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A Novel Agricultural Product Supply Chain Optimization Algorithm based on the Neural Network and Simulated Annealing Algorithm

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Abstract

With the rapid development of system science and engineering, the optimization of the supply chain has become the core of enterprise supply chain management goals. In this paper, we conduct research on agricultural product supply chain optimization algorithm based on the neural network and the simulated annealing algorithm. Agricultural product supply chain special the network environment as well as the characteristics of -based agricultural production and farm product, the peasant household risk mainly displays in the demand risk, the operational risk, the supply risk, the environment risk, the system risk and information risk aspect contents. From the demand angle analysis, the peasant household in transaction, product demand predict that transportation, storage and other aspects faced with many uncertainty, these uncertainty factors constituted the demand risk, the important source in relying on purchased and is hard forecast that in a small number of super clients the scale fluctuation and transport arrangement of demand cause the delivery extension and product to store up improper cause the critical requirement to be unassuageable and uncertain seasonal demand to fluctuate improper, as well as the purchase business buys on credit the issue seriously. To deal with this, the revised neural network and the simulated annealing jointed model are proposed. The performance is verified through the experimental analysis, compared with the other approaches, the proposed mode has the advantages.

Keywords: *Agricultural Product; Supply Chain Optimization; Neural Network; Simulated Annealing Algorithm (SAA); Simulation*

1. Introduction

The optimization of the supply chain has become the core of enterprise supply chain management goals. Through the implementation of enterprise supply chain optimization can reduce the enterprise production and the operation costs and improves the quality of enterprise's logistics and distribution activities and improves the level of enterprise supply chain performance, so as to increase shareholder value to improve the level of corporate profits [1, 2]. The service delivery chain is integrated supply chain led by the service, carrying on the supply chain design considers has very wide difference when the factor and manufacture that supply chain that reflects in the following aspect.

- The location problem of manufacturing supply chain, often by the logistics cost caused and in the service supply chain is not related to logistics cost, the logistics cost is small or negligible while its location problems tend to consider the cost of the facilities, and traffic facilities.

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- Manufacturing supply chain of core enterprises generally do not directly to the end customer, but through the product distribution layers. The market volatility will cause problems such as bullwhip effect and therefore, inventory management has always been to create the supply chain to solve an important issue.
- The core enterprise of manufacture supply chain will process the finished product the raw material will thus have the factory expense. The production that because serves and spends inalienablly, therefore in the service delivery chain, the service integration business may not pass through the processing the service of supplier but direct sale to customer but will not have the factory expense.

The global optimization is one of the CSM core issues. But the supply chain establishes in a series of self-interest economical world the principal-agent of above contract in fact relates the chain, its each link has the different resource conditions, from the perspective of principal-agent theory, the supply chain is not an economic entity of the unified pursue maximum benefit that is very difficult the situation of avoiding the various enterprise own maximum benefit and supply chain overall benefit conflicts [3]. Accordingly, in the figure one, we show the product supply chain construction procedures.

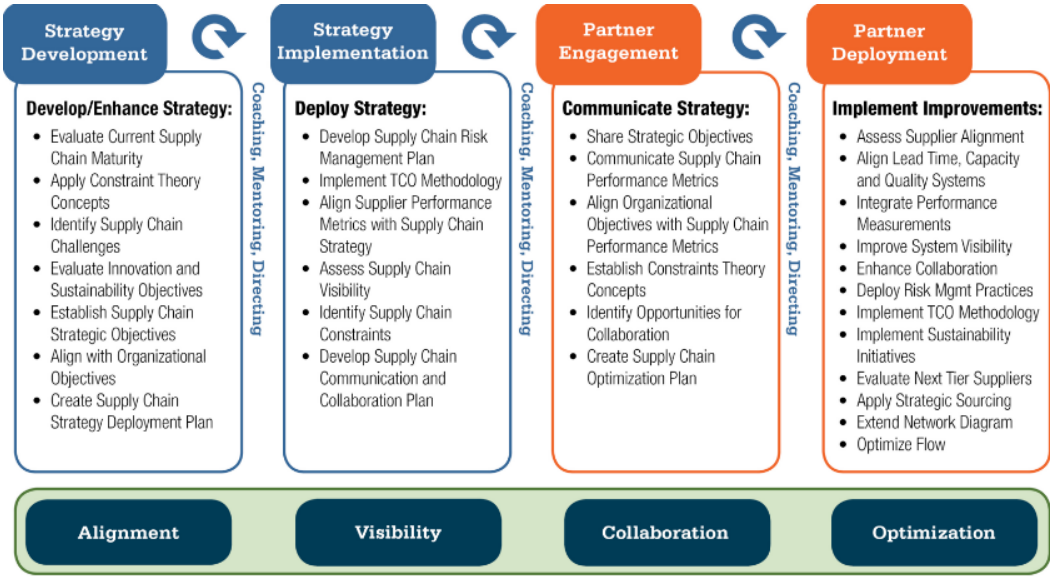

Figure 1.The Product Supply Chain Construction Procedures

Fresh agricultural products in our daily consumption accounts for a large proportion of the population, has a huge production groups and consumer groups. The long production cycle of agricultural products and the large number of intermediaries have resulted in the process of end-user demand transferring to the upstream of the supply chain, which makes the producers blindly organize production in the absence of timely and accurate supply and demand information and face greater risks. Therefore, it is very important to find an effective way to control the bullwhip effect in the supply chain of the fresh agricultural products for China's agricultural economy [4, 5]. In the later sections, we will then discuss or proposed method on agricultural product supply chain optimization algorithm based on the neural network and simulated annealing algorithm. Before which, we summarize the features of the agricultural product supply chain as the follows. (1) Integration. Supply chain based on core competitiveness of the supply chain is the core enterprise integration of the internal and external resources and the formation of the company, if there is no integration of valuable resources, supply chain management strategy cannot be effectively implemented, more difficult to form the core competitiveness, with access to competitive advantage. (2) Value. Supply chain-based core competitiveness is the rich strategic value,

it can make the supply chain more highly effective, provides the unique value and benefit for the final customer well, thus creates a higher value for the enterprise on chain, finally makes the enterprise obtain to surpass the same profession average profit levels over value profit. (3) Dynamic property. On the one hand, the supply chain itself is dynamic, and each node enterprise is based on the needs of the end customer and some dynamic combination, to meet the needs of users. On the other hand, the supply chain management strategy for chain continuously according to the market demand of the development of the core competitiveness, continuous accumulation, cultivation, development, use and discard the resources and capacity of enterprises to enhance the formation of circular loop [6].

2. The Theoretical Basis of the Proposed Methodology

2.1. The Modified Neural Network

The neural network is the nervous system of the simulation biology establishes, the complex network system that is formed by the massive simple neuron widely interconnections. It is the high non-linear, the parallel auto-adapted organizational system which is active marginal interdisciplinary studies [7, 8, 9]. The improvement of the BP network structure mainly includes the interconnection method, and transfer function and hidden layer nodes. The improvement of the algorithm mainly improves the network performance by modifying the error function, increasing the derivative of the activation function and combining with some other intelligent algorithms. Here, the author mainly constructs the compound error function to avoid the local minima, and uses a new method of adjusting the different learning rate to speed up the convergence speed, and proposes a new learning algorithm. In this paper, a novel improved fuzzy neural network model is proposed, and the genetic algorithm is used to train the neural network. In the process of learning to adjust the connection weights of the fuzzy neural network at the same time, through the adjustment of indirect incentive function parameters, so that the improved neural network than traditional neural network have more freedom and performance has stronger nonlinear ability and better performance.

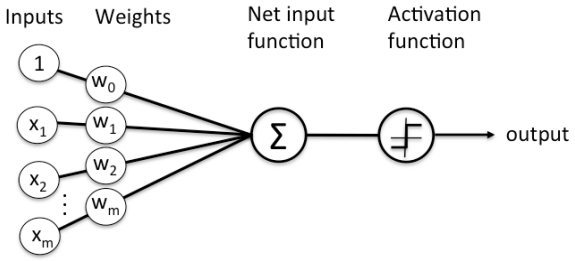

Figure 2.The general architecture of the neural network model

As shown in the Figure 2, the general architecture of the neural network model is illustrated. From the optimization theoretically, the BP algorithm is a descending gradient, the learning rate in traditional BP algorithm is the length of stride of descending gradient. In the BP algorithm the scope of the network parameter adjustment, carries on with the learning rate that the network error function is proportional by one each time. In the traditional BP algorithm, on hidden-layer on output level, in its connection the correction procedure of general weight and in threshold value parameter, learning rate always fixed invariable. In the following formulas, we define the procedures.

$$y = f\left(\sum_{j=1}^{d} w_j x_j + w_0\right) \equiv f\left(\sum_{j=0}^{d} w_j x_j\right) \quad (1)$$

$$E(\mathbf{w}) = E\left\{\mathbf{x}^{\alpha}, \mathbf{y}^{\alpha}, \mathbf{y}\left(\mathbf{x}^{\alpha}, \mathbf{w}\right)\right\} \tag{2}$$

$$f(a) = 1/(1+\exp(-a)) \tag{3}$$

$$| f(t+\Delta t) - f(t) | \leq const(\Delta t)^{\alpha(t)}, \alpha(t) \in [0,1] \tag{4}$$

From the training procedure demonstrated from the formula 1~4, we can see the core weakness issue of the network as follows.

1) The network uses the descending gradient, training the incline that starts from some beginning point together reaches the minimum value of error gradually. For a complex network, the error function is a surface of a multidimensional space, and thus may fall into a local minimum during its training. Although the traditional algorithm adds a new impulse term when the weights are updated to avoid falling into the local minimum, the effect is not obvious.
2) The layer as well as the selection of the hidden-layer nerve of number network hidden-layer still did not have the theoretical guidance, but selects according to experience, therefore, the network often has very big redundancy that increased the time of network.
3) Network learning, memory with instability, the new sample will affect the sample has been completed.
4) The convergence rate of learning algorithm is quite slow. When processing image fault online detection this kind of the quite complex issue, because the system timeliness request is very high, while this requests the learning algorithm the convergence rate to be quicker.

For enhancing the traditional architecture, we revise the activation function as follows.

$$f(Activation) = \frac{1}{1+\exp\left(\frac{\sum_{j=1}^{n} v_{ji} Z_j - P_{in}}{P_{ib}}\right)} \tag{5}$$

The advantage of using batch-based training to train the network is that the different learning rates can be adjusted appropriately after the training of each group of sample images is completed and the time for adjusting the learning rate can be reduced. In the Figure 3, we show the revised curve of the response features.

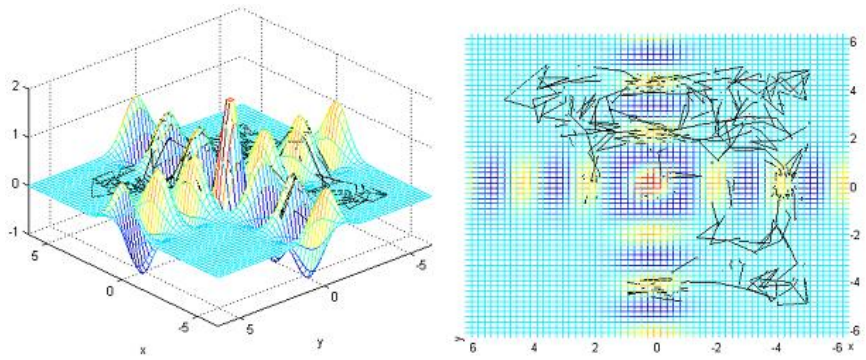

Figure 3.The revised curve of the response features for NN

In the initial stage of the training samples, the output value from the expected value, E is relatively large, the E has a larger decline in space, so E to accelerate the network convergence speed has a greater contribution; with the gradual increase of the number of training samples and the output value is gradually close to the expected value of the E decreases, the decline of delta E the space is shrinking, at this time, the convergence speed of network will become very slow. Learning rate the performance characteristics of choice to the neural network is important, the learning rate will be too small will make network restraining too slow, learning rate too then greatly will make the operation of the network unstable. Therefore, the revised error function can be defined as follows.

$$e_{revised} = e_t^k(\lambda, m) - \sum_{j=1}^{M}\sum_{t=1}^{L}\lambda\frac{\partial C_t^k(m)}{\partial v_{jt}(m)}\Delta v_{jt}(m) \quad (6)$$

2.2. The Simulated Annealing Algorithm (SAA)

The diffractive optical element is a highly effective global optimization method, its basic philosophy originates from the annealing process of solid, in 1982 Kirkpatrick, *etc.*, proposed this algorithm the annealing process introduction combination and optimization domain, and obtained the successful application in the large-scale combination and the optimization issue [10, 11]. The simulated annealing algorithm compares the optimization problem into a physical system. The objective function of the optimization problem is compared to the energy of physical system. The global optimal solution of optimization problem is obtained by simulating the cooling of the physical system to reach the lowest energy state. The mathematical model of the simulated annealing algorithm can be described as that after a given neighborhood structure, the simulated annealing process is a continuous random walk process from one state to another state. In the Figure 4, we show the systematic steps of the simulated annealing algorithm.

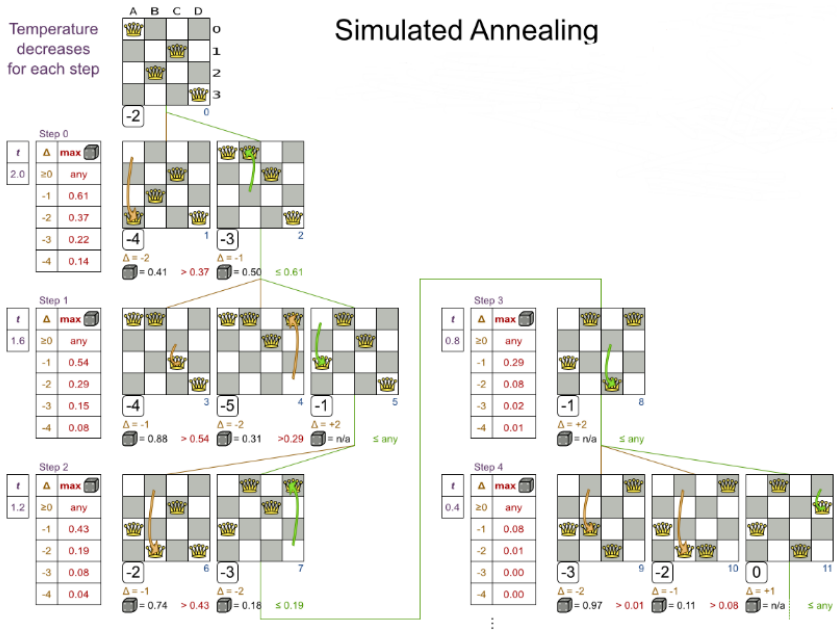

Figure 4.The systematic steps of the simulated annealing algorithm

Theoretically had shown that the basic PSO cannot guarantee restraining in the optimal solution, even is the local optimization and therefore stops having the flaw when with the current positions and all best positions of all particles to be the same the algorithm as the convergent rule, the method should be optimized. For the GPC problem, the particle

swarm optimization algorithm and the simulated annealing algorithm are used to obtain the optimal solution. In this algorithm, the quadratic performance index of constrained GPC is chosen as the fitness function of the particle swarm. In order to overcome the shortcomings of particle in the local convergence, the simulated annealing algorithm is introduced to help it out of the local and the searching ability in the solution space is expanded, and the feasibility rule of particle updating is given [12, 13, 14, 15].

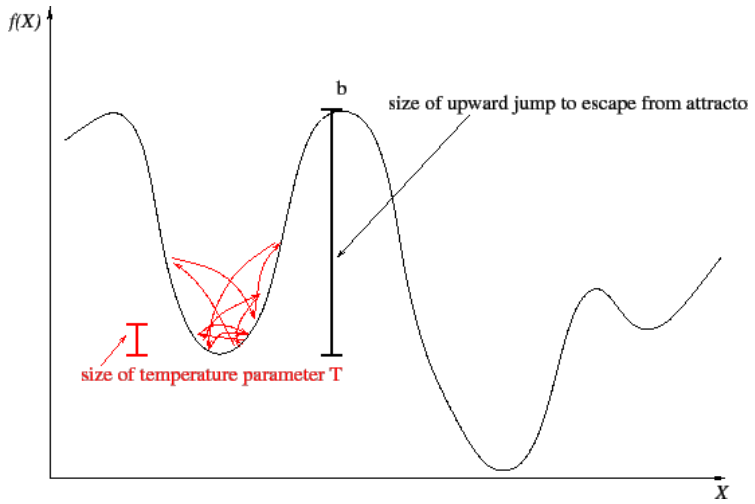

Figure 5.The revised optimization curve of the proposed model

As shown in the Figure 5, the revised optimization curve of the proposed model is shown. The diffractive optical element is the expansion of local search algorithm, this algorithm most remarkable characteristics cause the migration that the goal function value increases by certain probability acceptance that can therefore from the local optimization "trap" crawls, but will not terminate in a local optimization simply, namely has the global convergence. The diffractive optical element not only can cause system when temperature is high flees the local optimum, and can the guarantee system, in the temperature drops to the certain extent, but close globe optimum when accepts the suboptimal solution the possibility greatly to reduce, which can be reflected from the following steps.

Step one. Assigns the original state stochastically $T_0 > 0$ and the initial point, set the parameter $k = 0$ and calculate the value of $f(x_0)$.

Step two. If issues the internal recycling stop condition in this temperature, jump to the step three, or otherwise, calculate the formula 7.

$$\Delta f_{ij} = f(x_j) - f(x_i) \tag{7}$$

Step three. Set the formula 8 till the termination of the experiment.

$$T_{k+1} = d(T_k), \quad k = k+1 \tag{8}$$

For Step 2, there are two types of processing methods. The first is the homogeneous algorithm. For each fixed T, the corresponding Markov chain is calculated until a steady state is reached, and then the temperature is then decreased. The second type is a non-homogeneous algorithm, which requires that the temperature T decrease in two adjacent transitions while the outer loop is Step 3 and the stop condition. Here we use the genetic algorithm to search the global new population after several individual best annealed in their neighborhood respectively for local search and global optimal solution is far from individual local search. This can avoid unnecessary search, save a lot of computation time.

Regarding the traditional genetic algorithm, the competition is conducted in the filial generation, but between the filial generation and parent has not competed, the excellent individual in such parent may lose. Some algorithms through put in the next generation community to preserve the optimal solution the optimal solution in community directly, but this may cause the issue of convergence.

In addition, in genetic algorithm the production of new solution relies on overlapping and variation, but overlapping process to the duplication of parent information, only then the variation process can introduce the recent information and overlapping and variation process has not calculated the obtained new solution the sufficiency that is unable to guarantee that the filial generation is more outstanding than the parent. But new solution that in the SA introduces surpasses the original solution at certain probability which can thus accelerate the evolution of population greatly.

```
void SolvePM(    double BeginTemp,  /* temperature to start P.M. */
                 int SyncMethod,    /* SYNCHRONOUS or ASYNCHRONOUS */
                 int SyncInterval,  /* Intervals between synch */
                 const gsl_rng * r,
                 void *x0_p,
                 gsl_siman_Efunc_t Ef,
                 gsl_siman_step_t take_step,
                 gsl_siman_metric_t distance,
                 gsl_siman_print_t print_position,
                 gsl_siman_copy_t copyfunc,
                 gsl_siman_copy_construct_t copy_constructor,
                 gsl_siman_destroy_t destructor,
                 size_t element_size,
                 gsl_siman_params_t params);

SolvePims(int nPims, int nInteractions, siman_params params, ...)
{
  StartTemp = params.t_initial;
  do
  {
     FinalTemp = ComputeInterTemp(StartTemp,params,nInteractions);
     SolveMIR(StartTemp, FinalTemp, state[],...);
     Copy state[0] to state[1,2,3...,n]; /* state[0] is best solution */
     StartTemp = FinalTemp;
  }
  while (--nInteractions>0);
}
```

Figure 6.The core code of the revised SAA model

As shown in the Figure 6, the core steps are demonstrated. Accordingly, the revised optimal solution for the system can be them modelled as the follows.

$$nPopAnn = \sum_{i=1}^{nAnneal} r(i) \tag{9}$$

3. The Agricultural Product Supply Chain Optimization

"Quality chain" the agricultural product supply chain under environment is the agricultural product related industry organization group participates together, and quality process aggregate aimed at quality security, is the mass flow as well as the information flow and carrier of value class operation. "From farm to dinner table" this from the beginning end of the food safety food chain to the quality chain of basic terminal including planter, cultivation, processing, production, transportation, preserve, sale as well as basic consumer various types of organizations. Along with agricultural product the transformation of working expenses pattern, the agricultural product supply chain presents the integrated trend which reveals the characteristics of multi-dimensional quality chain shown as the Figure 7.

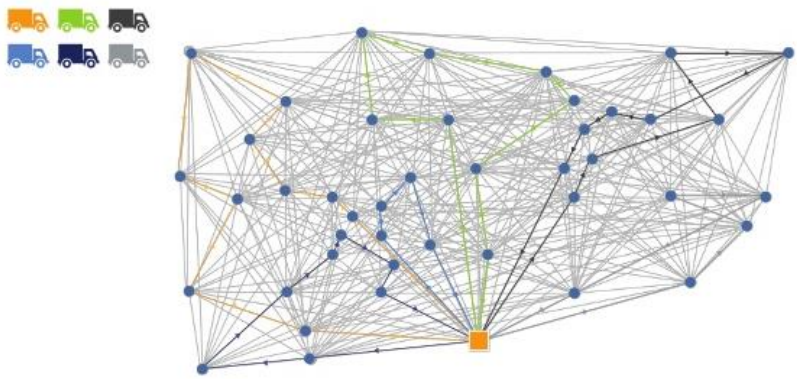

Figure 7.The architecture of the agricultural product supply chain

On the one hand, external quality chain of the organization group is constructed by many organizations, such as the crop cultivation (farmer) in the food chain, food producers at all levels and food distributors at all levels. On the other hand, within each quality chain organization, the internal quality chain structure is composed of product quality, production management, marketing service and so on. It forms the internal quality chain structure crisscrossing with the strategic layer, the tactical layer and the executive layer inside the organization, thus forming the organization quality chain, the quality flow and Internal quality chain, that is, three dimensions of basic quality chain management. The quality system integration structure of the agricultural supply chain is formed by controlling the key chain nodes by mass flow, information flow and value flow. From the systematic level, we should optimize the mechanism for the mentioned risks based on the following suggestions.

- In view of the general production and management of agricultural product, establishes the peasant household risk early warning organization, to some agricultural product analyzes through the production and sale of specialists', thus determined that the grade of products and carries on the information to issue, breaks the limit of peasant household limited information processing analysis capability that reduces the peasant household risk. Meanwhile, must improve peasant household's attaching great importance to degree to the agricultural product supply chain risk early warning core system. Although peasant household oneself to the recognition and control of risk is limited, it will affect the forewarning information to trust degree of risk forewarning information the use effect.
- The farmer's risk preference not only affects the choice of the production project, but also affects the scale of production. For the production of the agricultural products with higher risk levels, farmers tend to reduce capital investment or labor input, or diversification strategy.
- To build the supply chain of the agricultural products agricultural products industry association or farmer specialized cooperative economy organization based on coordination, establishes its core position in the supply chain risk management, and through the supply chain risk monitoring and the dynamic feedback to reduce farmers facing the risk of supply chain.

Risk that because supplier reason causes, displays in the time delay and quantity of the delivery is short, quality defect, place mistake. The reason that creates the supplier risk possibly came from the supplier, such as staff operates miss, the ill management and equipment failure, possibly as a result of the intentional violation

of supplier. There are a variety of risk control strategies to prevent supplier risk, one is to choose a strong, reputable, good performance, as easy to cooperate suppliers, reduce the level of risk from a single supplier; the same time with a number of suppliers. With one or more suppliers experiencing serious supply disruptions, other suppliers are able to guarantee the normal supply of the rest, minimizing possible impact of risk events. Each enterprise in the supply chain has a corresponding Agent classification, it plays a role of the liaison and type in the system, its main function is to collect all kinds of general effective information corresponding to enterprises, including transportation cost, inventory cost, ordering cost, shortage cost, inventory levels, production capacity and quantity etc. series of historical data, and transmit the data to the information processing center, information processing center will receive all kinds of information collected after transmission to the demand forecast of Agent according the following listed procedures and steps.

- The genetic algorithm is used to solve the optimization problem, it is not directly understand the spatial data, it is to be encoded by the gene string structure data. Choosing different coding schemes will have a great impact on the optimization performance (quality and efficiency) of the algorithm. Commonly used coding methods are binary coding, real number coding.
- In the article objective function takes for the general supply chain overall operational cost, is enables it to achieve is smallest, here takes various individual by the reciprocal of objective function the fitness functions.
- Genetic algorithm runs to the largest evolutionary algebra after the stop, and the generation of the best individuals as the optimal solution output.

4. The Numerical Verification and Simulation

In this section, we simulate the proposed method. Suppose each supplier's production capacity is limited. H suppliers, some suppliers appear to supply the obstacles to other suppliers to add orders, at least r suppliers to work properly, to ensure normal supply; more than suppliers cannot supply, it cannot guarantee the normal supply, usually cause serious consequences. Here r is then with the supplier's production capacity and the total procurement of the manufacturer. In the most extreme case, if the supplier's production capacity is large enough, then r =1. The strategy that the retail merchants adopt totally stems from the consideration of supply chain global optimization to spare no sacrifice own benefit that is called the selfless retail merchant behavior pattern. Using demand autoregressive coefficient ρ=0.7 as an example, in the multi-echelon supply chains the selfless retail merchant optimizes the optimal result under pattern to summarize as shown. And specifically described the optimal unit original value of corresponding cost as well as supply chain of various values and stages of proportional regulator and additionally, in the Figure 9, we demonstrate the comparison result for further analysis.

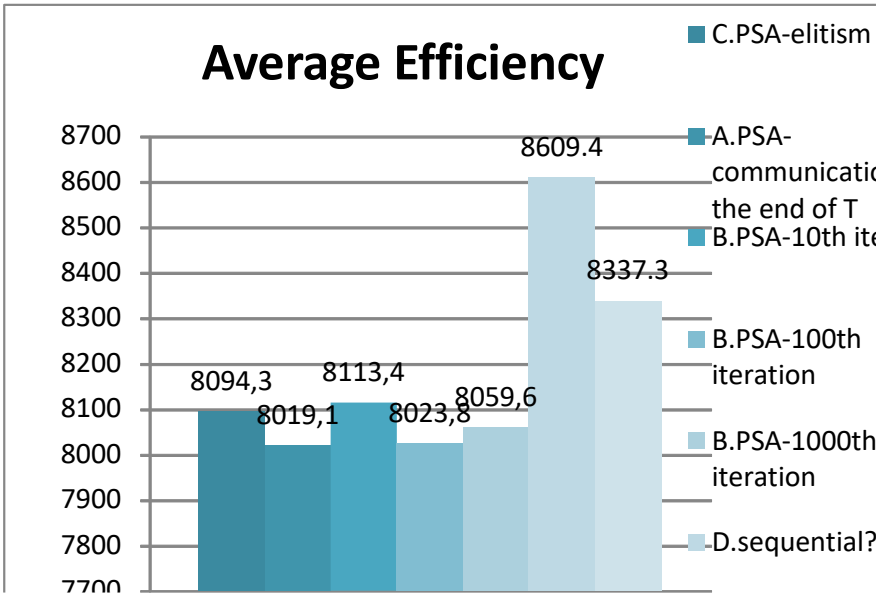

Figure 8.The efficiency test of the proposed methodology

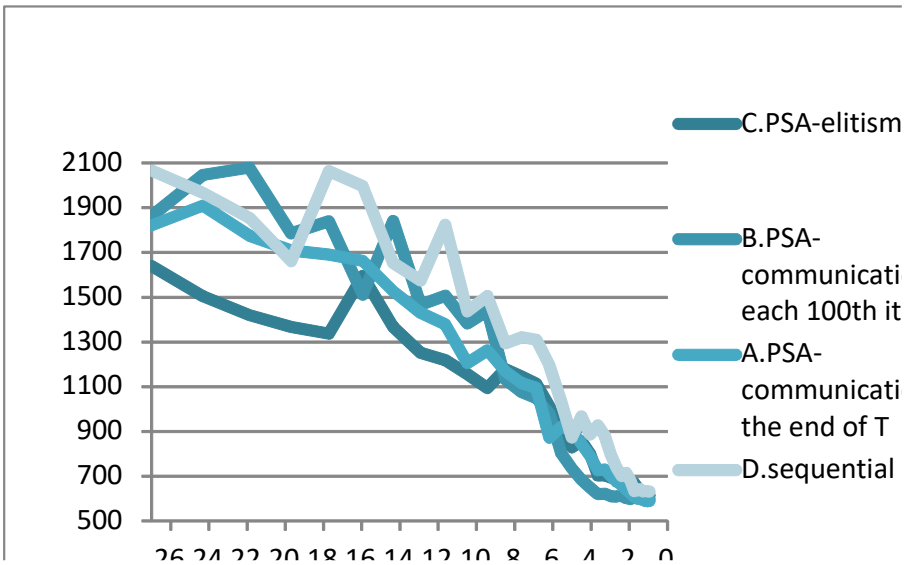

Figure 9.The comparison analysis of the methdologies

5. Conclusion and Summary

In this paper, we conduct research on agricultural product supply chain optimization algorithm based on the neural network and the simulated annealing algorithm. The agricultural products processing enterprise as the core enterprise of agricultural supply chain, along with the unceasing expansion of the scale, its production operation effect depends on the holistic efficiency of agricultural supply chain it is at more and more, the control and improvement ability to the supply chain becomes the one important CSF of agricultural products processing enterprise, from this, supply chain-based the agricultural products processing enterprise core competitiveness concept was proposed. In actual business decision-making, farmers in order to avoid risks, often choose low-income, low-risk business activities, leading to "risk" of agricultural commodity supply. Therefore, it is helpful to improve the risk management level of agricultural product supply chain, stabilize price of agricultural and sideline products and increase the income of peasants by studying the risk factors of peasant household in the agricultural supply chain and its

prevention mechanism. Under this basis, this paper proposes the agricultural product supply chain optimization algorithm and tests the performance. In the later time, we will then apply the methodology into more application scenarios.

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