A Dynamic Model for Risk Assessment of Cross-Border Fresh Agricultural Supply Chain

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***Abstract*—The cross-border trade of Fresh Agricultural Products (FAP) is widespread in the current society, and the demand for it is also increasing. The cross-border fresh agricultural product Supply Chain (SP) itself has strong complexity and high costs, and it also bears many risks. In order to alleviate the adverse impact of risk factors interfering with cross-border fresh agricultural product SPs and improve the overall SP efficiency, this study proposes a system dynamics model based on cross-border fresh agricultural product risk factors. The experiment first studied the possible risk factors in the SP of FAP. After discussing the causal relationship between possible risks, subjective and objective weighting methods were introduced to weight risk factors. After that, a system dynamics model of the cross-border fresh agricultural product SP was constructed for the purpose of enhancing product quality and the overall efficiency of the SP. In the system dynamics model constructed, risk factors are introduced for simulation experiments. It is demonstrated that the suggested model can truly reflect the dynamic changes of the actual SP, and can obtain the operational rules of the system.**

Keywords*—*Cross-border fresh agricultural products; supply chain management; risk identification; system dynamics model; risk weighting

I. Introduction

As a large country of agricultural production and consumption, the rational development of agriculture is the basis of the national economy and the necessary condition for the survival of other material sectors. Today, with the continuous advancement of economic globalization, the import and export scale of China's agricultural products has been firmly in the forefront of the world [1]. The increasing trade in Fresh Agricultural Products (FAP) has deepened international exchanges, but it also poses challenges to the Supply Chain (SP) management of cross-border FAP [2]. FAP, compared to other products, have the characteristics of perishability and are not easy to preserve, so their requirements for logistics and transportation are high. In addition, customs inspection of cross-border trade is relatively strict, and transportation time and distance are relatively longer, resulting in more risks. The cross-border fresh agricultural product SP has a higher complexity and a greater likelihood of risk occurrence [3]. Therefore, effective identification and timely avoidance of risk factors in the cross-border fresh agricultural product SP is crucial to ensuring the quality of FAP. System dynamics model is a qualitative and quantitative research method that can simulate and analyze the connection and development of complex problems from a holistic perspective, and is applicable to this research topic [4]. Currently, the academic community has conducted relevant research on the SP risk of cross-border FAP, and has also achieved certain results. However, it mainly focuses on SP inventory control, ordering strategies, and other aspects. There are few studies that use risk factors and system dynamics models to find the impact of risk variables on the SP [5]. Therefore, this experiment takes the cross-border fresh agricultural product SP as the research object, and introduces subjective and objective weighting methods to weight its risk factors. Based on this, a system dynamics model is constructed to explore the best solution for enhancing the overall efficiency of the SP.

The innovation of this study lies in: (1) The introduction of subjective and objective weighting methods to weight the risk factors of cross-border fresh agricultural products supply chain. (2) The system dynamics model of cross-border fresh agricultural products supply chain is constructed.

The study is divided into five parts. The first part is the introduction, which introduces the research background and significance; the second part is a literature review, which introduces the current development status of supply chain factor identification and system dynamics model. The third part is the establishment of system dynamics model for operational risk assessment of cross-border fresh agricultural supply chain. The fourth part is the performance verification of the constructed model. The last part is the summary of the full text and the prospect of future research.

II. Related Work

Currently, researchers have discussed the methods for identifying SP risk factors. Zhao and other researchers used topic analysis, fuzzy cross impact matrix multiplication analysis, and other methods to effectively manage the complexity and vulnerability of agricultural food SPs. The experiment classified risks based on their dependencies and driving forces, thereby helping to determine the relationship between risks and the most critical risk factors. The final result promoted the study of risk factors in the agricultural food SP [6]. To explore the sustainable impact of flood risk drivers on agricultural SPs, scholars such as Yazdani proposed a multi standard approach to assess flood risk in crop regions. This method ranked agricultural projects affected by floods to detect the best projects, thereby mitigating the greatest impact of flood risk on crop areas. This method had important practical significance for preventing flood risk [7]. In order to determine the impact of standardized management systems on selected risks in the SP, Zimon et al. applied basic data analysis methods to investigate logistics company staff. The experiment was conducted using a questionnaire survey, and the results showed that improving SP management can help managers [8]. Wang and other researchers conducted empirical research on the SP risk management of express delivery companies. The experiment mainly started with exploring the relationship between innovation capability and SP risk, and established a partial least squares method for structural equations based on the survey data. The study found that there is a negative correlation between them, so enterprises can try to decrease the negative impact of SP risk by developing their own innovation capability [9]. From the perspective of risk factors in the halal food SP, Khan S and other teams used a hierarchical fuzzy analysis method to rank the identified risk factors. This method can effectively rank the risk factors in the halal food SP, thereby helping managers take effective measures to mitigate risks. This result has practical significance for studying the risk management of halal food SP [10].

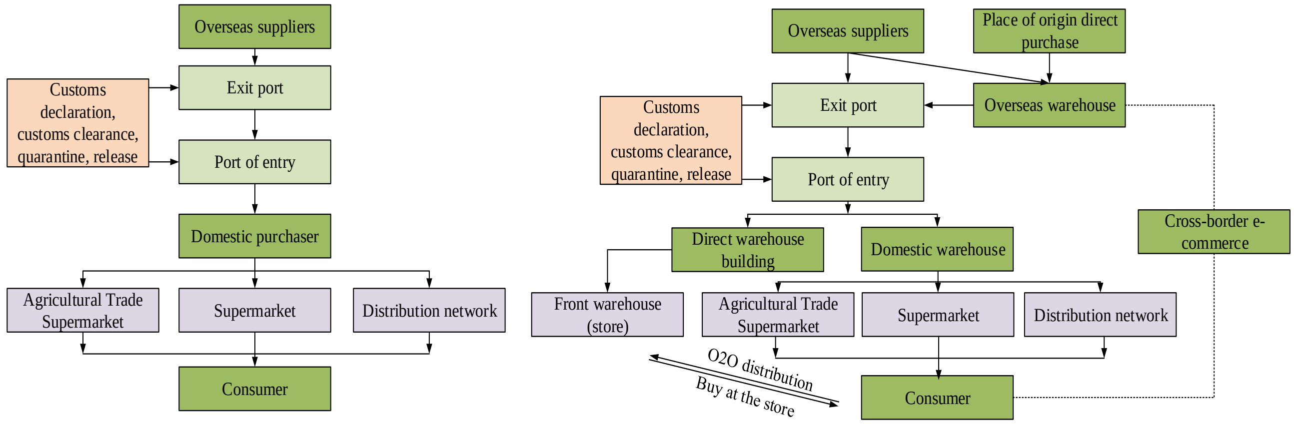
System dynamics model is a structural model that simulates the dynamic changes of a system, and has a wide range of applications in various fields. Based on system dynamics models, researchers such as Papachristos developed a simulation model that combines standard competitive dynamics theory. This model could be used as a powerful tool for enterprises to obtain competitive advantage. Simulation experiments on four standard competition cases showed that the simulation results of are consistent with real cases. Therefore, the proposed model could lay the foundation for theoretical and empirical research on standard competitive strategy [11]. Liu et al. established an environmental assessment model for construction waste using a system dynamics model. The impact on the environment, economy, and society was analyzed in the experiment. The final simulation results can provide reference value for construction waste treatment [12]. Rathore and other scholars used system dynamics models to promote the interaction between dynamic feedback effects and risks in grain transportation. The experiment used a system dynamics model that considers the value of the risk index to observe the impact of the risk value on grain inventory levels and vehicle capacity. The model proposed in the experiment could help improve food supply through comprehensive risk control in the SP, and can improve the efficiency of the food SP [13]. Sayyadi and other researchers proposed an integrated approach based on system dynamics and analytical networks to assess the sustainability of transportation policies. This method evaluated and ranks five policies, namely, travel sharing, reducing travel rate, reducing road network length, vehicle ownership, and average driving kilometers, through the third indicator of congestion degree, fuel consumption, and emissions. The research results verified the effectiveness of the constructed system [14]. Researcher Oleghe developed a system dynamics model based on end-to-end agribusiness and aquaculture SP models from the perspective of capacity expansion of aquaculture companies. This model covers unique dynamics related to the aquaculture SP and enables simulation of company working capital management rules. Experiments have verified that the proposed model can be applied to companies' management of working capital under different financing modes and capacity expansion rates [15].

To sum up, both have relevant applied research. However, there are still many limitations in the above research. For example, the construction of the index system of risk factors is not perfect, the effect of risk simulation is not good, and the risk management method still needs to be further improved. At present, there are no relevant studies combining risk factor variables with system dynamics models, and the description of cross-border FAP risk factors is insufficient. Therefore, this study introduced subjective and objective weighting methods, weighted its risk factors, and established a system dynamics model to explore ways to improve the overall efficiency of SP.

III. Construction of a System Dynamics Model for Risk Assessment of Cross-Border Fresh Agricultural Product SP Operation

A. Research on Main Risk Factors of Cross-Border Fresh Agricultural Product SP

The SP of traditional cross-border FAP is mainly composed of three main bodies: overseas SPs, domestic buyers, and relevant consumers. Its sales channels are mainly agricultural markets, supermarkets, and distribution outlets. The traditional sales channel that occupies the main position is the supermarket. The purchaser of the store first proposes an order demand to the overseas supplier; after receiving the order, the overseas supplier shall ship the goods by sea or air. During this process, FAP need to undergo customs clearance, inspection and quarantine before reaching the domestic purchaser's warehouse [16,17]. To reduce costs, cross-border e-commerce and other direct procurement operation models have gradually emerged in recent years. This mode is mainly for cross-border e-commerce enterprises to directly connect with overseas agricultural product suppliers and deliver products to consumers through front-end warehouses [18,19]. The operation mode of cross-border e-commerce has greatly shortened the length of the SP, effectively reducing production costs. Fig. 1 illustrates the overall operational process of the traditional cross-border fresh agricultural product SP and the cross-border e-commerce fresh agricultural product SP. The cross-border fresh agricultural product SP under both modes has similar operational links, namely, the supply link, the transportation link, and the sales link. In fact, various unexpected situations and constraints in reality have posed challenges to the SP management of cross-border FAP. Therefore, the three links of the SP are faced with varying degrees of risk possibilities.



(a) Traditional cross-border fresh agricultural product supply chain

(b) Cross-border e-commerce fresh agricultural product supply chain

Fig. 1. Operation process of two SPs.

Currently, FAP are vulnerable to risks due to the international situation, cold chain transportation, bottlenecks, import and export food safety, and other conditions. FAP are vulnerable to environmental changes. During the COVID-19 epidemic, people's demand for FAP increased sharply. Meanwhile, FAP appeared to be out of stock and not delivered in a timely manner. In this context, the cross-border fresh agricultural product SP is also subject to many restrictions, resulting in a longer overall warehousing time for goods. Secondly, FAP has high requirements for cold chain logistics of enterprises. Cold chain technique is a key technology to ensure the quality of FAP, so it has significant constraints on the SP of FAP. The cold chain logistics technology for FAP in China is still immature, and compared to other developed countries, the overall loss rate of products is relatively high, as shown in Fig. 2. Thirdly, the customs clearance efficiency of China's cross-border fresh agricultural product SP is low, which leads to low supply efficiency and poor operation of the entire chain [20]. Finally, China attaches more importance to the safety issues of imported and exported food quality, but the technology for safety testing needs to be strengthened. Compared to other cross-border commodities, FAP are perishable and resistant to bumps, with higher transportation requirements and costs [21]. Therefore, it is particularly important to accurately identify the actual operational risk factors in their SP.

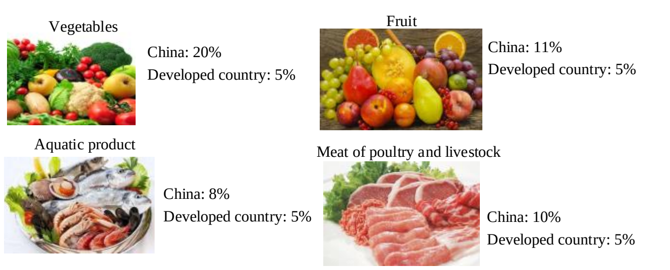


Fig. 2. Comparison of fresh agricultural product consumption rates between China and developed countries.

The risk factors of the cross-border fresh agricultural product SP mainly include the problems that are prone to occur in the operation of the SP and the statistical analysis results of existing SP accidents that have occurred. The main risk factors can be divided into three aspects, namely, SP risk factors, transportation chain risk factors, and sales chain risk factors. In the SP, supply delay risk, inventory risk, quality safety risk, and supply risk are prone to occur. Supply delay refers to the delay in delivery at the source caused by suppliers' inability to prepare goods from the origin on time, which has a negative impact on the operational efficiency of the entire SP [22]. Inventory risk refers to the phenomenon of excess inventory or shortage caused by supplier information lag or stock preparation delay. The quality safety risk is that the quality of FAP at the source of the supplier does not meet the standard. Supply risk refers to the insufficient supply quantity and poor product quality of the overall product. The risk factors faced in the transportation process mainly include shipment delay risk, cold chain risk, unexpected risk, and customs clearance risk. The risk of delivery delay refers to the failure of suppliers to deliver goods on time, resulting in poor operation of the total SP. Cold chain risk refers to the possibility of product loss caused by substandard cold chain technology. Sudden risks refer to unexpected events such as weather disasters and wars encountered during transportation. The destruction of products by sudden risks is irreversible, and the losses brought to the SP are irreparable. Customs clearance risk refers to the problems of excessive customs clearance time and low customs clearance efficiency during the quarantine process of commodity export and import. The final sales process also faces major risk factors such as sales delay risk, market risk, sales inventory risk, and cold chain risk. Fig. 3 demonstrates the causal relationship between various types of risks. In the figure, S represents an overseas supplier; P represents the domestic purchaser; "+" indicates positive feedback and "-" indicates negative feedback.

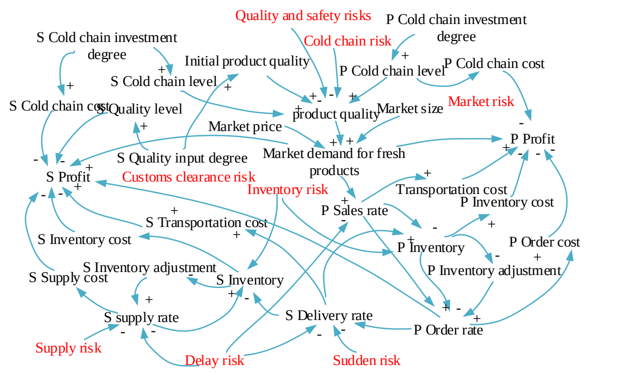


Fig. 3. The causal relationship between various types of risks.

B. Construction of System Dynamics Model for Cross-Border Fresh Agricultural Product SP

The previous section describes the causal relationship of risk factors in the SP of FAP. Common risks in cross-border fresh agricultural product SPs include supply delay risk, inventory risk, quality and safety risk, supply risk, shipment delay risk, cold chain risk, sudden risk, customs clearance risk, sales delay risk, market risk, sales inventory risk, and cold chain risk. For the establishment of this system dynamics model, it is first necessary to convert the above risks into state variables in the system. The above variables can be determined as state variables in the model, and their corresponding changes are rate variables. When using system dynamics to establish a risk assessment model for the operation of the fresh agricultural product SP, it is required to adopt some methods to define the functional relationship between various risk factors [23]. Among them, the most commonly used is the linear functional relationship, which is to establish system dynamics equations by calculating the weights of various risk factors. The weight determination method starts from three aspects: subjective weight, objective weight, and comprehensive integration weight [24]. The overall process of comprehensive empowerment through subjective and objective empowerment methods is shown in Fig. 4.

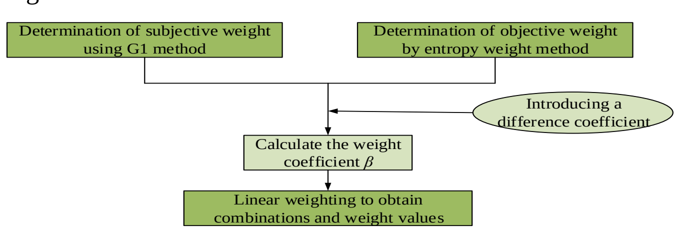


Fig. 4. Combination weight weighting process.

Firstly, the subjective weight is determined using the Order Relationship Analysis Method (G1) [25]. Assuming that there are N risk factors, ranking them according to the importance of each risk indicator can obtain the ranking results shown in Eq. (1):

$$a_1^{'} \geq a_2^{'} \geq \ldots \geq a_n^{'} \tag{1}$$

In Eq. (1), a_i represents the evaluation criteria and indicators. The ratio between $a_i^{'}$ and $a_{i-1}^{'}$ is the degree of relative importance, recorded as t_i. After reasonably assigning a value to t_i. Calculate the weight coefficient using Eq. (2):

$$\begin{aligned} m_i^{'} &= \left(1+\sum_{i=2}^{n}\prod_{k=i}^{n} t_i\right)^{-1} \\ m_{i-1}^{'} &= t_i m_i^{'} \quad (i=n,n-1,\ldots,2) \end{aligned} \tag{2}$$

In Eq. (2), both $m_i^{'}$ and $m_{i-1}^{'}$ represent weight coefficients. When using the G1 method to determine the weight, there is a situation where team experts' scores are inconsistent, so it is necessary to discuss the importance level. Assuming that there are $x(x \geq 1)$ experts in total, among which z experts have the same results for ranking indicators, there is an Eq. (3):

$$t_i^{*} = \frac{1}{a}\sum t_i \tag{3}$$

In Eq. (3), t_i^{*} represents the ratio of the relative importance between indicators $a_i^{'}$ and $a_{i-1}^{'}$. Then, the weight coefficient of this z expert can be determined as:

$$\begin{aligned} m_i^{'} &= \left(1+\sum_{i=2}^{n}\prod_{k=i}^{n} t_i\right)^{-1} \\ m_{i-1}^{i''} &= t_i^{*} m_i^{''} \quad (i=n,n-1,\ldots,2) \end{aligned} \tag{4}$$

Aside from that, assuming that the evaluation results of the remaining $x-z$ experts are different, averaging them can obtain Eq. (5):

$$\overline{m_i}^{'} = \frac{\sum m_i^{'}}{x-z} \tag{5}$$

Finally, combining the two types of results, Eq. (6) can be obtained:

$$m_i = k_1 m_i^{''} + k_2 \overline{m_i}^{''} \tag{6}$$

In Eq. (6), $k_1 = \frac{z}{x}$, $k_2 = \frac{x-z}{x}$. After determining the subjective weight, it is necessary to discuss the objective weight. The difference from subjective weight is that the final result of objective weight does not rely on subjective judgment, but rather decides the indicator weight based on the information of the sample itself. Entropy weight method is a commonly used objective weighting method, which mainly determines the weight through the degree of variation of indicators. The size of the entropy value can reflect the degree of variation of the index. The larger the entropy value, the greater the degree of variation and the more information it covers, so the higher the weight value. Suppose there is a judgment matrix (A P) that contains the judgment values of n experts on m risk factors, and the specific expression is:

$$P = \begin{bmatrix} A_{11} & A_{12} & \ldots & A_{1n} \\ A_{21} & A_{22} & \ldots & A_{2n} \\ \ldots & \ldots & \ldots & \ldots \\ A_{m1} & A_{m2} & \ldots & A_{mn} \end{bmatrix} \tag{7}$$

Standardize the data contained in Eq. (7) to obtain Eq. (8):

$$P_{ij} = \frac{A_{ij} - \min\left(A_{ij}\right)}{\max\left(A_{ij}\right) - \min\left(A_{ij}\right)} \tag{8}$$

In Eq. (8), $\min\left(A_{ij}\right)$ denotes the minimum value in the original judgment matrix; $\max\left(A_{ij}\right)$ denotes the maximum value in the original judgment matrix; P_{ij} represents a standardized value. The equation for calculating the proportion of each index is shown in Eq. (9):

$$r_{ij} = \frac{P_{ij}}{\sum_{j=1}^{n} P_{ij}}, \quad \left(i = 1, 2, \ldots, m\right) \tag{9}$$

Eq. (9) represents each indicator value's weight, so the entropy weight calculation Equation for the i index is:

$$w_i = \frac{1 - E_i}{m - \sum_{i=1}^{m} E_i} \tag{10}$$

After determining the subjective and objective weights, comprehensive weighting can be performed. This model can combine the advantages and characteristics of subjective and objective weighting methods to enhance the scientificity and rationality of the final result. The linear weighting method can not only compensate for the shortcomings caused by the uneven numerical values of other methods, but also have a relatively concise calculation process for finding the optimal combination weight. Therefore, this experiment uses a linear weighting method to restructure the weights. The basic calculation Equation is as follows:

$$Q_i = \beta m_i + \left(1 - \beta\right) w_i, \quad 0 \le \beta \le 1 \tag{11}$$

In Eq. (11), β denotes the proportional coefficient. The overall calculation equation is shown in Eq. (12):

$$Q_i = \frac{m}{m-1}\left[\frac{2}{m}\left(P_1 + 2P_2 + \ldots + mP_m\right) - \frac{m+1}{m}\right] \tag{12}$$

In Eq. (12), P_{ij} represents the number of indicator factors; P_{ij} represents the weight value of the P_{ij} values of each indicator factor after being sorted in ascending order. In addition to the above risk variables, there are also some boundary risk variables that cannot directly obtain data. For the assignment of boundary risk variables, this experiment was conducted using expert scoring. The scoring rules are shown in Eq. (13):

$$a_{ij} = \left(x + 4n + y\right)/7 \tag{13}$$

In Eq. (13), x, y, n represents the minimum, maximum, and most likely values that boundary risk factors may have an impact on the fresh agricultural product SP. i represents the i-th risk factor; j represents the j-th expert. Average all the obtained results to obtain the corresponding boundary risk value. Draw a system flow diagram for all risk variables based on the causal relationship diagram in the previous section. Fig. 5 shows the basic form of a system dynamics model for the cross-border fresh agricultural product SP.

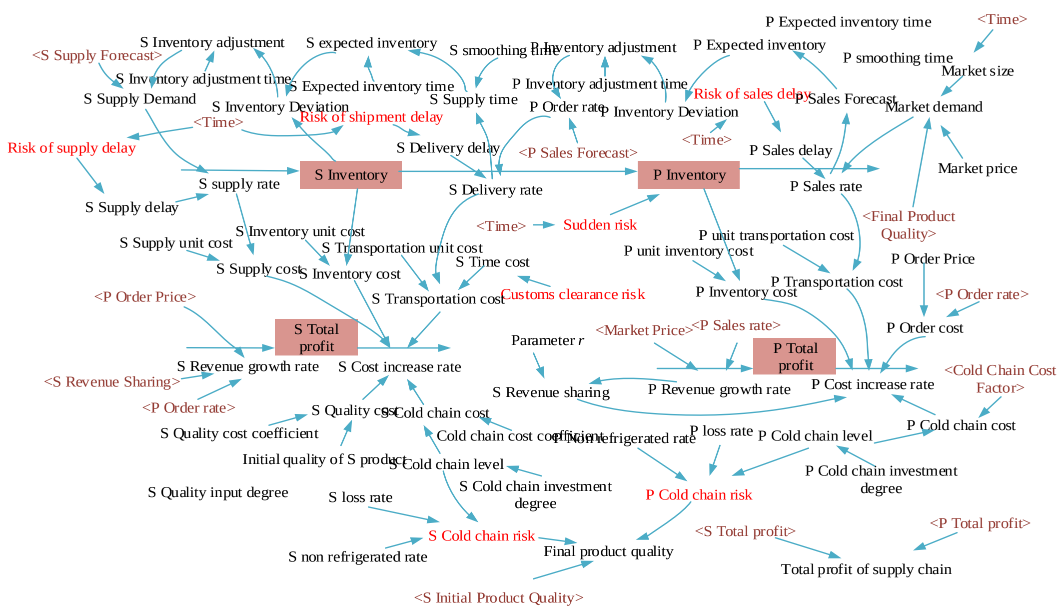


Fig. 5. Basic form of system dynamics model for cross-border fresh agricultural product SP.

IV. Simulation Experiment on System Dynamics Model of Cross-border Fresh Agricultural Product SP

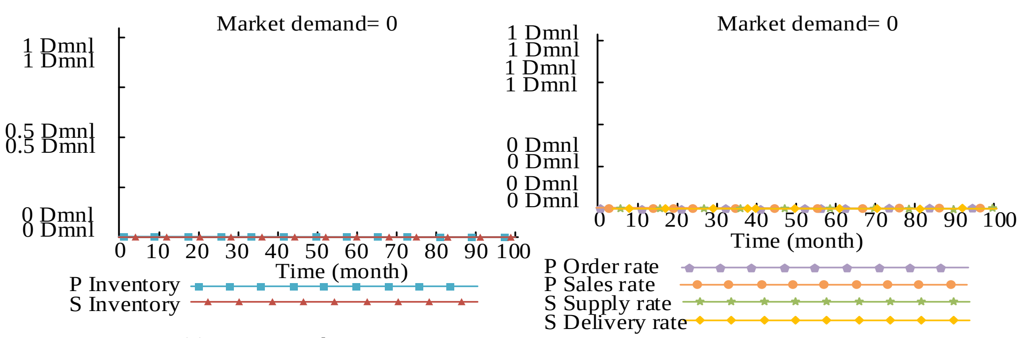
A. System Dynamics Model Test of Cross-Border Fresh Agricultural Product SP

To make the logic of the constructed model and functional equation reasonable, and ensure that the system operation can reflect the actual situation to a greater extent, model verification is conducted before conducting model simulation experiments. First, set the constants for the overall model, and the values set are obtained based on the relevant data in the industry report. To verify whether the model can truly, stably, and continuously reflect the actual change rules, experiments were conducted to test the realistic reproducibility of the model. In order to make the model truly reproducible, experiments were conducted to examine both extreme and actual situations. Table I shows the settings for some of these variables. The experiment was conducted using Vensim software.

Fig. 6 shows the model test results under extreme conditions where the market demand is zero. Set the market demand to a limit condition of 0, with the simulation starting at 0, ending at 100 months, and step length of 1 month. Then observe the operation effect of the system. When the market demand level is 0, the buyer does not sell the product and will not place an order. Therefore, both the sales and order ratios are 0. When the buyer does not need to place an order, the seller will not provide the goods and will not ship them. Therefore, both the supply ratio and the shipment ratio are 0. The company's inventory level remains at its initial level of 0. The model can be tested under extreme conditions.

TABLE I. PARTIAL PARAMETER SETTINGS OF SYSTEM DYNAMICS MODEL

Variable	Numerical Value	Variable	Numerical Value
Market price	101.22	Order Price	60.89
Purchaser smoothing time	2.13	Supplier smoothing time	2.16
Purchaser's expected inventory time	3.27	Supplier's expected inventory time	3.47
Purchaser inventory adjustment time	4.32	Supplier inventory adjustment time	5.24
Supplier Cost Quality Factor	45000	Cold chain cost coefficient	40000
Supplier attrition rate	0.1	Purchaser's loss rate	0.22
Supplier non refrigerated rate	0.1	Supplier non refrigerated rate	0.56
Supplier unit inventory cost	5.67	Supplier's unit transportation cost	20
Supplier unit supply cost	10.19		



(a) Inventory changes (b) Changes in orders, shipments, and sales

Fig. 6. Model test results under extreme conditions with market demand of 0.

After that, use the model to test the actual situation. Similarly, set the start time to the 0th month, the end time to the 100th month, and the step length to 1 month. At the same time, set the risk of sales delay in the 10th to 20th months; Risk of supply delay in the 20th to 40th months; the risk of shipment delay occurs in the 60th to 80th months; sudden risks occur in the 50th month. Fig. 7 shows the changes in purchasing inventory during this period. In the 10th month, there was a risk of sales delays, i.e. a decrease in the purchaser's sales rate, resulting in an increase in inventory and a decrease in the supplier's delivery rate. In the 50th month, there was a sudden risk that the purchaser's inventory decreased, leading to an increase in the supplier's delivery rate until it stabilized. In the 60th month, the risk of delivery delay occurred, and the supplier's delivery rate decreased, resulting in a slight decrease in the purchaser's inventory. In the 80th month, the risk of shipment delay disappeared and the purchaser's inventory gradually returned to normal levels. The operation of the model coincides with the actual situation.

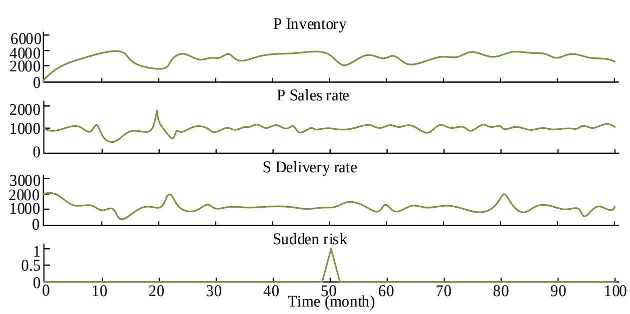


Fig. 7. Purchaser inventory changes.

Fig. 8 shows the inventory changes of suppliers during the above time period. In the 10th month, the supplier's shipment rate suddenly decreased, and the supplier's inventory was still able to meet downstream ordering requirements, so the supply rate was 0. After that, when the supplier's shipment rate began to pick up, the supply rate also began to gradually rise. However, the growth rate of the supply rate is slower than the delivery rate, until the two are equal, the supply inventory decreases to the minimum. When the supplier's inventory is at the lowest level, the supply rate will peak in a short period of time. Then, when the supplier's shipment volume remains basically constant, the supply rate will lag behind the inventory. The risk of shipment delay occurs between 60 and 80 months, and the supplier's inventory changes exhibit a similar pattern. The operation of this model is consistent with the actual situation.

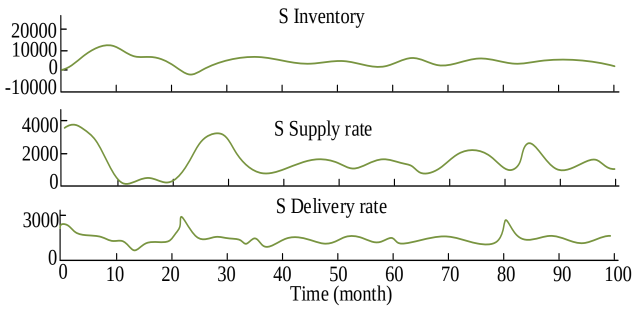


Fig. 8. Supplier inventory changes.

B. Simulation Analysis of Key Risk Variables in the Cross-Border Fresh Agricultural Product SP System Dynamics Model

Fig. 9 shows the level of impact of supplier quality input on the SP. As suppliers invest more in quality, product quality will gradually improve, thereby promoting an increase in market demand. As a result, the overall profit of the market has increased. However, for suppliers, the marginal benefits generated by continuing to increase investment in product quality are diminishing. The growth rate of product quality and market demand has stabilized, and high investment also means high costs. Therefore, the total profits of buyers and suppliers will gradually increase to a certain level and remain constant. This indicates that increasing the level of quality input from suppliers can improve the overall revenue of the SP, but there is an upper limit.

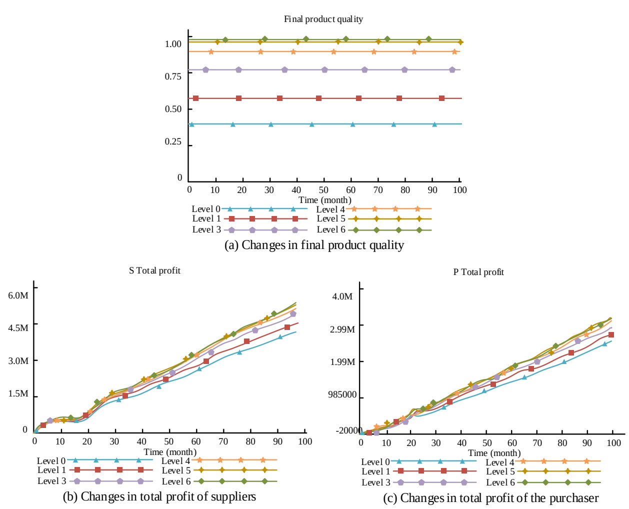


Fig. 9. Impact level of supplier quality input on SP.

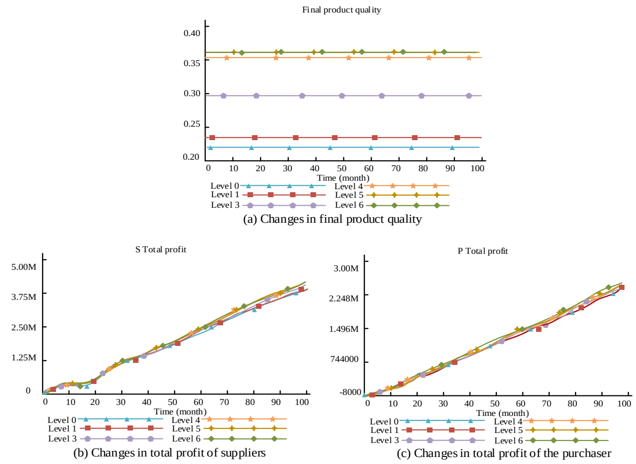


Fig. 10. Impact of purchaser's cold chain investment on SP.

Fig. 10 shows the impact of the purchaser's cold chain investment on the SP. The increased investment of buyers in the cold chain has led to the improvement of product quality, which has promoted the increase in market demand. Therefore, the overall interests of the market will increase accordingly. However, after investing in the cold chain to a certain level, the marginal income will suddenly rise and then decline after accumulating to a certain level. This is because cold chain logistics requires a certain amount of upfront investment. In the early stages of cold chain transportation, a large amount of money needs to be spent, resulting in a small return on investment in the early stage. High investment brings high costs. Thus the overall returns of buyers and suppliers will gradually increase until they remain unchanged. As a result, increasing the investment of suppliers in the cold chain can improve the overall efficiency of the SP, but also has an upper limit.

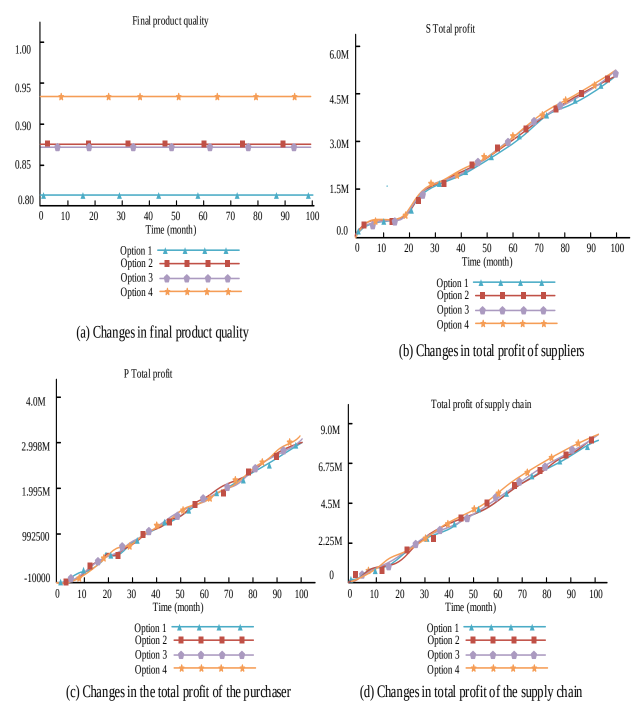


Fig. 11. Impact of different schemes on SP profits.

Fig. 11 shows the impact of various solutions on the SP system. There are four different schemes in the figure: Scheme 1 is the initial setting; Scheme 2: Increase input for suppliers; Scheme 3: Increase the degree of investment for the purchaser; Scheme 4 is the degree of joint cooperation investment. It can be seen from the figure that suppliers and purchasers will increase their investment in the product, which will improve the final quality of the product and the overall profit of the SP. When all members of the SP jointly increase their investment, both the benefits of both parties and the overall benefits of the SP are higher than when one party alone increases its investment level. Therefore, the two parties should actively establish a cooperative relationship and choose appropriate incentives. Suppliers increase their investment in product quality to improve quality products; the purchaser should increase investment in the cold chain and improve the cold chain management ability. This will maximize benefits while ensuring the overall efficiency of the SP.

V. Conclusion

Nowadays, the increasing demand for cross-border FAP poses a significant challenge to the management of their SP. To reduce the interference of risk factors on the cross-border fresh agricultural product SP, and thereby enhance the efficiency of the overall SP, the experiment weighted the possible risk factors and constructed a system dynamics model. The test results of the system dynamics model show that the proposed method can pass the test under extreme conditions, and its operation is consistent with the actual situation. Simulation experiments were conducted to introduce risk factors into the constructed system dynamics model. The simulation results indicate that increasing the supplier's quality input can enhance the overall revenue of the SP, but there is an upper limit; increasing the investment of suppliers in the cold chain can enhance the overall efficiency of the SP, but it also has an upper limit. Therefore, to ensure the overall efficiency of the SP and maximize benefits, suppliers increase their investment in product quality and improve the products' quality; the purchaser should increase investment in the cold chain and optimize the cold chain management ability. The proposed model can truly reflect the dynamic changes of the actual SP, and has good practicality. This experiment still has some limitations, that is, it fails to consider external macro risks and other factors, so the subsequent research can start from here.

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