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Research on Risk Early Warning of the Chemical Supply Chain Based on Improved PSO Algorithm

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Due to the particularity of chemicals, chemicals are prone to accidents during the operation of the supply chain. The chemical accidents cause great harm to people's lives, property and surrounding environment. In the daily operation process, the chemical enterprises not only consider the safety factors, but also think over the effective operation. There are many uncertainties in the chemical supply chain, which will bring potential risks to the safe and effective operation of the chemical supply chain. These risks are transitive. Once the risk occurs in one link of the supply chain, the risk will spread to the entire supply chain and bring great losses to the whole supply chain. In this paper, we research the risk early warning of chemical supply chain. We propose the new algorithm and establish the warning indicators. The experiments verify the effectiveness and accuracy of the proposed model.

1. Introduction

The chemicals are different from other commodities and have high risk characteristics. Some unsafe factors often lead to chemical accidents which bring serious consequences. The operation of the chemical companies is in the chemical supply chain. The risk of chemical supply chain has always been lurking in the supply chain of chemical. The instability in the chemical supply chain will increase the risk of accidents such as the accumulation of inventory, transportation unreasonable etc. It is a very important and meaningful subject to organize and plan the early warning and to prevent and improve the unsafe factors.

Supply chain risk management is important to the operation of the company. Facing on the supply chain risk, supply chain management needs specific and adequate measures, such as technology, attitude and strategy of risk management. In the daily operation of the company, supply chain risk management is an essential function. The basis of the effective supply chain risk management is cooperation (Lavastre et al., 2012). Due to the change of quantity and quality of products, the supply chain has deviation inevitably (Wang and Yue, 2017). In order to reduce the loss, people always want to find and understand the deviation before the risk occurs. Data mining is an ideal method for analysing data sources and extracting useful information. We can establish a supply chain risk early warning framework (Li et al., 2010). They can improve financial performance and strengthen trust between suppliers. The effectiveness of the risk of information sharing is determined by the trust of the suppliers and the relationship length. The effectiveness of the risk sharing mechanism is determined by the information sharing among supply chain risk management (Li et al., 2015). The cultural diffusion of the supply chain management and the support of the management team have a positive impact. Risk sharing mechanism has a positive impact on business performance (Fan et al., 2017). Some scholars put forward a food safety early warning system.

The origin of PSO algorithm is an additional intelligent optimization algorithm (Pandit et al., 2015) that came from human intelligence and swarm intelligence. PSO is a new evolutionary computation method for simulating foraging behaviour of birds (Binyamin et al., 2017). The new particle swarm algorithm has aroused worldwide scholars' attention. The universities focus on the algorithm. After that, the algorithm is widely used in subsequent studies (Liu and Liu, 2017).

ANN is one of the most active frontier research fields in the world (Garima et al., 2017). Different neural networks are formed in artificial neural networks from the different artificial neural network models. The BP neural network is mainly divided into two steps (Esther et al., 2016). The first is to train the network and the

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learning process. Then, we use it to solve the solution problem. The second is to the network test process. The basic principle of BP network is to use the gradient descent algorithm to minimize the error function.
At present, there is little research on the risk early warning of the chemical supply chain. In this paper, we analyse the importance of constructing the risk early-warning system and propose an improved PSO algorithm. In the experimental part, we set up the indicator and verify it. The structure of this paper is as follows. The first part introduces the research background. The second part researches the risk early warning of chemical supply chain and analyses the importance of constructing the risk early warning system of chemical supply chain. The third part introduces the improved PSO algorithm. The fourth part is the experiment and the fifth part is the conclusion.

2. Section headings risk early warning of chemical supply chain

Chemical supply chain is a network system structure with the core business for the two-way chemical root node. It includes manufacturers, retailers, consumers and so on. In addition, it also provides transportation, warehousing, handling, packaging and other services for the users of chemicals.
Chemical supply chain is a complex and huge developing system. The complexity and uncertainty of the chemical supply chain system will bring the great obstacles. The risk early warning refers that the chemical risk that may occur in the process of supply chain operation. It is through risk identification organized and planned and takes measures to prevent and control risks of the process.
The uncertainty and complexity of the chemical supply chain determine that the supply chain risk of chemical will be transformed into the supply chain crisis under the certain conditions. Therefore, we must strengthen the control ability. We should avoid chemical supply chain crisis and control the risk value of elements in the range of critical. It can prevent the supply chain crisis of chemicals. Therefore, it is particularly important to establish the chemical supply chain risk early warning system.

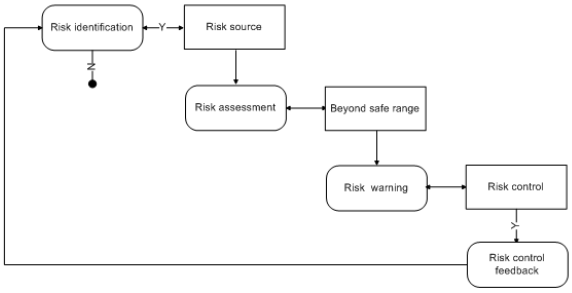

Figure 1: Supply chain risk early warning steps

The importance of the constructing the risk early-warning system of chemical supply chain is mainly manifested in the following aspects.
(1). The stability is the first condition of the efficient operation of the chemical supply chain. Whether the chemical industry can develop steadily or not also depends on the stability. The risk early warning system is the necessary measure to prevent the crisis effectively. Due to the particularity of chemicals, once the chemical supply chain crisis occurs, it will bring serious consequences. Chemical supply chain early warning system can control the risk to avoid the supply chain crisis.
(2). Risk early warning of chemical supply chain is a kind of active supply chain risk management. It means the identifies, analyses and assesses the all kinds of the risks in the operation actively. It also takes effective measures to prevent and control the risk. The early warning mechanism can provide targeted opinions on various decisions in the chemical industry chain.
(3). The system can reduce the probability of chemical accidents. Chemicals are flammable and explosive. Chemical accidents often bring huge losses to people's lives and property safety. It also causes irreversible damage to the surrounding environment. Once the chemical supply chain crisis occurs, it will greatly increase the probability of chemical accidents. The system can detect problems in advance and reduce the probability of chemical accidents timely.

3. Improved PSO algorithm

In order to better study the risk early warning of hazardous chemicals supply chain, we propose a new algorithm. We first use PSO to optimize the weights and thresholds of BP network, then use particle swarm

optimization algorithm to achieve the update of learning weights and threshold of BP network and get an optimal weight and threshold.

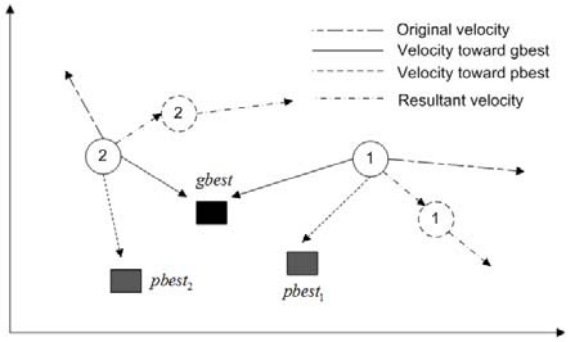

Figure 2: Basic schematic diagram of PSO

In *n* dimensional space, there are *m* particles to compose of the particle swarm $X=(x_1, x_2,\ldots, x_m)$ (Rico Merkert, Basil O 'Fee (2016)).The position after evolution for the *i* particle is

$$x_i = (x_{i1}, x_{i2}, \cdots, x_{im})^T \tag{1}$$

The velocity of particles is

$$V_i = (v_{i1}, v_{i2}, \cdots, v_{im})^T \tag{2}$$

In the search for generations, the optimal solution of each particle, that is, the individual optimal solution is expressed as

$$p_i = (p_{i1}, p_{i2}, \cdots, p_{im})^T \tag{3}$$

The optimal solution of the whole population is

$$p_g = (p_{g1}, p_{g2}, \cdots, p_{gm})^T \tag{4}$$

The updated velocity and position formulas for each particle are as follows.

$$v_{ik}(t+1) = w(t)v_{ik}(t) + c_1 r_1(p_{ik} - x_{ik}(t)) + c_2 r_2(p_{gk} - x_{ik}(t)) \tag{5}$$

$$x_{ik}(t+1) = x_{ik}(t) + v_{ik}(t+1) \tag{6}$$

Where, c_1 and c_2 are acceleration constants. r_1 and r_2 are the random number in [0,1]. The value of *i* is [1, *m*]. *m* is number size of population. The update of speed and location is one generation update. When the speed *V* of the particle exceeds the upper limit speed, the particle velocity is resetting. Similarly, the lower limit velocity can be set. When the particle velocity is lower than this velocity, the particle velocity will be reset.
The inertia weight *w* is to maintaining the motion inertia of particles in particle swarm. This inertia also allows the particles to have a wider range of search capabilities. The inertia weight *w* is beneficial to the search of particles. With the evolution process, the smaller the weight is, the better the optimization is. Therefore, the linear change inertia weight is adopted. The updating formula of inertia weight *w* is as follows.

$$w(t) = w_{\max} - t \cdot \frac{w_{\max} - w_{\min}}{T_{\max}} \tag{7}$$

In the formula, w_{max} refers to the maximum rate of particles in a particle swarm. The minimum rate of particles is w_{min}. T_{max} is the maximum evolutionary algebra of the particle swarm optimization algorithm.
The normal PSO optimizing BP network method is using the effect of particle swarm optimization. However, it does not take advantage of multilayer feedforward reverse propagation characteristics of the BP network. In this paper, we improve this problem and propose the improved PSO algorithm.
The formula for the position change of particles in a particle swarm is as follows.

$$x_{ik}(t+1)=\begin{cases}x_{ik}(t)+v_{ik}(t+1)+\eta H_j, k\in(0,I_1]\\ x_{ik}(t)+v_{ik}(t+1)+\eta Z_i, k\in(I_1,I_2]\\ x_{ik}(t)+v_{ik}(t+1)+H_j\delta, k\in(I_2,I_3]\\ x_{ik}(t)+v_{ik}(t+1)+Z_i\sigma, k\in(I_3,I_4]\end{cases} \tag{8}$$

According to the feedback network of the k particle, we change the positions of different particles. Among them, $I_1=l$, $I_2=I_1+l\cdot m$, $I_3=I_2+n$, and $I_4=I_3+l\cdot m$. n is the node number of the input layer, l is that of the hidden layer and m is the one of the output layer. η is learning rate of BP neural network. H_j is output quantity of hidden layer nodes. z_i is input quantity of the input layer node.. σ is the error signal between the input layer and the hidden layer node and δ is the one between the hidden layer and the output layer

The individual extreme value updating formula of particles is,

$$p_{ik}(t+1)=\begin{cases}x_{ik}(t+1), f(x_{ik}(t+1))\le f(p_{ik})\\ p_{ik}(t), f(x_{ik}(t+1))> f(p_{ik})\end{cases} \tag{9}$$

Where,

$$f=\frac{1}{n}\sum_{i=1}^{n}(O_i-T_i)^2 \tag{10}$$

Specific steps are shown in the following picture

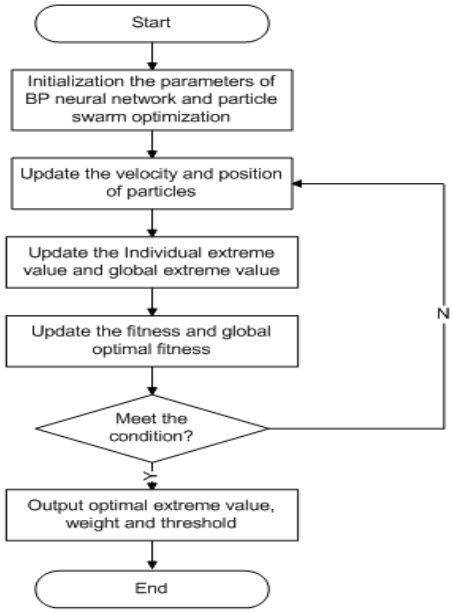

Figure 3: Supply chain risk early warning steps

The judgment condition is the number of evolutionary times being greater than the maximum number of evolutionary times or the output result being less than the predetermined precision.

4. Experiment

In order to research the risk early warning of the chemical supply chain, we need establish the evaluation index firstly. The following principles should be followed in the selection of the early warning indicators for chemical supply chain.

(1). Sensitivity principle. Chemical risk early warning indicator system can reflect all kinds of risks while reflecting the real situation of supply chain risk accurately and sensitively.

(2). Flexibility principle. The chemical risk early warning indicator system has certain flexibility which reflecting the most essential and important condition of the chemical supply chain.

3. Comprehensive principle. There are many factors that affect the chemical supply chain. Therefore, chemical risk early warning indicator system can not only reflect the chemical supply chain risk chemicals objectively and comprehensively, but also reveal the inherent relationship among the risk of chemical supply chain. At the same time, it can reduce the overlap area of each indicator and the correlation of each indicator.
(4). Combination of qualitative and quantitative indicators. The combination of qualitative and quantitative indicators is very important and it can comprehensively reflect the current situation and trend of supply chain operation.
The indicators are as follows.

Table 1: Indicators of risk early warning of the chemical supply chain

First level index	Second level index	Third level index
Risk early warning of the chemical supply chain	Internal risk	Information risk
		Demand risk of chemicals
		Chemical quality risk
		Chemical industry risk
		Risk of chemical manufacturers
		Risk of chemical suppliers
		Chemical dealer risk
	External risk	Natural environmental risk
		Social environmental risk
		Economic environmental risk
		War risk
		Policy and law risk
		Market environment risk
	System risk	Chemical supply chain collaboration risk
		Structure risk of chemical supply chain
	Operational risk	Financial risk
		Human risk
		Chemical production risk
		Chemicals inventory risk
		Chemical transportation risk
		Chemicals storage risk
		Information risk
		Demand risk of chemicals

After that, we analyze the data of the chemical supply chain and obtain the risk quantification value of the supply chain. The first 20 sets of data are used as training sets and the latter 5 sets of data are used as test sets. We will arrange the risk indicator value in a specific order as input vector and the risk value after quantification of chemical supply chain as output. Then, we obtain the result as follows.

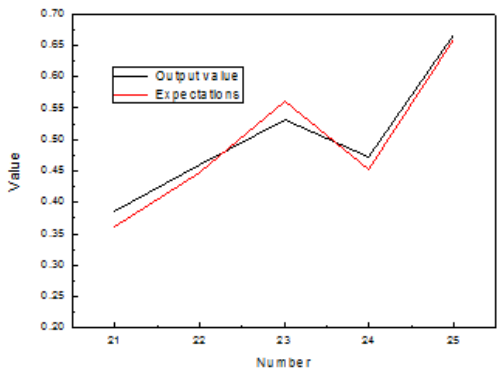

Figure 4: The result of the output value and the expectations

It can be seen from figure 3 that the prediction accuracy of supply chain risk is more than 90% by using the improved PSO algorithm. The system has reached the stability and the system error can meet the requirements of practical application.

5. Conclusion

The significance of chemistry is to enable people to understand the world more thoroughly. For our lives, chemistry has brought us many new materials that meet our needs and give us a lot of variables. However, hazardous chemicals have a variety of unsafe factors, which bring huge security risks to our lives.

The particularity of chemicals has the high requirement for chemical supply chain. The fast and effective chemical supply chain can reduce the possibility of chemical accidents and increase the profits of chemical enterprises. Risk early warning can detect risks in advance, avoid possible problems and improve the safety level of chemical supply chain. This paper mainly makes the following work. Firstly, this paper introduces the research background. Secondly, this paper analyzes the importance of risk early warning for the chemical supply chain. Thirdly, this paper proposes an improved PSO algorithm. In the experimental part, we put forward the early warning indicator of chemical supply chain risk and verify the validity and accuracy of the model and indicator proposed in this paper.

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