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Uncertain Environment of Enterprise Alliance in Supply Chain Network Optimization

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Abstract

According to the actual situation of the enterprise alliance of supply chain networks and considering the complexity of the various links in the supply chain of uncertain factors, it should be take a solution on decomposition strategy - coordination of the supply chain system optimization and focus on the supply cost analysis facility decision on supplier selection and cost, the two a problem of coordination through the integration of activity-based costing. Then establish the supply chain network design of robust model. Finally, using stochastic simulation method and the particle swarm algorithm based on hybrid intelligent algorithm for solving the robust optimal solutions of the model, and an example is used to demonstrate the feasibility and effectiveness of the model and algorithm.

Keywords*: supply chain, uncertainty, robust Model, the hybrid intelligent algorithm*

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1. Introduction

With the rapid development of social economy, the market competition has evolved into the competition of supply chain network business alliance, supply chain network optimization requires every enterprise alliance provides services through Internet, coordination and cooperation [1], so as to improve the supply chain network profits and performance. This process is in an uncertain environment, the uncertain environment means that according to the actual situation in the market, in every link of the strategic alliance of supply chain will appear all kinds of uncertain factors, including customer demand randomness, fuzziness, operating costs of production capacity uncertainty etc. In order to increase the flexibility and responsiveness of the whole supply chain system, thereby reducing the supply uncertainty risk, need such a collaborative optimization management can use management technology, information technology, process control technology, to be able to hand the suppliers, manufacturers, retailers, transport enterprises to solve the internal and external logistics problems with lower cost, the node enterprises coordinated response to customer demand; on the other hand, the integration of the resources better, enhance mutual trust and cooperation between the supply chain enterprises [2].

So how to decide construct its supply chain? How can maintain the cost saving, and can keep the stability conditions determine the supply chain structure mainly includes the supplier selection problem, detailed analysis? How to optimize the management of the supply chain network? This article will elaborate the modeling method, the mathematical model of the problem in the building process and the solving strategy, model algorithm design steps, and carries on the empirical analysis using randomly generated data.

2. The Idea of Scheme Modeling

A supply chain network can be divided into four types: one is the supplier, is responsible for the provision of raw materials to the factory; the two is the factory, will be responsible for the production of raw materials into products; three is the distribution center, responsible for the product sales to customers; four is the customer [3]. Supply chain network can be abstracted as a directed graph composed of nodes and arcs, and the four types of composition of the node of the supply chain. The research object of this paper is composed of multilayer Netlike Supply

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Chain System multiple suppliers, factories, multiple distribution centers and multiple customers, the system flow chart is shown in Figure 1.

Figure 1 flow chart of the system of supply chain

Due to the complexity of the system, the decomposition strategy to solve a coordination of the supply chain system optimization. The first step is the decomposition, the system is decomposed into local optimization of several lower order subsystems, here mainly for the objective function (supply chain cost function minimum) decomposition; the second step for the system coordination, in accordance with the overall goal of the system, based on the subsystem of bureau of fine after the decomposition, the total target function minimization, achieve the satisfactory solution, so as to realize the global optimization system. Specifically, the following modeling method:

First, on the issue of system analysis, establish supplier selection model (minimum purchase cost formula) and facility decision model (minimum value formula facility decision cost);

Second, to minimize the average total cost as the goal of system integration supplier selection decision and facilities (the purchase cost and facility decision cost formula of superposition, and put forward the corresponding constraints in reality), establish the optimization model of supply chain network design of robust integration;

Third, solving the model algorithm, a hybrid intelligent algorithm with stochastic simulation and particle swarm algorithm combining model;

The performance of fourth, test algorithm, using an empirical analysis of random data.

3. Uncertainty of Environment Model

For the sake of convenience, the definition of symbols and the parameters of the model, set up a total of three kinds of variables were normal variables, assignment and control variables, specific as shown in Table 1, 2, 3 show:

Table 1. Model Symbols and Parameters of Conventional Variable

The conventional variable				
Name	Symbol	Name	Symbol	Illustration
Suppliers set	A	Supplier number	a	a∈A, a is a natural number
Factory set	B	Factory number	b	b∈B, b is a natural number
Distribution center set	C	Distribution center number	c	c∈C, c is a natural number
The customer set	D	Customer number	d	d∈D, d is a natural number
Raw material collection	E	Raw material number	e	e∈E, e is a natural number
The set of products	F	Product number	f	f∈F, f is a natural number
Possible scenarios set	S	Scene number	s	s∈S

Table 2. Model and Parameter Assignment Symbol Variable

Assigned variable		
Sense	Symbol	Remarks
Whether to choose supplier A supply of raw material E	X_{ae}	Is the assignment of 1, not the assignment0
Whether the establishment of plant B	Y_b	Is the assignment of 1, not the assignment0
Whether to establish a distribution center C	Z_c	Is the assignment of 1, not the assignment0
Distribution center on customer D whether the supply of products to C	K_{cd}	Is the assignment of 1, not the assignment0
Factory production capacity of B	M_b	Maximum capacity
Distribution center C capacity	N_c	Maximum capacity

Table 3. Model Symbols and Parameters in the Control Variables

controlled variable Sense	Symbol
Under the s scenario factory B from supplier a purchase quantity of raw material e	G_{abe}^{s}
Under the s scenario distribution center C from a number of plant B transport F products	Q_{bcf}^{s}
Under the S scenario from the distribution center C to the number of products F to customers D	R_{cdf}^{s}

3.1. Supplier Selection Model

For supplier selection cost is mainly reflected in the purchase cost, including prices and transport costs, for the model definition cost parameters as shown in Table 4:

Table 4. The Supplier Cost Parameter Selection Model Definition

Supplier selection model cost parameter definition Sense	Symbol
Under the s scenario from supplier raw materials A purchase price of E	α_{ae}^{s}
Under the s scenario from the supplier to the factory a B buy raw material e unit transportation cost	β_{abe}^{s}
Supplier A supply capacity of raw materials of E	δ_{ae}
Ratio of the raw material E and F products	λ_{ef}

S ∈ S, means that the purchase cost, prices and transport costs for the product unit price and quantity of the respective, therefore the formula of 1 in real life, consideration must be given to the corresponding constraints: one is the supplier's supply capacity, two is the purchase quantity of raw materials must meet the need of production [4]. Therefore, under the s scenario factory B from supplier a purchase quantity of raw material E and whether to choose supplier a supply of raw materials, raw materials and products of e e ratio, f s scenario distribution center C from a constraint formula between plant B transport product F number: (1)

3.2. The Decision of Supply Chain Establishment Model

For the decision of supply chain establishment cost is mainly reflected in four parts, followed by facility operation fixed cost, infrastructure cost, business processing facilities between transportation cost, facility the ability to purchase cost, followed by.

For the model definition cost parameters as shown in Table 5:

Table 5. The Decision of Supply Chain Establishment Model Cost Parameter Definition

Decision of supply chain establishment model cost parameter definition Sense	Symbol
Under the S scenario factory fixed operating costs B	ν_{b}^{s}
Under the S scenario distribution center C fixed cost	ε_{c}^{s}
Under the S scenario production plant B F product unit cost	κ_{bf}^{s}
Under the S scenario distribution center C F of the product unit cost	μ_{cf}^{s}
Under the S scenario from the factory B products f transportation to distribution center C unit transportation cost	σ_{bcf}^{s}
Under the S scenario the f product from a distribution center C transport to the customer D unit transportation cost	ϖ_{cdf}^{s}
Under the S scenario factory unit capacity of B of the purchase cost	Γ_{b}^{s}
Under the S scenario distribution center C unit capacity cost	Ψ_{c}^{s}

$\forall$ S $\in$ S, facilities operation fixed cost for the plant and distribution center B C fixed operating costs and that is:

$$P_2 = \sum_b \nu_b^s \mathrm{Y}_b + \sum_c \varepsilon_c^s \mathrm{Z}_c$$

$\forall$ S $\in$ S, facilities for business processing cost for the factory production cost of B and distribution center C operation cost, i.e.

$$P_3 = \sum_b \sum_f \sum_c \kappa_{bf}^s Q_{bcf}^s + \sum_c \sum_f \sum_d \mu_{cf}^s R_{cdf}^s$$

$\forall$ S $\in$ S, cost of transportation facilities for plant B to distribution center C unit transportation cost and distribution center C to the customer D transportation cost, i.e.

$$P_4 = \sum_b \sum_f \sum_c \sigma_{bcf}^s Q_{bcf}^s + \sum_c \sum_f \sum_d \varpi_{cdf}^s R_{cdf}^s$$

$\forall$ S $\in$ S, capacity purchase cost purchase cost and distribution center C unit capacity cost and the factory B unit capacity, i.e:

$$P_5 = \sum_b \Gamma_b^s \mathrm{M}_b + \sum_c \Psi_c^s \mathrm{N}_c$$

Empathy for the formula 2-5 in reality should consider the corresponding constraints: one is the distribution center of the purchase amount not less than shipments, i.e:

$$\sum_b Q_{bcf}^s \geq \sum_d R_{cdf}^s$$

Two is the total output is not the factory more than its production capacity, i.e:

$$\sum_b Q_{bcf}^s \leq \mathrm{M}_b$$

Three is the purchase amount distribution centers and shipments and cannot exceed the throughput capacity, That is:

$$\sum_b \sum_f Q_{bcf}^s + \sum_c \sum_f R_{cdf}^s \leq \mathrm{N}_c$$

3.3. Design Model of Integrated Supply Chain Network

S $\in$ S, the integrated model of cost for the supplier selection model of cost and facility decision sub model cost (P_2、P_3、P_4、P_5), that is: $P_s = P_1 + P_2 + P_3 + P_4 + P_5$

$$P_s = \sum_a \sum_b \sum_e (\alpha_{ae}^s + \beta_{abe}^s)\mathrm{G}_{abe}^s + \sum_b \nu_b^s \mathrm{Y}_b + \sum_c \varepsilon_c^s \mathrm{Z}_c + \sum_b \sum_f \sum_c \kappa_{bf}^s Q_{bcf}^s + \sum_c \sum_f \sum_d \mu_{cf}^s R_{cdf}^s$$
$$+ \sum_b \sum_f \sum_c \sigma_{bcf}^s Q_{bcf}^s + \sum_c \sum_f \sum_d \varpi_{cdf}^s R_{cdf}^s + \sum_b \Gamma_b^s \mathrm{M}_b + \sum_c \Psi_c^s \mathrm{N}_c$$

The premise of all formulas above are in a s scenario, are now returning to the environment in the S collection, because the probability of each scenario is different, so the introduction of probability as s scenario, to establish a robust supply chain model integration ROM: Min P=four conditions above the same constraint equation 6.

4. Model Calculation

Because of the complexity of uncertainty planning, in order to reduce the solving difficulty, the application of simulation technology to calculate the fuzzy objective function and constraint checking randomly, and the simulation technology and particle swarm optimization

algorithm (PSO algorithm) are combined to form a hybrid intelligent algorithm to solve the robust model value [5]. The so-called particle swarm algorithm is by simulating the natural biological group behavior, here refers to the bird cluster line foraging behavior to achieve a method of artificial intelligence, namely through the birds between the collective cooperation to achieve optimal objective group. The PSO algorithm is to initialize these random particle (single bird individual), according to the speed and position of iterative screening, constantly updated individual optimal value, through a combination of all the optimal stochastic particle solution to determine the overall optimal solution, the algorithm process specifically as follows [6].

Step 1: particle initialization. The M parameter distribution random number as the initial solution using stochastic simulation technique, the initial solution is the initial speed of PSO algorithm. At the same time, check whether the number of open factories or distribution centers than a given number and make the corresponding choice and close the deal, make sure it is in the feasible region, which determines the choice of plant and distribution center, supply chain network structure can be defined.

Step 2: speed and position distribution. In the T iteration of particle I locations are represented as = (, lit,), flight speed expressed as = (, lit,); The particle I update their speed and position is in accordance with the following rules: first, the particle I in the (t+1) iteration of the speed of =w+ (-) + (-). Where W is the inertia weight,, two learning factor, (0,1), is a random number between, for individual extreme, as the global extremum. Second, the particle I in the (t+1) position to make the iteration of the [6]. Third, when the number of iterations is less than a specified number of iterations, continuous cycle of continued.

Step 3: update individual extremum, namely the optimal particle itself through solution. Fit 2 new calculation of each particle position according to the step value, if the fitness value is better than the individual extremum, then set the current fitness values for individual extremum.

Step 4: to determine the global extremum, which is the best of the whole population is currently experiencing a solution. The global extremum is determined according to the individual extremum in step 3 of each particle in the latest.

Step 5: step by step velocity and position updating of I 2 particles, number of cycles until given, searching for the optimal position in solution space.

Step 6: returns to update particle positions and the number of the best speed, so as to determine the optimal value of the objective function.

5. The Example Analysis

An important advantage of hybrid intelligent algorithm based on particle swarm algorithm was coded as real, compared with the genetic, immune optimization algorithm is simple, easy to achieve, so show its good application prospect in optimization problems.

A simple example is analyzed to illustrate with this: suppose a supply chain network, comprising 3 suppliers to be selected (A1, A2, A3), 3 plants to be selected (B1, B2, B3), 3 distribution centers to be selected (C1, C2, C3), meet the 4 customer needs (D1, D2, D3, D4). The false with 3 kinds of raw materials, the production of 1 products, 3 known species of raw materials according to the proportion of 1:1:1 products. The customer to the product demand is a random variable, the probability distribution in the [160,20], [200,10], [220,20], uniform distribution of [260,20] interval [7]. All the costs (raw materials prices, transportation costs, distribution center operation cost, the ability to purchase to production cost, the cost of operation) but also follow normal distribution, respectively in [10,5], [5,2], [10,5], [20,10], uniform distribution of [5,2] interval. The 4 kind of demands and 1 kinds of cost cross combination appear 4 different scenarios, assuming that each scenario probability is 25%, various scenarios of plant and distribution center of the fixed operating costs were 10000 and 8000 [8]. Calculation of robust model in accordance with the hybrid intelligent algorithm that given above, set the size of the particle swarm N is 50, the algebraic operation is 200, the fuzzy simulation for the number 3000, the design of robust hybrid intelligent algorithm that runs on a computer 4 scenarios of the supply chain network solution is 1, the maximum possibility is 0.85, therefore the supplier of choice for A1, A2, A3, choose to open factories for B2, B3, choose to open distribution centers for C1, c2.

6. Conclusion

There is a cost and customer demand of supply chain network of uncertainty enterprise alliance, this paper not only considers the randomness of customer needs, but also consider the fuzziness and production capacity of operating costs of uncertainty, the uncertainty planning, integration of suppliers selection and facilities decision problem, a robust optimization model for supply chain network design, and stochastic simulation and particle swarm algorithm combining, presents a hybrid intelligent algorithm to solve the model. Finally, practical examples of life to illustrate, shows that the model and the algorithm is feasible and effective, can effectively reduce the enterprise strategic alliance market risk, improve coordination and optimization of enterprise alliance in the supply chain network.

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