

Analysis and Simulation Examples of Agricultural Products Logistics and Distribution Based on System Dynamics

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Abstract:Basic principles and methods of system dynamics to explore the various elements of logistics and distribution of agricultural products during the affected system status, and analyzes the causal relationship and interaction between the various elements and build accordingly agricultural logistics system dynamics model of the distribution process draw the various elements of logistics and distribution of agricultural products causal diagram and flow chart. Finally, the specific agricultural enterprise as research object, an instance of the simulation study model.

Keywords: Agricultural products; Logistics and distribution; System dynamics; Simulation

INTRODUCTION

Our country is a big country of agricultural production, circulation and consumption, while the logistics of agricultural products in the proportion of the total social logistics is relatively low, which illustrated that most agricultural products were damaged in transit. Due to the strong seasonal agricultural products itself. Compared with other products, fresh agricultural products are perishable, easy loss, difficult preservation characteristics, the efficiency of logistics and distribution of agricultural products directly affect the quality of agricultural products. From a practical point of view, China's agricultural logistics exists many major problems, such as distribution channels is confusion, delivery time is long, distribution link is excessive, large cost, high cost, low efficiency and so on. For this reason. To ensure agricultural enterprises timely supply, reduce inventory costs, reduce inventory keep optimize and improve the agricultural distribution system, improve the efficiency of logistics and distribution of agricultural enterprises is of important significance.

BACKGROUND AND SIGNIFICANCE

Our country is a big country of agricultural production, circulation and consumption, the demand for high-quality agricultural products is also growing. However, due to the low efficiency of agricultural products circulation process, people's

needs are often unable to receive timely meet. From a practical point of view, China's agricultural logistics exists many major problems, such as distribution channels is confusion, delivery time is long, distribution link is excessive, large cost, high cost, low efficiency and so on. The traditional way of logistic distribution of agricultural products is mainly with farmers self-distribution model, but it was the higher cost of self-distribution model and the large one-time investment that caused it has the low capacity of the change in the market and emergencies. In the current market environment, logistics distribution systems for agricultural research are more generally use operations research methods by means of the establishment of inventory control models to analyze and adjust. But this type of mathematical methods in the field of logistics distribution for agricultural research still exist many problems, its strong emphasis on the accuracy and precision of the system data to find the optimal solution for the target: not only can the model abstract complex and lack of the intuitiveness, but also it is difficult to calculate. In addition, the model make a study of the individual problem for the inventory, it's don't pay attention to the integrity and overall so that it is difficult to achieve and improve overall system optimization. However, the system dynamics was found in the 1960s by a professor whose name is Forrester at the Massachusetts Institute of Technology. It's a study of the socio-economic sphere complex systems approach which is more suitable for

research on the development trend forecasting and data shortage problem.

INTRODUCTION TO SYSTEM DYNAMICS THEORY AND METHODS

The basic concepts of system dynamics

System dynamics method is a quantitative method which is based on feedback control theory and take the computer simulation technology as means to study of the complex social economic systems. System dynamics method contains the following key basic concepts:

(1) Causal feedback. If the event A cause event B, AB will form a causal relationship. If A is said to increase lead to B increased, it constitutes a positive causal relationship, that is a positive feedback. If A increase lead to B reduce, it is said that AB constitutes a negative causal relationship, that is a negative feedback. Feedback loop is made up of two or more causal chain end to end configuration, including positive and negative feedback loops.

(2) Stocks and Flows. If you use bath water to explain the stocks and flows. The stock is the bath water, the flow include the water which flowing on the faucet above the bathtub and outfall under the bathtub. Stocks make changes of the flow, the flow rate is the amount, which characterizes the rate of inventory changes.

(3) Delay. Delay is a process, its output behind its input in a pattern, and any delay must include at least one stock to cumulative the difference between the input and the output. Delay includes the materials delay and the information delay, the former describing the material (letters or raw materials) of physical mobility, the later describing the perception and the step by step adjusting for the identified (CPI or inflation).

General Procedure for System Dynamics Modeling

System dynamics modeling process has a general procedure. The first is to observation the reality system, and extract the representative data and information, and then get the model framework based on the assumption the problem, namely the establishment of the basic "qualitative" model. Further, the problem needs to be refined, it is simply the constraints and boundary conditions of the system to define and to collect the necessary data to achieve a specific model. This time, the actual data model already has the support of the model can analyze the evolution of the corresponding dynamic results, namely the establishment of "quantitative" models. In this step, we can analysis and observable the evolution of dynamic results of the model so that we can compare and contrast the reality of the system, and according to comparison results to adjust the

model accordingly. The entire modeling process is an ongoing process reciprocating screw forward.

All successful system dynamics modeling consists of the following five steps: clear expression the solve problem to ensure the boundaries of the system, raise questions about the causal relationship between a dynamic hypothesis or theory, write equations to test the dynamic hypothesis, test models until satisfied, the model has reached the goal and put forward the policy design and evaluation.

ZP AGRICULTURAL PRODUCTS COMPANY LOGISTICS SYSTEM DYNAMICS SIMULATION MODEL INSTANCE

ZP agricultural company logistics process analysis

In this paper, contrapose the logistics of agricultural enterprises using self-distribution model typical distribution to build a system dynamics model of agricultural import and distribution logistics distribution mode. Because the model is constructed for the majority of our large-scale agricultural enterprises of logistics processes so that the model has a more general applicability. However, in the agricultural logistics distribution constructed above SD model is applied to real cases in the process, also require further analysis of specific cases of the actual situation in order to improve the accuracy of the model simulation. Therefore, this chapter select a representative typical agricultural enterprises to analyze the logistics distribution processes, and apply system dynamics model to constructed instance simulation. tem dynamics model to constructed instance simulation.

This paper selected ZP agricultural products company as a case study. ZP company, like the majority of agricultural enterprises, the use of self-distribution model in which agricultural production enterprise product logistics business processes can be divided into three blocks, namely the supply of agricultural products, agricultural enterprises import and distribution centers as well as sales of agricultural products. Supply of agricultural products including from agricultural production enterprises, agricultural products processing all types of crude product. All kinds of products into large-scale agricultural enterprises import and distribution centers, through tested, refined processing, sorting, picking, equipped, delivery and other processes, direct distribution to the various retail stores, and the sale of high quality agricultural products in all retail stores to consumers. Compared with some large agricultural enterprises, ZP company's logistics node fewer intermediate node agents, which help ZP company's distribution efficiency. Its main product distribution process shown in Figure 1.

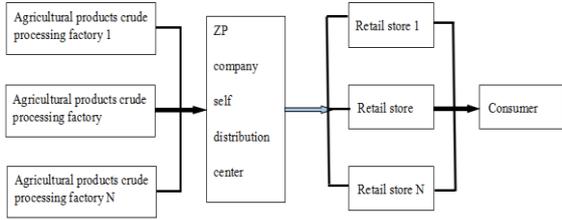


Figure 1:ZP agricultural company logistics processes

Construction of the ZP agricultural products company logistics SD model

By analyzing the distribution of agricultural products ZP company's processes and research ZP company agricultural logistics distribution systems in the logical links between the elements and the mutual influence, can draw ZP company's logistics and distribution processes causal feedback diagram shown in Figure 2.

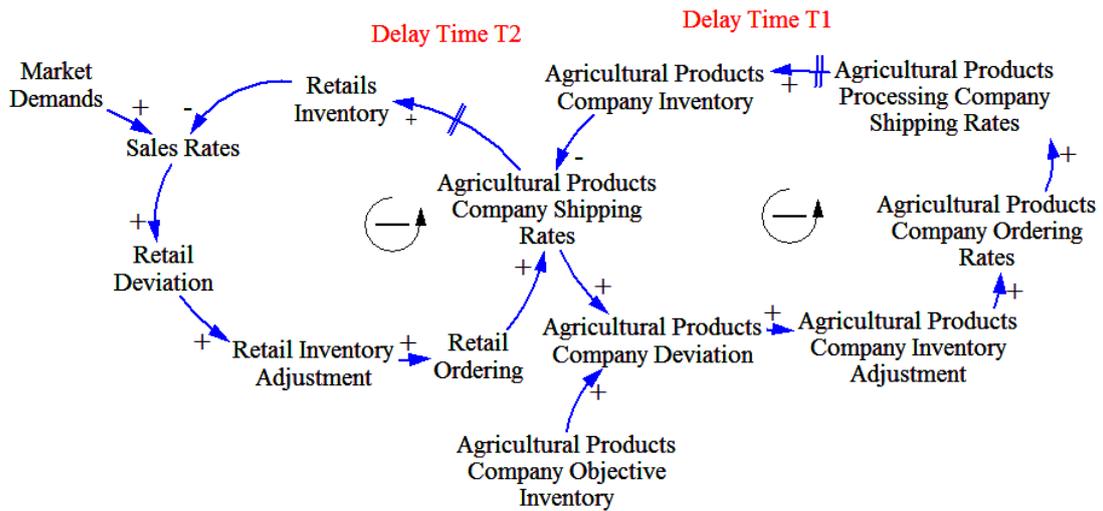


Figure 2 :ZP agricultural logistics company causal diagram

The use of system dynamics modeling simulation tools VENSIM PLE software, introduced the stock variables, flow variables, auxiliary variables, constants and other concepts, further analysis of the

logical connections ZP agricultural logistics company causal diagram between system variables, constructs ZP agricultural logistics company flow chart shown in Figure 3.

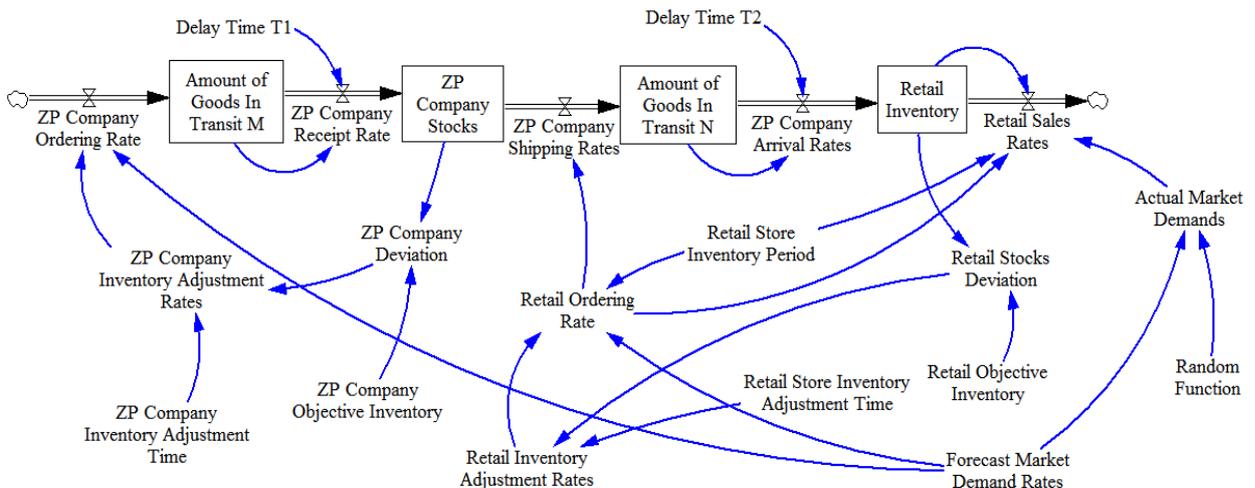


Figure 3:ZP agricultural logistics company flow chart

According to the above model of agricultural logistics SD causal diagrams and flowcharts to ZP company's actual operating conditions, choose one of ZP downstream retail company N to analysis the logical connections and interaction between each systems variable so that we can using SD models simulation tools Vensim PLE software to transform the logical relationships between variables in the system into a mathematical formula (language DYNAMO equations) and build the establishment of DYNAMO equation system for simulation and quantitative analysis. Equation system includes stock variable equation, flow variable equations, parametric equations and auxiliary variables constant.

Stock variable equation

ZP company stocks = INTEG (ZP company rate -ZP receipt of delivery rate, ZP company stocks initial value)

Retail inventory = INTEG (ZP company arrival rate - the rate of retail sales, retail inventories initial value)

Amount of goods in transit M = INTEG (ZP company ordering rate -ZP company receipt rate, 0)

Goods in transit volume N = INTEG (ZP company shipping company rate -ZP arrival rate, 0)

Flow variable equations

ZP company ordering rate = PULSE TRAIN (0,0,7,60) * (7 * predict market demand rate + ZP company's inventory adjustment rate)

ZP company receipt rate = DELAY1 (in the amount of goods in transit M)

ZP company shipping rates = retail orders

ZP company arrival rate ratio = DELAY1 (in the amount of goods in transit N, the delay time T2)

Retail sales ratio = MIN (retail inventory / retail inventory cycle rate + retail orders, the actual market demand rate / retail inventory cycle)

Parametric equations

ZP company deviation = ZP company objective stock -ZP company stock

Retail stocks deviation = Retail target inventory - Retail stocks

ZP company inventory adjustment rate = ZP company stocks deviation / ZP company inventory adjustment time

Retail inventory adjustment rate = retail inventory deviation / retail inventory adjustment time

Actual market demand =forecast demand rate ratio + random function

Auxiliary variables constant

Delay time T1 = no fixed set assignments , according to the actual situation

Delay time T2= no fixed set assignments according to the actual situation

ZP company inventory adjustment time = no fixed set assignments according to the actual situation

Retail store inventory adjustment time = no fixed set assignments according to the actual situation

Retail store inventory period= no fixed set assignments according to the actual situation

ZP company objective inventory = no fixed set assignments according to the actual situation

Forecast market demand rate = no fixed set assignments according to the actual situation

Random function= RANDOM UNIFORM (0.1,0.8,0.3)

According to the parameters listed in the equation all kinds of variables, using the simulation dynamics model system tool Vensim PLE software, causal diagram drawing software, stock-flow diagram (flow chart) set the corresponding equation for each variable to constitute the entire equation system to be introduced after the relevant initial data, the model was constructed simulation and analysis of results.

ZP agricultural logistics company SD model simulation and analysis

Data model initialization

Because agricultural itself has a strong seasonal and perishable agricultural products as difficult to save for a long time.ZP company uses the whole process of agricultural products circulation temperature, including frozen and refrigerated products, the frozen products a longer shelf life for about a year and a relatively short shelf life of refrigerated products, only a week or so.In this paper, the model simulation time is set for two months or 60 days, the simulation runs in steps of 0.25 days, the model shown in Figure 4 is set.

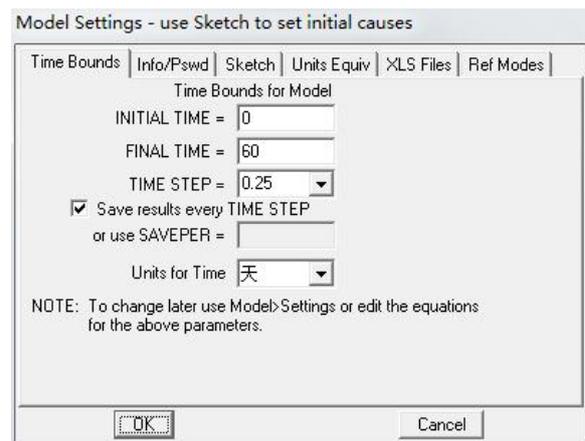


Figure 4: SD model simulation settings

According to the actual operation of the initialization assignment ZP downstream retail-oriented companies N, the introduction of the model initialization data for each variable construction, including ZP agricultural products company stock, the initial value of retail N stocks, and various constants.

Table 1:ZP agricultural logistics company SD model initialization data

Variable	Initializationvalue	Variable	Initialization value
ZPInventory	32Ton	Retail inventory	1.5 Ton
ZP objective Inventory	40 Ton	Retail NExpectedinventory	2.5 Ton
ZPInventory adjustment time	2Day	Retail Inventory adjustment time	1 Day
Delay time T1	3 Day	Retail Inventory period	5 Day
Delay time T2	0.5 Day	Random function	RANDOM UNIFORM (0.1,0.8,0.3)
Forecast market demand rates	3 Ton		

The ordering rate of ZP company

According to initial data provided above, we should have the conformance testing and reality testing on the model dimension to ensure that SD model constructed is reasonable. On this basis, the model simulation should first examine the company's agricultural products ZP order rate.

It can be drawn from Figure 5, ZP company own management under the circumstances, the order showed a regular fluctuation over time, that is taken once every seven days ordering activity,in the 60-day run length of time, the order quantity in each 20 tons to 23 tons, of which the first order quantity of 25 tons and showing successive reduction of health.

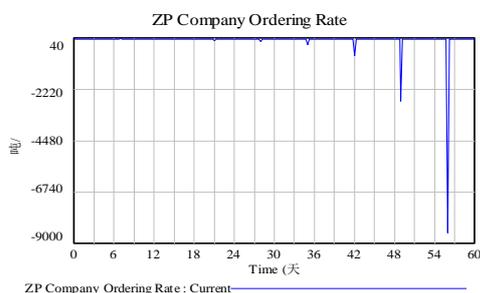


Figure 5:ZP company ordering rate graph

ZP company stocks

ZP company inventory change is a focus of the study variables, which includes changes to affect its flow, it's the study shipping rates and receiving rate. ZP company for changes in agricultural stocks were simulated, draw the following graphics.

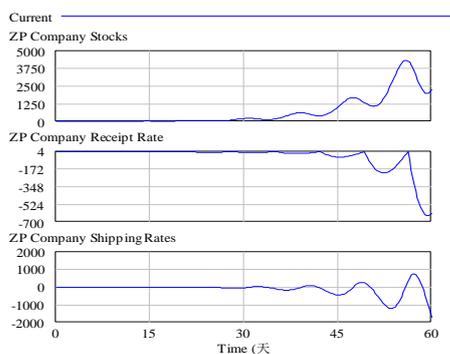


Figure 6:ZP company stock and flow changes graph

It can be drawn from Figure 6,the conditions of stocks and the influence flow (ZP companies receipt rate and delivery rate) is fluctuate change over time.It can be clearly seen from the picture that ZP company's receipt of the rate curve of cyclical fluctuations, the main reason is due to the company's order rate ZP showing repeated once every seven days rule.However,the ZP company order rate curve,after the initial 2-3 weeks through a relatively large fluctuations,the undulating of curves gradually stabilized.This is because in the initial stages of the simulation model, affected the initial operation of the delayed arrival of goods in transit, ZP retail companies can not timely delivery of agricultural products ordered.With the logistics were, after about three weeks, the curve of delivery rate fluctuations ZP slowing and its shipments remained at about 2.5 tons per day.The above situation can be seen, ZP agricultural logistics distribution company in the process is relatively stable.

ZP company order and receipt situation

Next, simulated the ZP company ordering, receiving and inventory operating conditions.At last draw the following overall curve diagram.

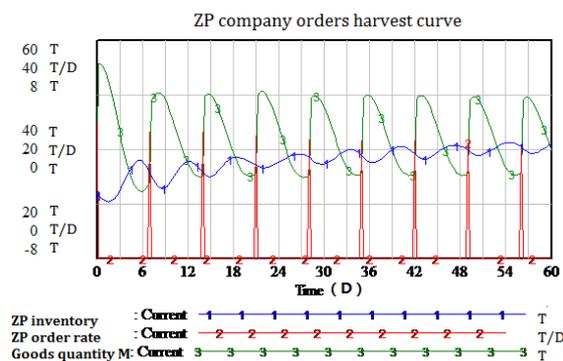


Figure 7:ZP firm order receipt graph

Compared with the ZP company inventory, order rates, and changes in the amount of goods in transit curve from Figure 7, the correlation can be drawn between them.Figure, curve 1 fluctuation in the beginning of a steady upward trend, then will fluctuate up and down along a straight line balance; curve 3 with curvy 2 rather straight up to a fixed

value, and when the curve 2 at 0 axis, the curve 3 starts to decline. Trend curve can be expressed as: ZP company according to their own circumstances, produce behavior orders once every seven days, resulting shipped from the processing of agricultural products ZP company produced a linear increase in the amount of goods in transit. After three days (delay time T1), the amount of goods in transit in this order behavior of all entered the ZP company's warehouse, a substantial increase in ZP company's inventory, and then go through two days (ZP company inventory adjustment time) ZP company stocks arrive one crest. The whole process can be described ZP company stocks increasing trend, namely ZP company's inventory ordering behavior and showed an increase with cyclical fluctuations, and because the initial rate is high due to the order of magnitude of the increase is large, then with the normal operation of the distribution, it gradually become more stable equilibrium fluctuations.

Arrival and inventory in the retail stocks

Next, the retail inventory and the amount of their goods in transit N positive feedback, ZP arrival rate of the three companies make simulation and analysis, the graphic below.

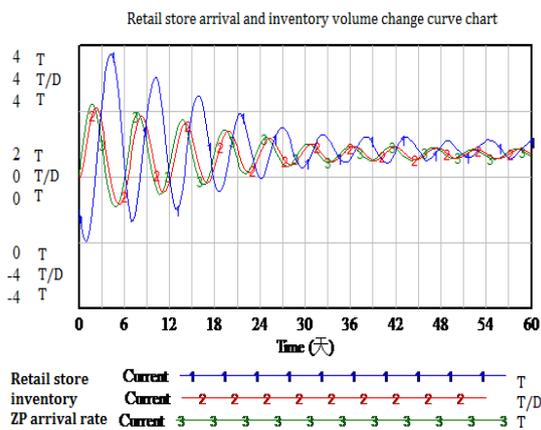


Figure 8: retail arrival and inventory change curve

As can be seen from Figure 8, curve 1 in an initial stage fluctuating, and once dropped to 0, over time, the volatility curve 1 in descending order, approximately 30 days after the start of a curve along a straight line smooth fluctuations. Curve 2 and curve 3 cycle fluctuations, fluctuations are highly consistent in all aspects, but there is a gap of two curves, three ahead of the curve and the curve 2; when the curve 3, curve 2 successively reach a peak, Time lag, the curve also reached a peak, and when the curve 3, curve 2 have been in a trough after the same time interval, the curve is also in a trough. Trend curve can be expressed as: ZP Company arrival rate and the amount of transit cargo destined for retail stores in close contact, both from the number of terms is consistent. That is, the amount of goods in

transit to determine the arrival rate of N. Thus, both the curve is the same in terms of amplitude and period, but due to the delay time T2 (i.e., the curve interval) during transit of goods into the warehouse retail stores, so the amount of goods in transit prior to N curves to ZP company cargo rates is early. In the latter two have reached the peak of the curve, that is, one in the amount of goods in transit cycle all entered the retail warehouse, then a significant increase in retail inventories; and lived for some time interval, ie, retail inventory adjustment time, retail The stock reached maximum.

ZP companies and retail N inventories contrast

Finally, Compared with the ZP company stocks and retail stocks N simulation, analysis of the quantitative relationship between the two. The results of the graphic below.

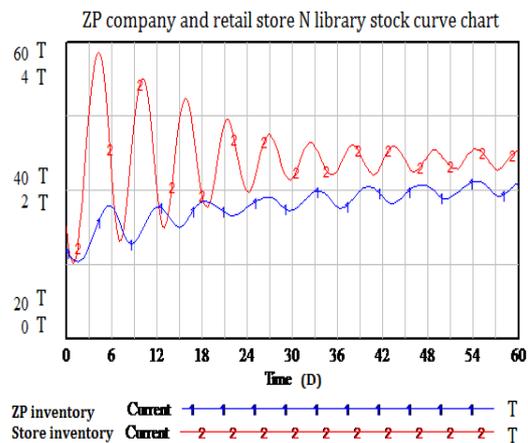


Figure 9: ZP companies and retail N stocks graph

Observe and compare the figure ZP company stock inventory and retail N curves can be found in the early stages of the two curves are model simulations of large fluctuations, but both stocks are appear to zero and below, the description of ZP company's inventory, retail inventory N and ZP company for retail N distribution activities are quite reasonable, does not appear out of stock, etc. ZP company inventory fluctuation curve showing the case of the initial rise in echelon, in about 30 days, fluctuation curve stabilized; the amplitude of the initial inventory of retail N successively reduce fluctuation curve, a straight line in the same balance 30 days, along the curve stabilized. Volatility stocks stabilized after two changes as shown below.

ZP inventory and Retail store inventory					
Time (D)	30.5	30.75	31	31.25	31.5
ZP inventory	37.55	37.73	37.95	38.19	38.45
Retail store inventory	2.245	2.306	2.387	2.458	2.536

Figure 10: ZP companies and retail N inventories contrast

Data can be drawn from Figure 10, after the two curves stabilized, ZP company stock between 37 tons to 41 tons, about 4 tons fluctuations; Retail store N inventory between 2.2 tons to 2.6 tons, which is about 400kg volatility. After two curves stabilized, volatility stocks still relatively large, it can be further optimized.

CONCLUSION

Using the basic principles and methods of system dynamics to solve the complex problem of logistics distribution of agricultural products, by exploring the internal state of the various elements of the system affect the system and analyze the causal relationship between the various elements and interactions to build the corresponding equation system, case through the system dynamics simulation tools Vensim PLE software for the health of specific agricultural enterprise simulation and the results were analyzed so that we don't need to have sufficient data in the information and analysis the issue of agricultural logistics dynamic.

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REFERENCE

- Tian Lixin, Li Wenchao, He Dan. (2014). The system dynamics study on the sustainable development of economy, energy and environment, take China as an example. *Journal of system science*.
- Wang Tingrui (2014). The study on the simulation dynamics of the agricultural supply chain finance system. *Shenyang Agricultural University*.
- Xu Jianling, Ding Yi, Liu Hongci (2014). Analysis of food security situation in Jiangsu based on system dynamics. *Journal of Central University of Finance and Economics*.
- Zhou Pengfei, Chen Dong, Wang Qiuliang (2014). Simulation analysis of building green supply chain: taking Dalian as an example. *Journal of system simulation*.