and transportation, etc., to standardize, collect, and integrate the sales model to create a new The sales model makes sales more concise and convenient, thereby promoting the increase in sales. It is a new sales model guided by network thinking through online and offline channels, plus mobile logistics, to encourage consumer consumption and improve my country's sales efficiency and level. The proposal for new retail solves the efficiency problem of traditional retail methods. It focuses on the two aspects of network and circulation. Sales are not limited to regional restrictions through the network and circulation of physical stores. Breaking the objective conditions promotes resources. At the same time, the application of artificial intelligence has continuously improved service efficiency, which can meet the needs of consumers well and enable the continuous development of my country's economy.

This article combines big data technology to optimize the agricultural product supply chain management system and builds an intelligent system to improve efficiency.

2 RELATED WORKS

Agricultural product supply chain management began to develop after the successful application of supply chain management technology in large foreign companies such as IBM and DELL. The United States, Japan, and the European Union have developed highly high agricultural product supply chains. There are three stages in foreign research and development: (1) Business flow stage. This stage mainly studies agricultural products' commercial flow from output to consumers [14]. (2)

Integrated logistics stage. The research content of this stage is to separate agricultural product logistics management from marketing and expand upstream to the processing process of agricultural product processing enterprises, emphasizing that production should be market-oriented and control the entire logistics link [13]. (3) The integration stage of the supply chain. The research scope of this stage is further extended to the upstream enterprises in the supply chain, such as the suppliers of raw materials such as seeds and fertilizers, to track and monitor the information on the entire supply chain to find and solve problems quickly and effectively [6]. The United States attaches great importance to food safety issues and is leading food supply chain technology research. Among developed countries, the United States has a complete agricultural product supply chain service system and advanced methods and has realized an all-round society service before, during, and after [17]. Japan has established a supply chain information tracking system. The system's characteristics are as follows: a unified national database system has been established, and a national shared data platform has been formed. Consumers can find any information about agricultural products in the database. The EU has gradually increased its agricultural product supply chain investment in recent years [2]. The EU has begun to build a unified and complete food safety system and technical standards and has established a corresponding agricultural product supply chain information system. For example, a beef supply chain management information system is established to record information about the whole process of beef, from breeding, slaughtering, segmentation, processing, packaging, and final consumption. In addition, barcode technology is used to store information such as the origin, slaughter area, and slaughter approval number of beef [23]. Each node unit on the chain, including consumers, can easily query information. Kiwifruit, produced in New Zealand, has also realized the importance of information system management in the supply chain. Western developed countries have used a lot of computer science and technology in the supply chain management of agricultural products, conducted much research on the management system, established a tracking and traceability system for agricultural product supply chains, and effectively solved the problem of agricultural product (food) safety [8].

Literature [11] constructed a supply chain alliance benefit distribution model, analyzed the benefit distribution mechanism under asymmetric information from the perspective of the alliance, and put forward suggestions and enlightenment. Literature [20] established a Starkberg game model of the secondary supply chain composed of agricultural product producers and agricultural product retailers. It analyzed the profits of the entire agricultural product supply chain and the agricultural product manufacturers and manufacturers under the two conditions of cooperation and non-cooperation. The retailer's profit situation indicates that collaboration between enterprises at the farm product supply chain node can increase profits. Literature [21] takes the agricultural product supply chain dominated by third-party logistics companies as an example, analyzes the problem of benefit distribution, and proposes the benefit distribution based on the Sharpley value method to enable all participants in the supply chain to share the benefits and bear the risks together. Method. Literature [4] applies the basic principles of game theory to analyze the changes in the profit of each node member when the cooperative relationship of the agricultural product supply chain changes and proposes a series of suggestions to promote the reasonable distribution of cooperative earnings in the agricultural product supply chain and ensure the long-term stability of the supply chain.

Literature [3] summarizes the definition and types of agricultural product supply chain coordination and analyzes the factors that hinder agricultural product supply chain coordination from a system perspective. In particular, it points out that the contract incentive mechanism and benefit distribution are the constraints on the coordinated operation of the agricultural product supply chain. Mechanism. Literature [1] summarized the concepts and types of agricultural product supply chain coordination, comprehensively analyzed the factors that affect coordination, and proposed agricultural product supply chain coordination strategies; summarized the kinds of supply chain coordination strategies driven by interests, and at the same time constructed agricultural product supply The pricing game model of agricultural product processors and sellers in the chain system during cooperation and non-cooperation, and analyzes and compares two interest coordination strategies based on the Shapley value method and the same profit growth rate. Literature [5] studied the efficiency of agricultural product supply chain organization, constructed a supply chain organization efficiency model, obtained first-hand data through field questionnaire surveys, verified various assumptions in the model through SPSS software test calculations, and discussed the impact on agricultural product supply chains. Many factors of organizational efficiency.

3 OPTIMIZATION ALGORITHM OF AGRICULTURAL PRODUCTS SUPPLY CHAIN MANAGEMENT

This chapter analyzes data on agricultural product supply chain management systems using big data technology. To improve the efficiency of agricultural products and supply chain management, we need to analyze and improve the algorithm performance combined with the agricultural product supply chain [9]. Suppose $Y_1, Y_2, \cdots, Y_n$ is a series of independent random variables with the same distribution; the distribution function is $F(x)$, for probability level τ, within the tau-horizontal of $\xi_\tau = F^{-1}(\tau)$, the distribution F has a continuous density function $f(x)$ (where $f(\xi_\tau) > 0$), and the τ horizontal quantile of the sample is [2]:

$$\widehat{\xi}_\tau = \inf_{\widehat{\xi}} \left\{ \widehat{\xi} = \min_{\xi \in R} n^{-1} \sum_{i=1}^{n} \rho_\tau (Y_i - \xi) \right\} \tag{1}$$

The first derivative of ξ is obtained:

$$g_n(\xi) = n^{-1} \sum_{i=1}^{n} \left(I(Y_i < \xi) - \tau \right) = n^{-1} \sum_{i=1}^{n} \left(I(Y_i < \xi) - \tau \right) \tag{2}$$

It can be seen that $g_n(\xi)$ increases monotonically concerning ξ; with the increase of ξ, The characteristic function improves, and so $g_n(\xi)$ also increases. Next, we will give the proof process of the probability event $\hat{\xi}_\tau > \xi \Leftrightarrow g_n(\xi) < 0$.

Proof: first, it is proved that $\Rightarrow$. The objective function $n^{-1} \sum_{i=1}^{n} \rho_\tau (Y_i - \xi)$ is not differentiable only at $Y_i - \xi = 0, i = 1, 2, \cdots, n$, But also, at other points, it can be differentiable. So, from the definition of $\hat{\xi}_\tau$ obtained

$$g_n(\hat{\xi}_\tau) = 0 \tag{3}$$

If we know $\hat{\xi}_\tau > \xi$ and $g_n(\xi)$ is monotonically increasing, we can get $g_n(\hat{\xi}_\tau) > g_n(\xi)$ [22].

According to the above, $g_n(\xi) < 0$ establish. Then prove $\Leftarrow$. According to the known conditions,

$$g_n(\xi) = n^{-1} \sum_{i=1}^{n} \left(I(Y_i < \xi) - \tau \right) < 0 \tag{4}$$

According to $\Rightarrow$, $g_n(\hat{\xi}_\tau) = 0$, so we can get $g_n(\hat{\xi}_\tau) > g_n(\xi)$. According to $g_n(\xi)$ is monotonically increasing, we can get $\hat{\xi}_\tau > \xi$. It's proving over. According to the above conclusion can get,

$$
\left.\begin{aligned}
P\left(\sqrt{n}\left(\hat{\xi}-\xi_{\tau}\right)>\delta\right) &= P\left(\hat{\xi}_{\tau}>\xi_{\tau}+\frac{\delta}{\sqrt{n}}\right) \\
&= P\left(n^{-1}\sum_{i=1}^{n}\left(I\left(Y_{i}<\xi_{\tau}+\frac{\delta}{\sqrt{n}}\right)-\tau\right)<0\right)
\end{aligned}\right\} \tag{5}
$$

Through calculation, the expected value of $g_{n}\left(\xi_{\tau}+\frac{\delta}{\sqrt{n}}\right)$ is:

$$
\left.\begin{aligned}
E\left(g_{n}\left(\xi_{\tau}+\frac{\delta}{\sqrt{n}}\right)\right) &= n^{-1}\sum_{i=1}^{n}E\left(I\left(Y_{i}<\xi_{\tau}+\frac{\delta}{\sqrt{n}}\right)-\tau\right) \\
&= (1-\tau)F\left(\xi_{\tau}+\frac{\delta}{\sqrt{n}}\right)-\tau\left(1-F\left(\xi_{\tau}+\frac{\delta}{\sqrt{n}}\right)\right) \\
&= F\left(\xi_{\tau}+\frac{\delta}{\sqrt{n}}\right)-\tau
\end{aligned}\right\} \tag{6}
$$

Through calculation, the variance of $g_{n}\left(\xi_{\tau}+\frac{\delta}{\sqrt{n}}\right)$ is as follows:

$$
\left.\begin{aligned}
V\left(g_{n}\left(\xi_{\tau}+\frac{\delta}{\sqrt{n}}\right)\right) &= V\left(n^{-1}\sum_{i=1}^{n}\left(I\left(Y_{i}<\xi_{\tau}+\frac{\delta}{\sqrt{n}}\right)-\tau\right)\right) \\
&= n^{-2}\sum_{i=1}^{n}V\left(I\left(Y_{i}<\xi_{\tau}+\frac{\delta}{\sqrt{n}}\right)-\tau\right)
\end{aligned}\right\} \tag{7}
$$

Using the variance calculation formula of random variable X

$$
Var(X)=E(X^{2})-\left[E(X)\right]^{2} \tag{8}
$$

Available

$$
\left.\begin{aligned}
V\left(I\left(Y_{i}<\xi_{\tau}+\frac{\delta}{\sqrt{n}}\right)-\tau\right) &= \left(1-\tau-F\left(\xi_{\tau}+\frac{\delta}{\sqrt{n}}\right)+\tau\right)^{2}F\left(\xi_{\tau}+\frac{\delta}{\sqrt{n}}\right) \\
&\quad+\left(-\tau-F\left(\xi_{\tau}+\frac{\delta}{\sqrt{n}}\right)+\tau\right)^{2}\left(1-F\left(\xi_{\tau}+\frac{\delta}{\sqrt{n}}\right)\right) \\
&= \left(1-F\left(\xi_{\tau}+\frac{\delta}{\sqrt{n}}\right)\right)^{2}F\left(\xi_{\tau}+\frac{\delta}{\sqrt{n}}\right) \\
&\quad+\left(F\left(\xi_{\tau}+\frac{\delta}{\sqrt{n}}\right)\right)^{2}\left(1-F\left(\xi_{\tau}+\frac{\delta}{\sqrt{n}}\right)\right) \\
&= F\left(\xi_{\tau}+\frac{\delta}{\sqrt{n}}\right)\left(1-F\left(\xi_{\tau}+\frac{\delta}{\sqrt{n}}\right)\right)
\end{aligned}\right\} \tag{9}
$$

Then, we can get the following results [10]:

$$V\left(g_n\left(\xi_\tau + \frac{\delta}{\sqrt{n}}\right)\right) = n^{-2}\sum_{i=1}^{n} F\left(\xi_\tau + \frac{\delta}{\sqrt{n}}\right)\left(1 - F\left(\xi_\tau + \frac{\delta}{\sqrt{n}}\right)\right) \tag{10}$$

Due to the characteristic function being an independent binomial distribution, so $I\left(Y_i < \xi_\tau + \frac{\delta}{\sqrt{n-\tau}}\right)$ $i = 1,2,\cdots,n$ is a binomial distribution sequence with probabilities $F\left(\xi_\tau + \frac{\delta}{\sqrt{n}}\right)$ and $1 - F\left(\xi_\tau + \frac{\delta}{\sqrt{n}}\right)$ taking values $1-\tau$ and τ respectively, get a result from Laplace's limit theorem:

$$g_n\left(\xi_\tau + \frac{\delta}{\sqrt{n}}\right) = n^{-1}\sum_{i=1}^{n}\left(I\left(Y_i < \xi_\tau + \frac{\delta}{\sqrt{n}}\right) - \tau\right) \tag{11}$$

It is an asymptotically normal distribution.

$$\omega^2 = \frac{\tau\ 1-\tau}{f^2}\ \xi_\tau \tag{12}$$

There are

$$\begin{aligned} P\ \sqrt{n}\ \hat{x}_t - x_t\ > d\ &= P\left(\hat{x}_t > x_t + \frac{d}{\sqrt{n}}\right) = P\left(g_n\left(x_t + \frac{d}{\sqrt{n}}\right) < 0\right) \\ &= P\left(\frac{g_n\left(x_t + \frac{d}{\sqrt{n}}\right) - f\ x_t\ \frac{d}{\sqrt{n}}}{\sqrt{\frac{t\ 1-t}{n}}} < \frac{-f\ x_t\ \frac{d}{\sqrt{n}}}{\sqrt{\frac{t\ 1-t}{n}}}\right) \\ &= P\left(\frac{g_n\left(x_t + \frac{d}{\sqrt{n}}\right) - f\ x_t\ \frac{d}{\sqrt{n}}}{\sqrt{\frac{t\ 1-t}{n}}} < -w_n^{-1}\ d\right) - F\left(w^{-1}d\right) \end{aligned} \tag{13}$$

Therefore, the following conclusions can be drawn.

$$\sqrt{n}\ \hat{\xi}_\tau \sim \xi_\tau\ - N\ 0,\omega^2 \tag{14}$$

Robustness refers to data being insensitive to outliers and model assumptions. When there are some deviations or differences between the population distribution and the hypothetical distribution, it is generally expected that the estimator's good properties can be maintained and will not be significantly affected. This kind of estimator is called robust estimation. Quantile regression does not make any assumption on the distribution of random error terms, so the model established by quantile regression is powerful. Usually, the influence function is to analyze robustness.

Describes the influence of the pollution function on the function θ defined on the distribution function $F\ x$, denoted as $\theta\ F$. The pollution function changes the partial value εF of $F\ x$ at Y point into ε (y is any actual number), thus polluting the distribution function $F\ x$. The distribution function after pollution is[7]:

$$F_\varepsilon = \varepsilon\delta_y + 1-\varepsilon\ F \tag{15}$$

Where δ_y is a single point distribution with a probability of 1 and gets a value of Y. The influence function of function θ on the distribution function $F\ x$ is defined as:

$$IF_\theta\ y,F = \lim_{\varepsilon\to\infty} \frac{\theta\ F_\varepsilon - \theta\ F}{\varepsilon} \tag{16}$$

For the mean value function, there are:

$$\left.\begin{aligned} \hat{\theta}\ F_\varepsilon &= \int ydF_\varepsilon = \int yd\ \varepsilon\delta_y + 1-\varepsilon\ F \\ &= \varepsilon\int \varepsilon d\delta_y + 1-\varepsilon\ \int ydF \\ &= \varepsilon y + 1-\varepsilon\ F\ y \\ &= \varepsilon y + 1-\varepsilon\ \hat{\theta}\ F \end{aligned}\right\} \tag{17}$$

So, the influence function of the mean value is

$$\left.\begin{aligned} IF_{\widehat{\theta}\ y,F} &= \lim_{\varepsilon\to\infty} \frac{\widehat{\theta}\ F_\varepsilon - \widehat{\theta}\ F}{\varepsilon} \\ &= \lim_{\varepsilon\to\infty} \left[\frac{\varepsilon y + 1-\varepsilon\ \widehat{\theta}\ F - \widehat{\theta}\ F}{\varepsilon}\right] \\ &= \lim_{\varepsilon\to\infty}\ y - \widehat{\theta}\ F \\ &= y - \widehat{\theta}\ F \end{aligned}\right\} \tag{18}$$

For the median, the median of all Y values, there are

$$\tilde{\theta}\ F_\varepsilon = F_\varepsilon^{-1}\left(\frac{1}{2}\right) \tag{19}$$

$$\left.\begin{aligned} F_\varepsilon\ \tilde{\theta}\ F_\varepsilon &= \frac{1}{2}\left[\varepsilon\delta_y + 1-\varepsilon\ F\right]\ \tilde{\theta}\ F_\varepsilon \\ &= \frac{1}{2}\ 1-\varepsilon\ F\ \tilde{\theta}\ F_\varepsilon \\ &= \frac{1}{2} - \varepsilon\delta_y \end{aligned}\right\} \tag{20}$$

Through calculation, it can be concluded that:

$$\tilde{\theta}\ F_\varepsilon = F^{-1}\left(\frac{\left(\frac{1}{2} - \varepsilon\delta_y\right)}{1-\varepsilon}\right) \tag{21}$$

So, the influence function of the median is

$$IF_{\tilde{\theta}\ y,F} = \lim_{\varepsilon\to\infty} \frac{\tilde{\theta}\ F_{\varepsilon}\ - \tilde{\theta}\ F}{\varepsilon} \tag{22}$$

When $y < F^{-1}\left(\frac{1}{2}\right)$

$$\tilde{\theta}\ F_{\varepsilon}\ = F^{-1}\left(\frac{1}{2} - \frac{\varepsilon}{2}\right) \tag{23}$$

The influence function of the median is as follows:

$$\left.\begin{aligned} IF_{\tilde{\theta}\ y,F} &= \lim_{\varepsilon\to\infty} \frac{\tilde{\theta}\ F_{\varepsilon}\ - \tilde{\theta}\ F}{\varepsilon} \\ &= \lim_{\varepsilon\to\infty} \frac{\left[F^{-1}\left(\frac{1}{2} - \frac{\varepsilon}{2}\right) - F^{-1}\left(\frac{1}{2}\right)\right]}{\varepsilon} \end{aligned}\right\} \tag{24}$$

The numerator denominator is derived from ε at the same time, we can get the following result:

$$IF_{\tilde{\theta}\ y,F} = \lim_{\varepsilon\to\infty} -\frac{1}{2}\left[F^{-1}\left(\frac{1}{2} - \frac{\varepsilon}{2}\right)\right]' \tag{25}$$

If the density function of distribution F exists, then

$$\left.\begin{aligned} IF_{\tilde{\theta}\ y,F} &= \lim_{\varepsilon\to\infty} -\frac{1}{2f\left[F^{-1}\left(\frac{1}{2} - \frac{\varepsilon}{2}\right)\right]} \\ &= \frac{1}{2f\left[F^{-1}\left(\frac{1}{2}\right)\right]} \end{aligned}\right\} \tag{26}$$

When $y > F^{-1}\left(\frac{1}{2}\right)$,

$$\tilde{\theta}\ F_{\varepsilon}\ = F^{-1}\left(\frac{1}{2} + \frac{\varepsilon}{2}\right) \tag{27}$$

In the same way, we can get the following results:

$$IF_{\tilde{\theta}\ y,F} = \frac{1}{2f\left(F^{-1}\left(\frac{1}{2}\right)\right)} \tag{28}$$

When $y = F^{-1}\left(\frac{1}{2}\right)$:

$$\tilde{\theta}\left(F_{\varepsilon}\right) = F^{-1}\left(\frac{1}{2}\right) \tag{29}$$

The distribution function is not affected, so the influence function is 0. In conclusion, we can get the following conclusions:

$$IF_{\tilde{\theta}}\left(y,F\right) = \frac{\operatorname{sgn}\left(y-\tilde{\theta}\left(F\right)\right)}{2f}\left(F^{-1}\left(\frac{1}{2}\right)\right) \tag{30}$$

By comparing the influence functions of mean and median, it is found that under the mean function, the pollution effect of Y at $F\left(x\right)$ is proportional to Y. As long as the difference between the Y point and the mean is large, the estimator's mean value will deviate from the correct mean value. For the median, because the influence function is related to $\operatorname{sgn}\left(\cdot\right)$, the influence of infection at the Y point is bounded. The comparison shows that the median is more robust than the mean.

The robustness conclusion also applies to other quantile and quantile regression problems. The influence function of tau quantile can be obtained by replacing 1-half of the above formula. The boundedness of the quantile influence function remains unchanged, so the influence of outliers on quantile regression is relatively tiny. The model established by quantile regression is relatively robust.

Suppose $Y_1, Y_2, \cdots, Y_n$ is a series of independent random variables with the same distribution; the distribution function is $F\left(x\right)$, for probability level τ, within the neighborhood of $\xi_{\tau} = F^{-1}\left(\tau\right)$, The distribution F has a continuous density function $f\left(x\right)$ (where $f\left(\xi_{\tau}\right) > 0$), and the τ horizontal quantile of the sample is:

$$\widehat{\xi}_{\tau} = \inf_{\hat{\xi}}\left\{\widehat{\xi} = \min_{\xi\in R} n^{-1}\sum_{i=1}^{n}\rho_{\tau}\left(Y_i - \xi\right)\right\} \tag{31}$$

The first derivative of ξ is obtained.

$$g_n\left(\xi\right) = n^{-1}\sum_{i=1}^{n}\left(I\left(Y_i < \xi\right) - \tau\right) = n^{-1}\sum_{i=1}^{n} I\left(Y_i < \xi\right) - \tau \tag{32}$$

It can be seen that $g_n\left(\xi\right)$ is monotonically increasing concerning ξ; with the increase of ξ value, the characteristic function increases, and so $g_n\left(\xi\right)$ also increases. Next, we will give the proof process of the probability event $\widehat{\xi}_{\tau} > \xi \Leftrightarrow g_n\left(\xi\right) < 0$.

Proof: firstly, it is proved $\Rightarrow$. The objective function $n^{-1}\sum_{i=1}^{n}\rho_{\tau}\left(Y_i - \xi\right)$ is not differentiable only at $Y_i - \xi = 0, i = 1,2,\cdots,n$, But also at other points. So, from the definition of $\hat{\xi}_{\tau}$ can know,

$$g_n\left(\hat{\xi}_\tau\right)=0 \tag{33}$$

We know $\hat{\xi}_\tau>\xi$ and $g_n(\xi)$ are monotonically increasing; we can get $g_n(\hat{\xi}_\tau)>g_n(\xi)$ In conclusion, $g_n(\xi)<0$ is established. Then prove $\Leftarrow$. According to the known conditions,

$$g_n(\xi)=n^{-1}\sum_{i=1}^{n}\left(I(Y_i<\xi)-\tau\right)<0 \tag{34}$$

According to $\Rightarrow$, $g_n(\hat{\xi}_\tau)=0$, So we can get $g_n(\hat{\xi}_\tau)>g_n(\xi)$. According to $g_n(\xi)$ is monotonically increasing, we can get $\hat{\xi}_\tau>\xi$. According to the above conclusion can know,

$$\begin{aligned}P\left(\sqrt{n}\left(\hat{\xi}_\tau-\xi_\tau\right)>\delta\right)&=P\left(\hat{\xi}_\tau>\xi_\tau+\frac{\delta}{\sqrt{n}}\right)\\&=P\left(n^{-1}\sum_{i=1}^{n}\left(I\left(Y_i<\xi_\tau+\frac{\delta}{\sqrt{n}}\right)-\tau\right)<0\right)\end{aligned} \tag{35}$$

Through calculation, the expected value of $g_n\left(\xi_\tau+\frac{\delta}{\sqrt{n}}\right)$ is:

$$\begin{aligned}E\left(g_n\left(\xi_\tau+\frac{\delta}{\sqrt{n}}\right)\right)&=n^{-1}\sum_{i=1}^{n}E\left(I\left(Y_i<\xi_\tau+\frac{\delta}{\sqrt{n}}\right)-\tau\right)\\&=(1-\tau)F\left(\xi_\tau+\frac{\delta}{\sqrt{n}}\right)-\tau\left(1-F\left(\xi_\tau+\frac{\delta}{\sqrt{n}}\right)\right)\\&=F\left(\xi_\tau+\frac{\delta}{\sqrt{n}}\right)-\tau\end{aligned} \tag{36}$$

Through calculation, the variance of $g_n\left(\xi_\tau+\frac{\delta}{\sqrt{n}}\right)$ is :

$$\begin{aligned}V\left(g_n\left(\xi_\tau+\frac{\delta}{\sqrt{n}}\right)\right)&=V\left(n^{-1}\sum_{i=1}^{n}\left(I\left(Y_i<\xi_\tau+\frac{\delta}{\sqrt{n}}\right)-\tau\right)\right)\\&=n^{-2}\sum_{i=1}^{n}V\left(I\left(Y_i<\xi_\tau+\frac{\delta}{\sqrt{n}}\right)-\tau\right)\end{aligned} \tag{37}$$

Using the variance calculation formula of random variable X

$$Var(X)=E(X^2)-\left[E(X)\right]^2 \tag{38}$$

Available

$$V\left(I\left(Y_i<\xi_\tau+\frac{\delta}{\sqrt{n}}\right)-\tau\right)=\left(1-\tau-F\left(\xi_\tau+\frac{\delta}{\sqrt{n}}\right)+\tau\right)^2 F\left(\xi_\tau+\frac{\delta}{\sqrt{n}}\right)$$
$$+\left(-\tau-F\left(\xi_\tau+\frac{\delta}{\sqrt{n}}\right)+\tau\right)^2\left(1-F\left(\xi_\tau+\frac{\delta}{\sqrt{n}}\right)\right)$$
$$=\left(1-F\left(\xi_\tau+\frac{\delta}{\sqrt{n}}\right)\right)^2 F\left(\xi_\tau+\frac{\delta}{\sqrt{n}}\right) \tag{39}$$
$$+\left(F\left(\xi_\tau+\frac{\delta}{\sqrt{n}}\right)\right)^2\left(1-F\left(\xi_\tau+\frac{\delta}{\sqrt{n}}\right)\right)$$
$$=F\left(\xi_\tau+\frac{\delta}{\sqrt{n}}\right)\left(1-F\left(\xi_\tau+\frac{\delta}{\sqrt{n}}\right)\right)$$

Then we can get the following results:

$$V\left(g_n\left(\xi_\tau+\frac{\delta}{\sqrt{n}}\right)\right)=n^{-2}\sum_{i=1}^{n}F\left(\xi_\tau+\frac{\delta}{\sqrt{n}}\right)\left(1-F\left(\xi_\tau+\frac{\delta}{\sqrt{n}}\right)\right) \tag{40}$$

Due to the characteristic function being an independent binomial distribution, $I\left(Y_i<\xi_\tau+\frac{\delta}{\sqrt{n-\tau}}\right)\ i=1,2,\cdots,n$ is a binomial distribution sequence with probabilities $F\left(\xi_\tau+\frac{\delta}{\sqrt{n}}\right)$ and $1-F\left(\xi_\tau+\frac{\delta}{\sqrt{n}}\right)$ taking values $1-\tau$ and τ respectively, from Laplace's limit theorem, we can get:

$$g_n\left(\xi_\tau+\frac{\delta}{\sqrt{n}}\right)=n^{-1}\sum_{i=1}^{n}\left(I\left(Y_i<\xi_\tau+\frac{\delta}{\sqrt{n}}\right)-\tau\right) \tag{41}$$

$$\omega^2=\frac{\tau\ 1-\tau}{f^2}\ \xi_\tau \tag{42}$$

$$P\ \sqrt{n}\ \hat{\xi}_\tau-\xi_\tau\ >\delta\ =P\left(\hat{\xi}_\tau>\xi_\tau+\frac{\delta}{\sqrt{n}}\right)$$
$$=P\left(g_n\left(\xi_\tau+\frac{\delta}{\sqrt{n}}\right)<0\right)$$
$$=P\left(\frac{g_n\left(\xi_\tau+\frac{\delta}{\sqrt{n}}\right)-f\ \xi_\tau\ \frac{\delta}{\sqrt{n}}}{\sqrt{\frac{\tau\ 1-\tau}{n}}}<\frac{-f\ \xi_\tau\ \frac{\delta}{\sqrt{n}}}{\sqrt{\frac{\tau\ 1-\tau}{n}}}\right) \tag{43}$$
$$=P\left(\frac{g_n\left(\xi_\tau+\frac{\delta}{\sqrt{n}}\right)-f\ \xi_\tau\ \frac{\delta}{\sqrt{n}}}{\sqrt{\frac{\tau\ 1-\tau}{n}}}<-\omega^{-1}\ \delta\right)$$
$$\to 1-\Phi\left(\omega^{-1}\delta\right)$$

Therefore, the following conclusion can be obtained:

$$\sqrt{n}\ \hat{\xi}_{\tau} \sim \xi_{\tau}\ - N\ 0,\omega^{2} \tag{44}$$

4 SUPPLY CHAIN MANAGEMENT OPTIMIZATION SYSTEM OF AGRICULTURAL PRODUCTS BASED ON BIG DATA TECHNOLOGY

Based on the principle of equality, win-win cooperation, efficiency, and fairness, this paper puts forward some synergy mechanisms such as trust mechanism, restraint mechanism, information sharing and transmission mechanism, and profit-sharing mechanism among establishing node enterprises (or individuals) by using the related concepts of supply chain management. As shown in Figure 1, the coordination mechanism among node enterprises (or individuals) in the circulation channel of agricultural products is an organic whole. Among them, the trust mechanism is the precondition to realize cooperation among node enterprises (or individuals), the information sharing and transmission mechanism is the foundation to acknowledge the collaboration among node enterprises (or individuals), and the constraint mechanism is the guarantee to realize the cooperation among node enterprises (or individuals). The profit-sharing mechanism is the core of collaboration among node enterprises (or individuals).

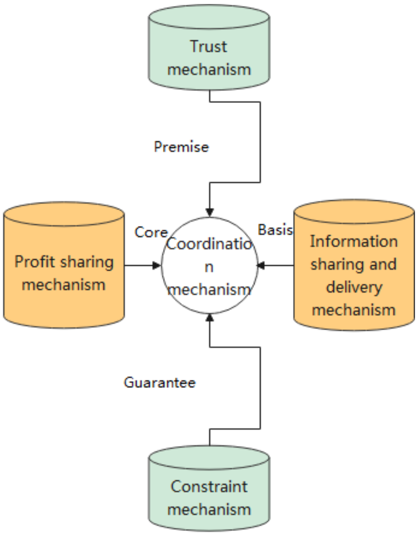

Figure. 1: Relationship between synergistic mechanisms of agricultural products.

In the circulation channels of agricultural products, node enterprises (or individuals) in different positions have differences in resource endowments. To maximize circulation efficiency, node enterprises (or individuals) with varying resource endowments undertake different channel functions, thus forming an interdependent relationship between node enterprises (or individuals). At the same time, due to the difference in resource endowments among node enterprises (or individuals), enterprises (or individuals) with resource endowments have a strong channel control ability. Generally speaking, they also have a desire to control their channels. The process of establishing trust between node enterprises (or individuals) is shown in Figure 2. The implementation path of a trust mechanism between node enterprises (or individuals) mainly includes the capability and relationship paths, as shown in Figure 3. The circulation channel of agricultural products is an enterprise (or individual) alliance formed by independent stakeholders. Different node enterprises (or individuals) have different information, which could be complementary and dependent on each other.

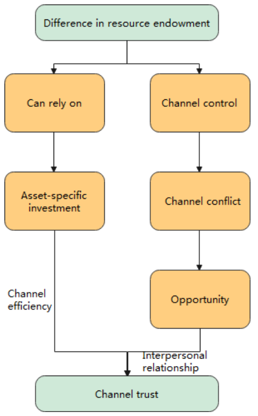

Figure 2: Establishing trust between node enterprises (or Individuals).

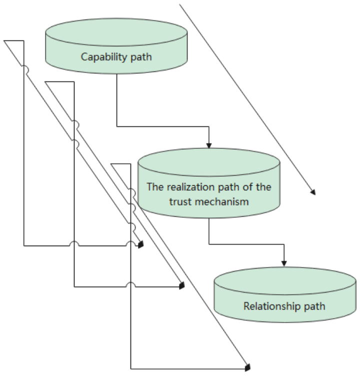

Figure 3: Implementation path of trust mechanism between node enterprises (or Individuals).

The diffusion and transfer of information among various node enterprises (or individuals) constitute the information resources among node enterprises (or individuals) in the circulation channel of agricultural products. As shown in Figure 4, each node enterprise (or individual) in the farm product circulation channel forms its unique knowledge information by interacting with the external environment of the information system. To maximize the overall efficiency of the circulation channel and maintain a long-term stable cooperative relationship, the node enterprises (or individuals) in different positions of the circulation channel will exchange and transfer information. After a node enterprise (or individual) obtains the information of other node enterprises (or individuals), it will digest and absorb it according to its needs. A complex information chain in the circulation channel is formed through information transmission, digestion, and absorption among node enterprises (or individuals).

The implementation path of an information-sharing and transmission mechanism among node enterprises (or individuals) mainly includes technical guidance, personnel exchange, and technical cooperation, as shown in Figure 5. In the circulation channels of agricultural products, there are opportunistic motives among node enterprises (or individuals) due to information asymmetry and a low degree of knowledge sharing.

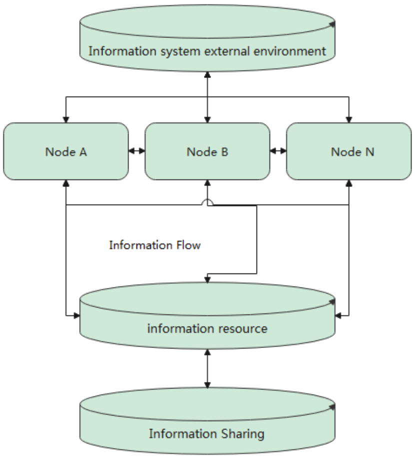

Figure 4: Establishment of information sharing process and transmission mechanism between node enterprises (or individuals).

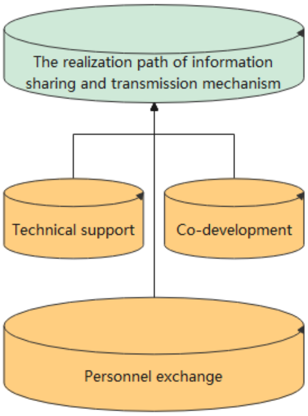

Figure 5: Implementation path of information sharing and transmission mechanism between node enterprises (or Individuals).

A constraint mechanism must be established to ensure a lasting and stable relationship between node enterprises (or individuals), prevent the influence of opportunistic behavior on the efficiency of agricultural products' circulation channels, and ensure the effective operation of circulation channels. Figure 6 shows the construction and implementation path of a constraint mechanism between node enterprises (or individuals).

Channel function refers to the smooth and efficient process of transferring products from producers to consumers, eliminating or narrowing the differences between product supply and consumption in time, place, product variety, and quantity. The function flow of the channel is the expression form of the channel function. It corresponds to the channel function, and channel function flow mainly includes entity, ownership, promotion, negotiation, financing, risk, ordering, information, and payment flow. In the circulation process of agricultural products, the functions and flows of each node enterprise (or individual) are shown in Figure 7.

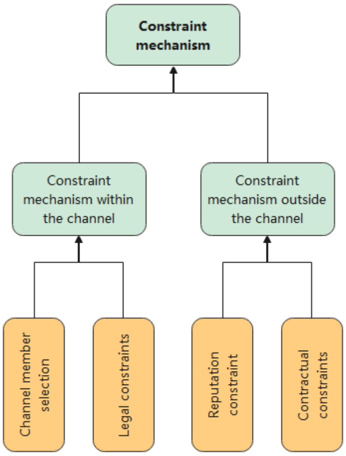

Figure 6: Construction and implementation path of constraint mechanism between node enterprises (or Individuals).

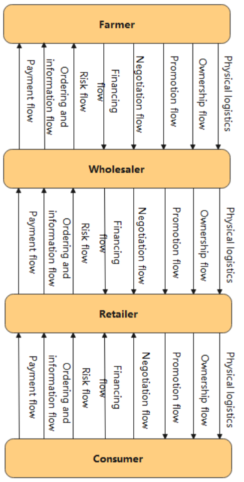

Figure 7: Channel function and flow between node enterprises (or Individuals).

In the circulation process of agricultural products, information is the carrier of communication between node enterprises (or individuals). Since each enterprise (or individual) is at different nodes of the circulation channel, the information they hold is often different in quantity and quality. Establishing an information platform to strengthen the management of information can enhance the flow of information between node enterprises (or individuals) and then deliver supply and demand information to each node enterprise (or individual) in the supply chain in a timely and accurate manner shared.

Compared with other information systems, the functions of the Internet-based management information system platform truly realize the sharing of information between enterprises at various nodes in the supply chain and between enterprises and customers. (1) Using the information system platform, connecting multiple supply chain enterprises distributed in different regions and remotely carrying out information releases in the agricultural product industry and business data transmission between enterprises through the Internet is possible. (2) The information system collects the demand and orders of agricultural products worldwide through the Internet. The information system platform implements unified control of agricultural product resources nationwide. It is possible to provide customers with the best quality at the lowest cost through specialized logistics and transportation. Agricultural products. (3) Provide farmers and consumers with the latest agricultural product information nationwide and provide enterprises with personalized information services. (4) For small and medium-sized agricultural products merchants who still need the implementation of an information system. You can join the information management platform through member registration. Develop online business at low cost, share information in the agricultural product industry, and broaden the scope of business, as shown in Figure 8.

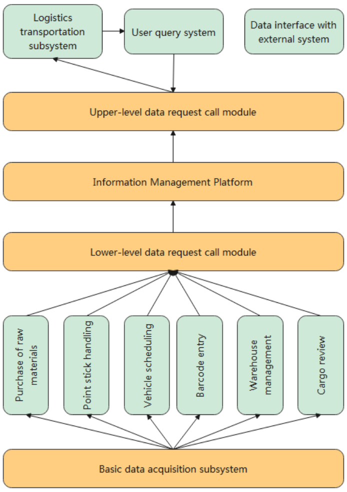

Figure 8: Chain management system of agricultural product supply based on big data technology.

5 OPTIMIZATION OF AGRICULTURAL PRODUCTS SUPPLY CHAIN MANAGEMENT BASED ON THE BIG DATA TECHNOLOGY

This paper optimizes the agricultural product supply chain management system with big data technology, integrating E-commerce and Human-Computer Interaction (HCI) principles for enhanced efficiency and usability. By analyzing agricultural product supply chain management nodes, the paper constructs a corresponding model system that leverages E-commerce platforms and HCI-driven interfaces. Through intuitive design and collaborative tools, stakeholders can effectively navigate and manage the supply chain, promoting transparency and streamlining operations. This interdisciplinary approach fosters innovation and sustainability across the agricultural sector, facilitating informed decision-making and driving overall system improvement. On this basis, the performance of this system is verified through data research. Firstly, the effect of agricultural product supply chain management is analyzed through extensive data mining, and the mining effect is statistically analyzed. In this paper, a large amount of information is obtained through the China Statistical Yearbook, and the impact of extensive data mining on agricultural product supply chain management is counted through multiple groups of experiments. The results are shown in Table 1 and Figure 9 below.

	Supply chain data mining	*NO*	*Supply chain data mining*	*NO*	*Supply chain data mining*
1	*81.0*	*29*	*80.6*	*57*	*85.6*
2	*81.2*	*30*	*92.3*	*58*	*88.0*
3	*82.4*	*31*	*93.7*	*59*	*93.2*

4	*93.5*	*32*	*88.3*	*60*	*82.8*
5	*91.1*	*33*	*82.4*	*61*	*83.2*
6	*86.9*	*34*	*89.8*	*62*	*80.0*
7	*88.0*	*35*	*94.4*	*63*	*79.7*
8	*88.7*	*36*	*83.7*	*64*	*93.2*
9	*86.1*	*37*	*85.2*	*65*	*92.5*
10	*82.2*	*38*	*85.3*	*66*	*84.5*
11	*84.5*	*39*	*82.3*	*67*	*79.6*
12	*94.2*	*40*	*93.5*	*68*	*90.4*
13	*81.2*	*41*	*87.2*	*69*	*94.3*
14	*92.4*	*42*	*94.3*	*70*	*93.9*
15	*84.2*	*43*	*91.3*	*71*	*80.1*
16	*80.9*	*44*	*82.5*	*72*	*84.7*
17	*91.8*	*45*	*80.7*	*73*	*82.8*
18	*91.8*	*46*	*90.8*	*74*	*89.1*
19	*89.1*	*47*	*89.8*	*75*	*79.7*
20	*92.6*	*48*	*84.3*	*76*	*90.4*
21	*83.1*	*49*	*82.9*	*77*	*90.0*
22	*86.3*	*50*	*93.3*	*78*	*84.9*
23	*92.7*	*51*	*88.6*	*79*	*80.3*
24	*91.8*	*52*	*81.0*	*80*	*93.0*
25	*82.8*	*53*	*91.0*	*81*	*93.6*
26	*87.5*	*54*	*81.5*	*82*	*86.0*
27	*88.6*	*55*	*92.7*	*83*	*86.7*
28	*92.8*	*56*	*89.7*	*84*	*88.7*

Table 1: Statistical table of agricultural product supply chain management effect of big data.

The above research shows that the agricultural product supply chain management optimization system based on big data technology has specific practical effects. Based on this, the system constructed in this paper is used for experimental management in the follow-up agricultural product supply chain management.

6 CONCLUSIONS

The construction of the agricultural information system of supply chain management is a complicated system project related to multidisciplinary knowledge, such as Systems Engineering, Management Science, Economics, etc.; the research on the construction is also a new subject in its early stage. Based on the broad research statutes and home, this paper expounds on the relevant theory of agricultural supply chain management and our country's current situation and problems. Then, it brings up the issues and challenges we have so far regarding the safety problem of agricultural products and the information construction of supply chain management. The construction scheme of China's supply chain management information system of agricultural products is proposed and explained in detail. By incorporating E-commerce and Human-Computer Interaction (HCI) principles, the system aims to enhance accessibility and user experience. Based on experimental research, the optimization system, utilizing big data technology alongside E-commerce functionalities and HCI design, proposed in this paper demonstrates practical effectiveness.

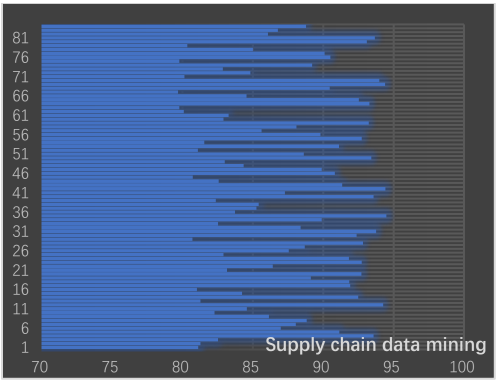

Figure 9: Statistical chart of agricultural product supply chain management effect of extensive data mining.

Through intuitive interfaces and collaborative tools facilitated by HCI, stakeholders can efficiently navigate and utilize the system, promoting transparency and efficiency across the agricultural supply chain.

Yuanyan Xia, https://orcid.org/0009-0002-7230-2043

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