Application System Research on Incentive Management Mechanism of Logistics and Supply Chain in Regional Economy

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Abstract: Aiming at the problem that product recovery is not considered in supply chain model, which is unfavorable to cost control of supply chain of short life period products, the Gaussian Harmony Search (GHS) recycle supply chain model establishment and optimization algorithm based on recycle cost income is put forward. Firstly, supply chain is described according to five stages and model construction of product recycle process is considered. At the same time, the minimal cost optimization target of supply chain model that is established based on storage cost, shortage cost and transfer cost is utilized. Secondly, model optimization is implemented by introducing Harmony Search Algorithm, meanwhile self-adaption search is implemented by utilizing Gaussian traversal control parameters to improve effectiveness of Harmony Search and self-adaption of algorithm. Finally, sensitivity to parameter to GHS is analyzed by standard test function and model algorithm research has been implemented. The experiment result shows that proposed algorithm can obtain the lower supply chain transportation cost.

1. Introduction

In order to improve income cost, manufacturer will tend to recycle surplus value of products by remanufacturing process. Products will be transformed into well-liked new products during remanufacturing by refurbishment, maintenance and update, which can save considerable cost [1-2].

The research is implemented under two closed supply chain system frames and relevant demand product recycle problem is considered and inventory system development is implemented. The development model is constructed based on literature [9] and in proposed model, the quantity of decision is decided dynamically, which depends on quantity change of recycled products in remanufacturing process. Proposed models refer to four warehouses, while inventory level keeping of four warehouses refers to a series of cost factors, such as transportation cost and shortage cost, etc. Therefore, by taking inventory level of four warehouses as optimal input vector and by implementing model optimization by adopting Harmony Search Algorithm [10] and at the same time, to improve algorithm performance, self-adaption searching is implemented to Harmony Search step range by utilizing Gaussian traversal [11] control parameters to improve self-adaption ability of algorithm.

2. Model Stage Description

In actual supply chain system, supply chain not only manages inventory level, at the same time, but also provides raw material and new product production; however, recycled products can bring more benefit to members of supply chain. A two-stage supply chain system constituted by manufacturer and retailer has been developed, as shown in Fig. 1. Fig. 1 includes four kinds of warehouses, such as new product warehouse of retailer (warehouse 1), new product warehouse of manufacturer (warehouse 2), recycle warehouse of manufacturer (warehouse 3) and recycle warehouse of retailer (warehouse 4).



Fig. 1. Product development and recovery process

In this model, it is assumed that recovery rate of demand rate (sum) has characteristics of confirmation, fixation and evenness in the whole supply period. Products are returned to retailer warehouse by customer recycle (warehouse 4) and then recycled products are transferred to return warehouse of manufacturer (warehouse 3). In production, products produced by manufacturer have been transported to new product warehouse of retailer (warehouse 1) by new product inventory of manufacturer (warehouse 2) and are delivered to terminal customer finally.

In proposed two-stage supply chain system, detailed description can be implemented by five stages. In each stage, inventory level of warehouse is generally influenced by product circulation. See Fig. 2 for details:

Stage 1: starting point of period; stage 2: warehouse inventory has been delivered from warehouse 4 to warehouse 3 by time L2; stage 3: remanufacturing process ends; stage 4: new product production ends. When inventory of warehouse 2 is less than that of warehouse 1, the stage will be implemented; stage 5: at stage time end, products can be delivered to warehouse 1. Detailed information of all stages will be described in the follows.



Fig.2. Stages of recycling supply chain

3. GHS Supply Chain Optimization of Recovery Cost and Income

3.1 GHS algorithm design

In HS optimization, music elements are introduced, of which parameters involved mainly include: storage scale ($^{C}_{HMS}$), storage parameter ($^{C}_{HM}$), reference rate index ($^{C}_{HMCR}$), interval proportion adjustment parameter ($^{C}_{PAR}$) and width distance adjustment parameters ($^{C}_{bw}$), etc. Element creation process of Harmony Search Algorithm obtains vector individual update process by element creation: vectors existing in $^{C}_{HM}$ are obtained randomly and new vector individuals are obtained by utilizing $^{C}_{HMCR}$. Then, vector individual adjustment is implemented based on $^{C}_{PAR}$ and $^{C}_{bw}$, as shown in formula (30):

$$\begin{cases} x_{new,i} = x_{r,i} \pm c_{rand} \times c_{bw}, & \text{if } c_{rand} < c_{PAR} \\ x_{new,i} = x_{r,i}, & \text{if } c_{rand} \ge c_{PAR} \end{cases}$$
(1)

However, there is problem of not high differentiation degrees in adjacent periods in group evolution process during search process for fixed C_{bw} value adopted by standard HS search process.

Therefore, improvement parameter is to set variable step range C_{bw} parameter; besides, creation and improvement to elements are implemented by Gaussian traversal and self-adaption adjustment process of vector element individual is obtained based on PAR and parameter C_{bw} . Influence of parameter C_{bw} to HS search process is very large and too large value is unfavorable to HS depth search, but too small value C_{bw} is unfavorable to HS breadth-first search. Scientific change strategy is to select large and small parameter values in adjacent periods of HS search and to realize influenceive control of algorithm performance. Change strategy of control parameter α is:

(2)

$$\alpha = 1 - \lambda \times t_{current} / t_{max}$$

Creation and improvement to HS element are implemented based on Gaussian traversal and depth search to existing position is implemented by small step and breadth-first search to unknown position is implemented by utilizing large step and creation and improvement process by adopting Gaussian traversal g and control parameter α are as follows:

$$\begin{cases} x_{new,i} = x_{r,i} \pm g \times a \times c_{bw}, & \text{if } c_{rand} < c_{PAR} \\ x_{new,i} = x_{r,i}, & \text{if } c_{rand} \ge c_{PAR} \end{cases}$$
(3)

In formula (32), $g \sim \mathcal{N}(\mu, \sigma^2)$ influence of traversal variance distribution of Gaussian function *s* on HS is very large. See Fig. 5 for traversal distribution form.



Fig. 3. Gaussian traversal

3.2 Model optimization steps

Step 1: (initialization) inventory level of all warehouses is taken as optimal input vector $X = [x_1, x_2, x_3, x_4]$ and input vector data are stored in HM and its value interval is set. Then, harmony group with size HMS is obtained by formula (41), which is stored in HM. Initialization formula is:

$$x_{r,i} = x_{l,i} + c_{rand} \times (x_{u,i} - x_{l,i})$$
(4)

In formula (1), $x_{u,i}$ and $x_{l,i}$ are respectively upper and lower limits of the *i* variable value in vector individual

Step 2: (element creation) vector individual update process is obtained by element creation: vector in C_{HM} is obtained randomly and at the same time, new warehouse inventory level vector individual is obtained by utilizing C_{HMCR} . Then, vector individual adjustment is implemented based on C_{PAR} and C_{bw} , as shown in formula (31):

$$\begin{cases} x_{new,i} = x_{r,i} \pm c_{rand} \times c_{bw}, & \text{if } c_{rand} < c_{PAR} \\ x_{new,i} = x_{r,i}, & \text{if } c_{rand} \ge c_{PAR} \end{cases}$$
(5)

Step 3: (individual update) adaptive value calculation is implemented to element individual, which is compared with original individual and element individual with advantageous adaptive

value is kept to realize individual update to HM algorithm.

Step 4: (algorithm termination) If present optimal adaptive value individual meets termination setting, HS algorithm will be stopped and the optimal warehouse inventory level will be output, otherwise, it will return to step 2.

4. Conclusion

A kind of GHS recycle supply chain model establishment and optimization algorithm based on recycle cost income is proposed in this paper. The supply chain process is disintegrated to build model by utilizing five stages and considering product recycle process, to optimize model by introducing Harmony Search Algorithm. The experimental results show that algorithm proposed can obtain lower supply chain transportation cost.

Next, the following aspects shall be researched mainly: (1) object function design to reduce demand response time to the maximum; (2) model development problem considering warehouse space limit; (3) recycle recreation expansion considering different kinds of remanufacturing process models; (4) model expansion problem of multi-type product recycle.

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