Optimal Model of Agile Supply Chain Based on Fuzzy AHP and Genetic Algorithm

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Abstract: The partner optimal selection for agile supply chain is a traditional and typical problem. AHP is an optimum method for multi-objective decision, but, AHP can't resolve the fuzzy attribute problem, however, combining triangular fuzzy number; the Fuzzy AHP can resolve the fuzzy problem. Genetic algorithm is a method for combinatorial optimization problem. A partner selecting model based on fuzzy AHP and genetic algorithm for agile supply chain is presented. In order to confirm the availability and feasibility of the model, a prototype system is developed based on Microsoft .NET platform. Moreover, the running interface is shown.

Keywords: fuzzy AHP; optimization problem; genetic algorithm; agile supply chain

1 Introduction

With globalization of the economy and consumer personalization, product life cycles continue to be shorten. Market competition has surpassed individual enterprises, and increases the supply chain competition. Supply chain is a network and chain structure system connecting suppliers, manufacturers, distributors, retailers and users. Supply chain system and the market which is the supply chain's environment are opening, complex and nonlinear dynamic system, and they constantly exchange the information flow, logistics and funds flow so that they are interdependent and mutually constraints.

Therefore, in order to adapt to the market, the supply chain must be perpetual in the dynamic structure away from balancing. The senior management of supply chain must continually adjust its operational objectives and organizational structure to better adapt to the changes in the market environment, and to shorten the gap with the market reaction.

For modern enterprises, agility is the most crucial. Agility can produce the product with shortest delivery time, the greatest profit for enterprises, and the highest quality for the most satisfactory service for customers. The agile supply chain includes several links, and in every link, there are many partners, how to select the most suitable partners to form the optimal supply chain? In general, there are several points worthy of further research. Firstly, how to choose any number of partners in every link in the agile supply chain but not omitting any possible combination is difficult. Secondly, how to decide the weight of every evaluation criterion scientifically is very complex. In this paper, a model based on fuzzy AHP and genetic algorithm for agile supply chains is proposed.

2 Model Based on Fuzzy AHP and Genetic Algorithm for Agile Supply Chain

Generally, the agile supply chain is divided into five kinds of link; there are procurement, design, produce, sale and service. Given there are many partners in every link. The ultimate goal of the agile supply chains is focus on C(C-Cost);T(T-Time to market); Q(Q-Quality); S (S-Service), namely, producing the product with shortest delivery time to the market; spending the smallest cost for enterprises; providing the product with highest quality; providing most satisfactory service for customers.

After initial screening, given there are still three partners for design, two partners for procurement three partners for produce, two partners for sale and two partners for service. Of course, in reality, the quantity level of the partners should be much higher than this level. In this paper, in order to introduce the model clearly, let the quantity level low, but the model is valid to large-scale number for real system.

3 Model Construction

How to construct reasonable fitness function is a key problem in genetic algorithm. In the agile supply chain, the ultimate goal is CTQS, so, the fitness function needs focusing on the same goal.

Given T_{ik} mean the time that the kth partner in ith link of the agile supply chain.

Given C_{ik} mean the cost that the kth partner in ith link of the agile supply chain.

Given Q_{ik} mean the quality value that the kth partner in ith link.

Given S_{ik} mean the service value that the kth partner in ith link.

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Given $CONT_{ikjl}$ mean the connection time between the kth partner in the ith link and the lth partner in jth link.

Given $CONC_{ikjl}$ mean the connection cost between the kth partner in the ith link and the lth partner in jth link. Given δ (ik,jl)=1 ;if the kth partner in ith link and the lth partner in jth link take part in the agile supply chain at the same time, else, δ (ik,jl)=0.

Given β(ik)=1; if the kth partner in ith link is chosen to take part in the agile supply chain, else, β(ik)=0.
If the goal is letting the cost minimum, then

$$\min C=\sum\beta(ik)C_{ik}+\sum\sum\delta(ik,jl)CONC_{ikjl} \qquad (1)$$

If the goal is letting the time minimum, then, get the definition:

$$\min T=\sum\beta(ik)T_{ik}+\sum\sum\delta(ik,jl)CONT_{ikjl} \qquad (2)$$

In the reality, in every link of the agile supply chain, it is necessary that one partner is chosen to take part in the agile supply chain at least.

$$\text{Namely: }\forall\ (i)\ \sum_{k=1}^{n}\beta(ik)>0 \quad i=1\ldots\ldots5 \qquad (3)$$

If the goal is letting the quality maximum, then, get the definition:

$$MAX_Q=\sum\beta(ik)Q_{ik} \qquad (4)$$

If the goal is letting the service maximum, then, get the definition:

$$MAX_S=\sum\beta(ik)S_{ik} \qquad (5)$$

Finally, the goal is letting Time, Cost, Quality and Service all be ideal values, so definite the fitness function for:

$$f'(t)=\ \omega_T*(1/T(t))+\omega_C*(1/C(t))+\omega_Q*Q(t)+\omega_S*S(t) \qquad (6)$$

't' is the individual code of the genetic algorithm. $\omega_T,\omega_C,\omega_Q,\omega_S$ is the weigh value of Time, Cost, Quality and Service parameters respectively.

5 Fuzzy AHP

How to decide the values of the $\omega_T,\omega_C,\omega_Q,\omega_S$ is a difficult problem. AHP (Analytic Hierarchy Process) is a feasible method to resolve the problem. The basic principle of AHP is comparing the importance each other, then get the finally value of every approaches. But, sometimes, while comparing, the value can't be descript by a concrete value. So, combining triangular fuzzy number, Fuzzy AHP is adopted to resolve the different weight values of $\omega_T,\omega_C,\omega_Q,\omega_S$.

Definition 1[4]:

If M=(l,m,u)、M1=(l_1,m1,u1)and M2=(l_2,m2,u2) are all triangular fuzzy numbers, then:

M1⊕M2=(l_1,m1,u1)⊕(l_2,m2,u2)=(l_1+l_2,m1+m2,u1+u2) (1-1)

M1⊗M2=(l_1,m1,u1)⊗(l_2,m2,u2)=(l_1 l_2, m1m2, u1u2) (1-2)

∀ (λ)∈R，λM=λ(l,m,u)=(λl,λm,λu) (1-3)

$$\frac{1}{M}=(\frac{1}{u},\frac{1}{m},\frac{1}{l}) \qquad (1\text{-}4)$$

Let M1≥M2 :V(M1≥M2)，then，the necessary and sufficient condition of V(M1≥M2)=1 is m1≥m2，if m1≤m2 ： V(M1≥M2)= $\frac{l_2-u_1}{(m_1-u_1)-(m_2-l_2)}$ = $\frac{u_1-l_2}{(u_1-l_2)+(m_2-m_1)}$ （if l_2 ≤u1）； V(M1≥M2)=0 （if l_2 ≥u1） (1-5)

Let the value of M is larger than k triangular fuzzy numbers: Mi(i=1,2,3…,k) be V(M≥M1,M2,…,Mk), then: V(M≥M1,M2,…,Mk)=minV(M≥Mi)(i=1,2,3…,k) (1-6)

Let M_{Ei}^{j} (j=1,2,…,m) is the values of the jth approch to m goals,the value of the"General weight"is ：

$$s_i=\sum_{j=1}^{m}M_{Ei}^{j}\bullet w_i^j\otimes\left[\sum_{i=1}^{n}\sum_{j=1}^{m}M_{Ei}^{j}w_i^j\right]^{-1}$$

i=1,2,…,n； w is the weight value，

$$\forall(\lambda),\sum_{j=1}^{m}w_i^j=1. \qquad (1\text{-}7)$$

The value of the approach: X_i is prior to the other approaches is：d(x_i)=minV($s_i\geq s_j$)j=1,2,…,n； while j≠i, and provided：V($s_i\geq s_i$)=1 (1-8)

Fractal theory is created by the French mathematician Benoit B. Mandelbrot. His definition of "fractal" : A fractal is a shape made of part similar to the whole in some way, and the relatively independent parts of fractal overall is called fractal module or fractal unit. The self-similarity in fractal body can be identical, and it could be similar by the sense of statistics, that is, part and the whole body with the similarity of statistical significance in the form, function, information, time, space, and other aspects.

The similarity is scale invariance, that is, in the usual geometry transformation the fractal is invariance. Fractal dimension (D_f) is the dimension number of the fractal, and it metrics the ability of system filled space (compact) or crannies (osteoporosis), and characterizes the system disorder, at the same time, it characterizes the most basic unit or the number of independent variables in the dynamic system.

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6 Conclusion

The agile supply chain is very complex, in our model, we omitting a lot of complicated factors, such as: how to organize the agile supply chain, because it relates to the interests and the law. But, from the example, the model provides an effective and feasible method for partners-selecting optimally. The model has three advantages. Firstly, it can choose any number of partners in every link to take part in the agile supply chains and can't omit any possible combination. Secondly, it can decide the weight of every evaluation criterion of Cost, Time, Quality and Service scientifically. Thirdly, it is simple, realized easily by computer, and running fast. When the number of partners becomes larger, the advantages of this model become more apparent.

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