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Abstract: At supply chain development model problem of small and micro tourist enterprise at big data era, supply chain design method of small and micro tourist enterprise based on dynamic guidance and multi-objective harmony search algorithm is put forward. Firstly, construct multi-objective optimization model of supply chain of small and micro tourist enterprise based on the objective of minimizing the total cost and maximizing satisfaction of logistics demand node enterprise; secondly, bring in harmony search algorithm, construct new fitness function on the basis of α dominance relation and realize performance improvement of optimization process; finally, display that the proposed method has relatively high optimization accuracy in supply chain design of small and micro tourist enterprise through simulative example with more reasonable design process and it is significant to improve competitiveness of small and micro tourist enterprise.

1. Introduction

Human society has been in a period when rapid expansion of data appears. Total data size generated globally in 2016 is the sum of data generated in the past 5000 years ending in 2010. Arrival of big data era highlights value of data day by day and makes it become important asset of enterprise, which changes natural mode of traditional enterprise and breaks original operation mode. As important constituent part of small and micro enterprise, small and micro tourist enterprise plays a decisive role in enlarging employment, improving people’s livelihood, promoting stability and driving effective development of regional economy. But double effect of free competition environment of market and information transparency intensifies product homogeneity and causes continuous cutthroat competition and frequent price war, which makes the entire commercial environment enter into low gross margin era. It is quite tough for small and micro enterprise surviving in the gap to develop, but arrival of “big data” era brings new horizon and new commercial opportunity to enterprise, and the whole world is shocked by energy of big data. Considering that data is generated newly, those who master data can perform transboundary overthrow. Tourist industry is different from traditional manufacturing industry, and particularity of its supply-demand relationship makes data play more important role in operation of the entire industry.

Supply chain model parameter is in time-varying condition because of change of economic environment. Deviation will appear if fixed parameter model is still considered. In this paper, multi-facility location problem of double supply chain of product from small and micro tourist enterprise is researched to lower the total cost maximally and improve customer satisfaction. Based on feature of product from small and micro tourist enterprise, traditional transportation cost and fixed facility location cost shall be considered, and treatment cost of waste and scrap and tracing cost shall be considered simultaneously. In addition, satisfaction attenuation function shall be established to express satisfaction of member in supply chain. Then fuzzy multi-objective two-phase method is applied to solve the model.
2. Description on product supply problem of small and micro tourist enterprise

Theoretically, product supply chain network of small and micro tourist enterprise is complex big system. Decision maker needs to consider different constraint and collision problems among production base, wholesaler and final user. In addition, he has to consider difference of plant equipment location and function. In this research, supply chain network \( G = (A, E) \) is defined, including double channels and four stages: production base, logistics center, distribution center and client. \( A \) represents network node and \( E \) is network connection edge. Full line represents supply process of traditional channel while dotted line represents supply process of e-commerce channel, which is as shown in Fig.1. To optimize supply chain, the first objective of this paper is supply network design and equipment location problem under uncertain economic environment. Fundamental assumption involved is:

1. Network planning problem of single agricultural product supply within period shall be considered.

2. In each layer, manual handling cost of product from small and micro tourist enterprise is set the same.

3. Demand on product from small and micro tourist enterprise at each node of supply chain shall be followed.

Multi-objective linear programming model of product probability of small and micro tourist enterprise is as follows:

Objective 1: (minimization of total cost) under general condition, transportation cost in supply chain is concerned with location and capacity limitation of multi-objective facility. Transportation cost can be lowered maximally through fixation of plant facility. However, in product supply process of small and micro tourist enterprise, a great deal of product loss exists, and therefore, labor costs for waste treatment are necessary. Supposed that customer demand is followed after total production quantity of product from small and micro tourist enterprise subtracting loss, loss treatment cost of product from small and micro tourist enterprise is:

\[
W_d = \tilde{w}_d \left( \sum_{i \in I} \alpha_{ij} x_{ij} + \sum_{(j,k) \in E} \alpha_{jk} y_{jk} + \sum_{(k,l) \in E} \alpha_{kl} z_{kl} \right)
\]

\[+ \sum_{(j,k) \in E} \alpha_{jk} x_{jk} + \sum_{(k,l) \in E} \alpha_{kl} z_{kl} \]

(1)

In the formula, \( \alpha_{ij} \) represents wastage rate from production base \( i \) to logistics center \( j \); \( \alpha_{jk} \) represents wastage rate from logistics center \( j \) to distribution center \( k \); \( \alpha_{k1} \) represents wastage rate from distribution center \( k \) to client \( l \); \( \alpha_{ij} \) represents wastage rate from production base \( i \) to distribution center \( k \); \( \alpha_{kl} \) represents wastage rate from logistics center \( j \) to client \( l \).

In addition, food safety problem is the main problem concerned by people. For client and relevant organization, information attribute, coverage planting location, producer, seed gene, production ledger and date and time of food shall embody modernized food supply chain
information sufficiently.

Tracing cost of product from small and micro tourist enterprise can be summarized as follows:

\[ W_i = \sum_{(i,j) \in E} (1 - \alpha_i) x_{ij} + \sum_{(j,k) \in E} (1 - \alpha_k) x_{jk} \]

(2)

In formula (2), the first term is tracing cost of logistics center and the second term is tracing cost of distribution center. On the basis of above analysis, the entire operation cost of product supply chain of small and micro tourist enterprise includes transportation cost between nodes, equipment location fixation cost, loading and unloading cost and system tracing cost. Because of rapid change of economic environment, relevant parameter for product supply chain design of small and micro tourist enterprise is not precise. Objective function for supply chain design under imprecise environment:

\[
\begin{align*}
\min Z_i &= (\sum_{(i,j) \in E} \hat{x}_{ij} x_{ij} + \sum_{(j,k) \in E} \hat{x}_{jk} y_{jk} + \sum_{(j,l) \in E} \hat{u}_{jl} z_{jl}) \\
&+ \sum_{(i,j) \in E} \hat{s}_{ij} x_{ij} + \sum_{(j,i) \in E} \hat{u}_{ji} y_{ji} + \sum_{i} \hat{f}_i v_i \\
&+ \sum_{j} \hat{g}_j f_j + \sum_{k} \hat{h}_k r_k + W_2 + W_1
\end{align*}
\]

(3)

Where, \( \hat{x}_{ij} \), \( \hat{y}_{ij} \), \( \hat{u}_{ij} \), \( \hat{u}_{ji} \), \( \hat{f}_j \), \( \hat{g}_j \) and \( \hat{h}_k \) are imprecise parameters under triangular distribution. 1~5 items in formula (3) represent transportation costs of each layer, 6~8 items represent fixed costs of production base, logistics center and distribution center to be chosen and 9~10 items represent traceable cost and waste treatment cost.

Objective 2: (satisfaction of logistics demand node enterprise) classical facility location problem can be described as follows: certain covering radius is owned by all equipment nodes. When each demand point is within covering radius, then system client will be covered completely. Scholars establish attenuation function model of facility service coverage on the basis of upper and lower limit range of facility service provided by the maximum coverage problem. Aimed at logistics demand response time at node of supply chain, customer satisfaction function based on service time is introduced:

\[
g_{ij}(t) = \begin{cases} 
    x_{ij}, & \text{if } t_y \leq t_j \text{ and } x_y > 0 \\
    x_{ij}(T_j - t_j), & \text{if } t_j < t_y \leq T_j \text{ and } x_y > 0 \\
    0, & \text{if } t_y > T_j \text{ or } x_y = 0
\end{cases}
\]

(4)

In the formula, \( t_y \) is the minimum response time required by demand node \( j \), \( T_j \) is the maximum response time required by demand node \( j \). \( t_y \) is the shortest logistics time from production equipment \( i \) to distribution demand point \( j \) and \( x_y \) is logistics demand quantity of demand point \( j \). When logistics distribution can be finished within the minimum required time (\( x_y > 0 \)), customer satisfaction can be set as \( x_y \). When logistics distribution cannot be finished within the maximum required time or when \( x_y = 0 \), customer satisfaction shall be set as 0. For those between the maximum and the minimum delivery time, satisfaction will decrease gradually with increase of delivery time, which is as shown in Fig.2.

![Fig.2. Customer satisfaction function](image-url)
Above method is also applicable to satisfaction function of quantized logistics demand point $k$ and $l$. Therefore, for all logistics demand points, objective function of the maximum satisfaction of product from small and micro tourist enterprise can be defined as:

$$
\text{max } Z_i = \left[ \sum_{(i,j) \in E} g_i(t_{ij}) + \sum_{(j,k) \in E} g_j(t_{jk}) + \sum_{(k,l) \in E} g_k(t_{kl}) + \sum_{(l,m) \in E} g_l(t_{lm}) \right]
$$

(5)

Model constraint is:

$$
\sum_{(l,j) \in E} x_q + \sum_{(j,i) \in E} x_{ji} + \gamma_i \sum_{j} a_i v_j \leq R_v \sum_{i} q_i
$$

(6)

$$
\sum_{(i,j) \in E} (1-\alpha_i) x_i \sum_{(j,m) \in E} y_i + \sum_{(j,m) \in E} z_i \leq \sum_{j} b_r f_j
$$

(7)

$$
\sum_{(i,j) \in E} y_i (1-\alpha_j) + \sum_{(j,m) \in E} x_a (1-\alpha_i) = \sum_{i} z_{ii}
$$

(8)

$$
\sum_{(j,m) \in E} z_{ij} \leq \sum_{a} c_{ij} q_i
$$

(9)

$$
\sum_{(j,m) \in E} z_{ij} (1-\alpha_j) + \sum_{(j,m) \in E} z_{ji} (1-\alpha_i) \leq \sum_{i} d_i
$$

(10)

$$
\sum_{j} v_j \leq V, \sum_{j} r_j \leq R, \sum_{i} g_i \leq P
$$

(11)

Where, $v_i, r_j, q_i \in [0,1]$ and $x_i, x_{ji}, y_{ij}, z_{ij}, z_{ji} \geq 0$. Above constraints (6~10) give capacity constraints of production base, logistics center and distribution center in double-channel supply chain. Constraint (11) gives the maximum number restriction on equipment location.

3. Dynamic Guidance and Multi-objective Harmony Search Algorithm

3.1 Harmony search

Some scholars put forward harmony optimization algorithm\(^{11}\) on the basis of composition features of music. Parameters set in the algorithm: function of storage (HM) is to store input data (vector), HMS represents size of HM, and HMCR is reference rate index, representing rate of referring to existing music clips, $\text{HMCR} \in [0,1]$. $\text{PAR}$ is spacing music note adjustment rate and $bw$ is width music note adjustment rate. Algorithm process is as follows:

Step 1: Optimization objective input shall be stored in HM firstly and input valuing interval shall be set. Generation form of input vector is:

$$
\chi^i = \chi^i + \text{rand} \times (\chi^u - \chi^l)
$$

(12)

In formula (12), $\chi^u$ is upper valuing limit of variable $i$ while $\chi^l$ is lower valuing limit of variable $i$.

Step 2: Firstly, judge whether existing individual in HM shall be chosen or brand-new individual shall be generated. If the former way is adopted, then adjustment shall be performed according to $\text{PAR}$ and $bw$ parameter setting.

$$
\begin{cases}
\hat{x}_{ij} = x_i + \text{rand} \times bw, \text{ if } \text{rand} < \text{PAR} \\
\hat{x}_{ij} = x_i, \text{ if } \text{rand} \geq \text{PAR}
\end{cases}
$$

(13)

Step 3: Calculate individual adaptive value. Choose adaptation individual on the basis of elite evolution method and realize HM renewal process.

Step 4: Test whether optimum adaptive value set is followed, and if it is followed, algorithm shall be terminated and output optimum value; otherwise return to Step2 for continuous evolution.
3.2 New fitness function on the basis of \( \alpha \) dominance relation

\[ k_1(x) = f(x), \quad k_2(x) = G(x). \]

For the convenience of expression, 2 optimization objectives are still in the form of: \( k_1(x) = f(x) \) and \( k_2(x) = G(x) \).

Definition 1: \((\alpha \text{ dominance})\) optimization objective (12) shall be rewritten, denoted as:

\[
\begin{aligned}
\Omega_1(k_1(x), k_2(x)) &= k_1(x) + \alpha_{12} k_2(x) \\
\Omega_2(k_1(x), k_2(x)) &= k_2(x) + \alpha_{21} k_1(x)
\end{aligned}
\]

In formula (14), \( \alpha_{12}, \alpha_{21} \geq 0 \). If following conditions are met:

\[
\begin{aligned}
\Omega_1(x_i) \leq \Omega_2(x_i) \land \Omega_2(x_i) < \Omega_1(x_i) \\
\Omega_1(x_i) < \Omega_2(x_i) \land \Omega_2(x_i) \leq \Omega_1(x_i)
\end{aligned}
\]

It indicates that \( x_\alpha \) is \( x_\alpha \) of \( \alpha \) dominance, denoted as \( x_\alpha \prec x_\alpha \).

In definition, if \( \alpha_{12} = \alpha_{21} = 0 \), \( \alpha \) dominance changes to Pareto dominance form and that is to say that \( \alpha \) dominance is special form of Pareto dominance. As shown in Fig. 3(a), Pareto dominance space shown in solution \( A \) is right front of \( BAC \) broken line location and \( \alpha \) dominance space of solution \( A \) is right front of \( EAD \) broken line. Under Pareto relationship dominance, in dominance space \( BAC \) and \( EAD \), mutual non-dominating relationship of solution \( A \) exists. Under \( \alpha \) dominance, \( A \) can dominate solution in \( BAC \) and \( EAD \). Therefore \( \alpha \) dominance realizes restriction broadening of Pareto dominance and increases solution dominance space.

Gain leading edge of Pareto with \( \alpha \) dominance. The form is \( \alpha - \text{PF changing} \) with change of value of \( \alpha_{12} \) and \( \alpha_{21} \). \( \alpha - \text{PF} \) also changes at leading edge of Pareto. See Fig. 3(b) for details. Therefore \( \alpha_{12} \) and \( \alpha_{21} \) can be used to adjust and guide optimization objective to restrain within different solution set space of Pareto dominance.

![Diagram](image_url)

(a) Pareto dominance

![Diagram](image_url)

(b) \( \alpha \)-PF dominance

Fig.3. Pareto dominance and \( \alpha \)-pf dominance
4. Conclusion

This paper puts forward supply chain design method of small and micro tourist enterprise based on dynamic guidance and multi-objective harmony search algorithm, constructs multi-objective optimization model of supply chain of small and micro tourist enterprise and performs optimization design on the basis of dynamic guidance and multi-objective harmony search algorithm with reasonable algorithm design process, which is important to improve competitiveness of small and micro tourist enterprise. In next step, application system development of algorithm and practical application effect verification will be focused mainly.

References


