Research on Multi-objective Programming of Raw Material Ordering and Transportation Process based on Genetic Algorithm

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Abstract: Based on the discussion of the ordering and transhipment process of suppliers' raw materials, the optimal scheme of three kinds of raw materials in ordering and transportation is studied. This paper uses the fuzzy evaluation method to evaluate the suppliers comprehensively. Then under the condition of ensuring the production demand of the enterprise, the corresponding planning model is established, and the optimal raw material ordering scheme and transfer plan are established to meet the needs of the enterprise. Then the coefficient of variation method is used to eliminate the influence of different dimensions of each index and judge the resolving power of the index. The fuzzy evaluation model is used to analyze the supply characteristics of each supplier quantitatively. On the premise of ensuring the normal production capacity demand of the enterprise, the 50 most important suppliers are selected. Then, the ordering stage and the transfer stage are considered, respectively, and the goal programming model is established, which is considered from three aspects: decision variables, objective function and constraint conditions. Firstly, the 0-1 selection matrix of whether or not to select suppliers is constructed to establish the 0-1 programming model, and the least supplier scheme is obtained, which focus on the cost problem. The cost only includes the raw material unit price factor, establishes the planning model to get the most economical raw material ordering plan in the next 24 weeks, and finally establishes the model to get the transfer plan with the least transportation loss. In the process of data processing, due to a large amount of data, the genetic algorithm is used for optimization, and the simulation results show that the scheme's effect is good.

1. Introduction

Materials refer to the basic raw materials used by production enterprises to form certain products, which can be generally divided into two categories. One is products in natural forms, such as iron ore and crude oil. One is agricultural products, such as cotton, oil, etc. [1]. Raw materials are the starting point of a product production chain, so the ordering and transportation of raw materials is a crucial link to ensure the production of enterprises.

2. The establishment of fuzzy evaluation model

2.1. Model building

The first step is to determine the factor set of the evaluated object $X = \{x_1, x_2, x_3\}$, where X1 is supplier's supply satisfaction = supply quantity/order quantity, X2 is supplier's supply capacity = average weekly supply, x3 is supplier's stable supply capacity = weekly supply variance. The second step is to determine the weight of each factor and the membership vector to obtain a 3*402 fuzzy evaluation matrix.

2.2. Supplier evaluation index

The paper uses the known data to construct the following three evaluation indicators:

Tab.1. The evaluation index

Supplier supply stability ∂ ==== Weekly variance of supply
Supplier availability η ==== Average weekly supply
Supplier order fulfilment level χ ==== (The number of days on which supply exceeds order quantity-The number of days when the quantity of supply and order is zero)/ (240-The number of days when the quantity of supply and order is zero)the number of days there are orders

2.3. The solution of fuzzy evaluation model

Taking the optimal value of each column [2] as the ideal index, the evaluation matrix is constructed according to the relative deviation evaluation method, and then the evaluation weight vector is determined by the variation coefficient method. Finally, the deviation of each scheme is weighted and averaged to get a comprehensive evaluation.

Tab.2. Quantitative analysis table of supply characteristics

The material classification	A	B	C
Number of suppliers $\mho$	146	134	122
Stability of supply ∂	66.81	77.06	62.59
Supplier availability η	41.47	46.60	49.46
Degree of supply completion χ	0.52	0.53	0.55

Based on the guarantee of enterprise production, C is the preferred material. Since the supply stability of B is less than that of MATERIAL A, but the supply capacity and order completion degree of material B are both greater than that of material A, we should choose between A and B according to specific needs[3]. If supply stability is much important, material A should be given priority; otherwise, material B should be considered.

In the case of ensuring the production of the enterprise, the fuzzy evaluation model based on relative deviation is used to evaluate the importance of each supplier to the enterprise comprehensively, and the most important suppliers are as follows:

Tab.3. 50 suppliers list

Ranking	Supplier	Ranking	Supplier	Ranking	Supplier	Ranking	Supplier	Ranking	Supplier
1	S229	11	S194	21	S40	31	S266	41	S5
2	S361	12	S356	22	S364	32	S67	42	S30
3	S340	13	S308	23	S346	33	S239	43	S213
4	S275	14	S352	24	S367	34	S174	44	S189
5	S329	15	S330	25	S294	35	S362	45	S169
6	S282	16	S247	26	S218	36	S221	46	S3
7	S268	17	S143	27	S80	37	S342	47	S351
8	S131	18	S31	28	S244	38	S55	48	S237
9	S306	19	S365	29	S178	39	S175	49	S7
10	S108	20	S284	30	S53	40	S379	50	S98

3. Minimum supplier solutions

3.1. Scheme determination

In order to find the minimum number of suppliers to meet the production demand, all selected suppliers are required to supply to the enterprise as much as possible, without focusing on the loss in the transhipment stage[4]. Therefore, solving the average loss of attachment 2 can temporarily reduce the loss rate to 1%. Taking into account the relationship between the amount of data, the model can first arrange the three kinds of raw materials, and it can be found that the supply volume of suppliers has a certain periodicity, so in order to optimize the data.

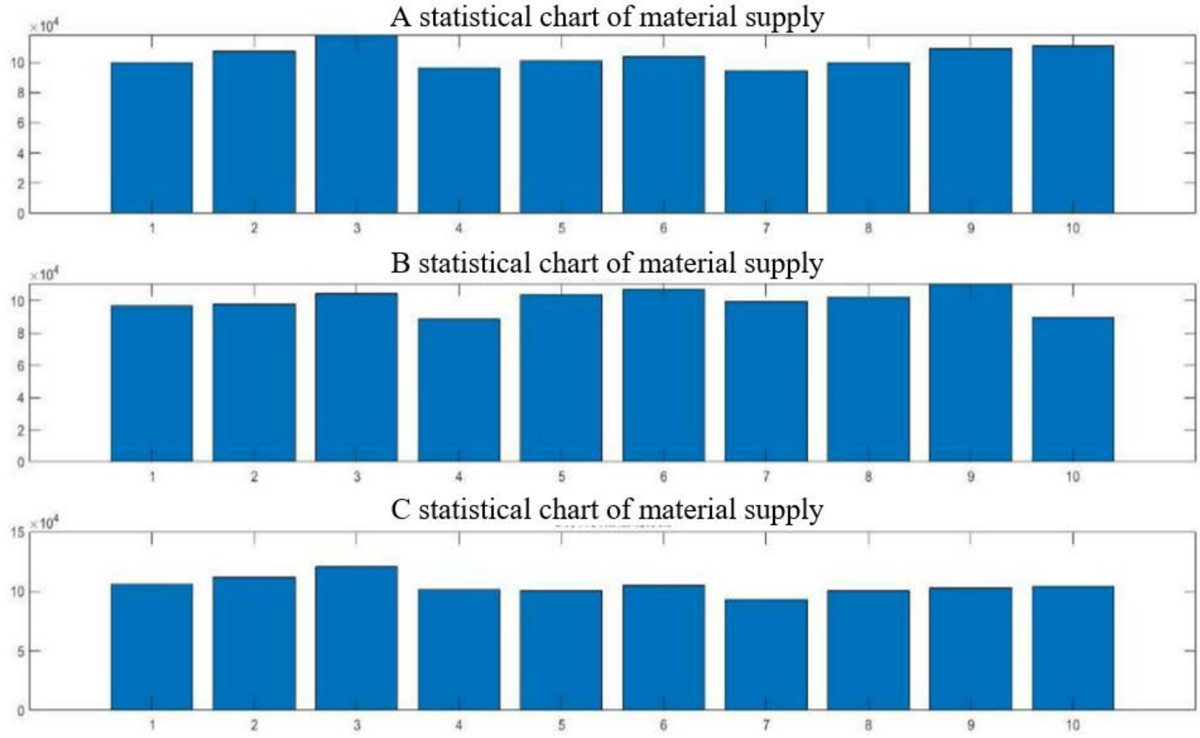

Fig.1. Statistical chart of material supply

3.2. The decision variables

The main solution is the minimum number of suppliers. Therefore, for each supplier, as long as the choice of judgment can be. After analysis and preliminary inspection[5], the model has no solution when selecting 50 suppliers. Therefore, it is judged that the number of suppliers needed must be more than 50, so the model carries out optimal solution planning for all decision variables. Taking 146 suppliers of raw material A as an example, the decision variable A lent the choice of 146 suppliers in 24 weeks, forming A 24-row and 146 columns 0-1 matrix, where 1 means that the enterprise chooses the supplier and demands to supply according to the maximum quantity; otherwise, 0 means no supply.

3.3. Objective function

The programming model requires the objective function to be the minimum number of suppliers, so it can be converted into a mathematical expression using the selection matrix λ_A. Add up the 24 selection data in each column of a store, and if this data is not equal to 0[6], then the store is selected in the supply process. In the same way, we do the same forλ_B , λ_C. In other words, the objective function ω _ 1 is expressed as follows:

$$\min\ \omega_1 = num\left(\sum_{j=1}^{146}\sum_{i=1}^{24}(\lambda_A)_{ij} \neq 0\right) + num\left(\sum_{j=1}^{134}\sum_{i=1}^{24}(\lambda_B)_{ij} \neq 0\right) + num\left(\sum_{j=1}^{122}\sum_{i=1}^{24}(\lambda_C)_{ij} \neq 0\right) \tag{1}$$

3.4. The constraint

The capacity provided by A, B and C raw materials was calculated separately, and the energy produced by the product was 28,200 cubic meters higher than the demand. Meanwhile, considering that the energy produced in the first week should meet the demand of the first two weeks, the energy produced by the product should be twice the original demand, that is, 56,400 cubic meters. The mathematical expression of the constraint conditions is:

$$(1\text{-}1\%)\cdot\left(\frac{\lambda_A\cdot\max\limits_A}{0.6}+\frac{\lambda_B\cdot\max\limits_B}{0.66}+\frac{\lambda_C\cdot\max\limits_C}{0.72}\right)\geq\begin{pmatrix}5.64\times10^4 & \cdots & \cdots & \\ \vdots & 2.82\times10^4 & & \vdots \\ \vdots & & \ddots & \vdots \\ & \cdots & \cdots & 2.82\times10^4\end{pmatrix} \tag{2}$$

4. The most economical way to order raw materials

4.1. Decision variables

The obtained ω_1 suppliers, which make the most economical raw material ordering plan each week, can still be used as a supply planning model, which can be divided into three kinds of raw materials: a _ Magi B ~ C for supplier selection. It is divided into A, B and C raw materials for supplier selection. Therefore, taking raw material A as an example, the quantity supplied by the supplier I in week j is$(P_A)_{ij}$.

4.2. The objective function

For the purchase unit price of raw materials A, B and C, it can be assumed that the unit price of raw material C is 10,000 yuan/cubic meter, so raw material A is 12,000 yuan/cubic meter, and raw material B is 11,000 yuan/cubic meter. The specific objective function is established as:

$$\min\omega_2=1.2\times\sum_{i=1}^{a}(P_A)_{ij}+1.1\times\sum_{i=1}^{b}(P_B)_{ij}+1\times\sum_{i=1}^{c}(P_C)_{ij} \tag{3}$$

4.3. The constraint

It is necessary to ensure that the supply volume meets the capacity demand, that is, the enterprise capacity demands that the sum of the actual quantity received by a supplier in week j is greater than or equal to week j.

$$(1\text{-}1\%)\times\left(\frac{\sum_{i=1}^{a}(P_A)_{ij}}{0.6}+\frac{\sum_{i=1}^{b}(P_B)_{ij}}{0.66}+\frac{\sum_{i=1}^{c}(P_C)_{ij}}{0.72}\right)\geq N_j \tag{4}$$

and $N_j=\begin{cases}5.64\times10^4, j=1\\ 2.82\times10^4, j\neq1\end{cases}$

The supply quantity of supplier I in week J shall not exceed the maximum supply it can provide:

$$\begin{cases}(P_A)_{ij}\leq(\max\limits_A)_{ij}\\ (P_B)_{ij}\leq(\max\limits_B)_{ij}\\ (P_C)_{ij}\leq(\max\limits_C)_{ij}\end{cases} \tag{5}$$

5. Transport scheme with least loss

5.1. Model assumes

The transportation loss rate has the possibility of the same periodic fluctuation, so through simple chart statistics, the model also takes 48 weeks a year as a cycle, and the average value of the corresponding weeks per year represents the transport loss rate of the corresponding weeks of a transporter. If we take the first week of each year as an example, by calculating the arithmetic average eight times, we can get the loss rate matrix of each transporter in the first week:

$$\mu_{i1}=\begin{pmatrix}1.91\\0.74\\0.11\\0.56\\0\\0.01\\1.12\\0.64\end{pmatrix} \quad (6)$$

5.2. The decision variables

This paper aims to establish a cooperative relationship between each supplier and which transporter. According to the basic idea of the 0-1 programming problem, a 0-1 matrix is established for 127 suppliers obtained by the previous model: supplier transporter cooperation matrix. The I supplier chooses the j transporter to cooperate in the k week, 1 indicates that the I supplier establishes a cooperative relationship with the j transporter in the k week. Otherwise, 0 indicates no cooperation.

5.3. The objective function

The transport scheme with the least transport loss should be based on the corresponding supply quantity of the supplier and the loss cost of the cooperative transporter, so the expression of the objective function can be obtained:

$$\min \omega_3 = \begin{pmatrix}P_A\\P_B\\P_C\end{pmatrix}\cdot C_k \cdot \mu_k \quad (7)$$

5.4. Constraints

Each supplier must have only one transporter to cooperate in material transportation. That is, supplier transporter cooperation matrix Ck satisfies the mathematical relationship:

$$\sum_{j=1}^{8}\left(C_k\right)_{ij}=1 \quad (8)$$

Each transporter has a capacity of 6000 m^3/week

$$\begin{pmatrix}P_A\\P_B\\P_C\end{pmatrix}\cdot C_k \le \begin{pmatrix}6000\\\vdots\\6000\end{pmatrix} \quad (9)$$

6. Solution of the objective programming model

6.1. Code design

This model adopts three layers of coding: at the first layer, the minimum supplier selection adopts 0-1 coding, which is 0 when the supplier is not selected, and 1 when the supplier is selected. The most economical ordering scheme at layer 2 uses integer encoding for the quantity supplied, with each floating-point number representing the quantity supplied by the supplier in that week. The third layer has the smallest loss. That is, the selection of the transporter adopts the 0-1 code. When a supplier is selected, the value is 0 if the transporter is not selected, and the value is 1 if the transporter is selected. Such encoding means clear meaning and does not need to decode, which improves the transmission rate.

6.2. Genetic strategy

Crossover: Set the crossover probability of the population to Pc. Two chromosomes were randomly selected, and when the crossover condition was satisfied, two crossover points were randomly generated, and the T1 periodic data of chromosome 1 and the T2 periodic data of chromosome 2 were exchanged.

Variation: Set the mutation probability of the population to Pm. Randomly select a chromosome, when the variation condition is satisfied, randomly generate two mutation points, t1, t2 ∈ [1, T], and exchange the chromosomet1,t2 cycle data.

According to the above planning model, the enterprise should select at least 127 suppliers to supply raw materials to meet the production needs, and the selected suppliers are shown in the following table (the selected suppliers are marked in the table):

Tab.4. Minimum supplier selection table

1	21	41	61	81	101	**121**	**141**	161	181	**201**	**221**	241	261	281	301	321	341	**361**	381
2	22	**42**	62	82	102	122	142	162	182	**202**	222	242	262	**282**	302	322	342	**362**	382
3	**23**	43	63	83	103	**123**	**143**	**163**	183	203	223	243	**263**	283	303	323	343	363	**383**
4	24	44	64	84	**104**	124	144	164	184	204	**224**	**244**	264	284	304	**324**	344	**364**	384
5	**25**	45	65	85	105	125	145	165	185	205	225	**245**	265	285	305	325	345	**365**	385
6	26	46	**66**	**86**	106	**126**	**146**	166	**186**	206	**226**	**246**	**266**	286	**306**	326	**346**	366	386
7	27	47	67	87	107	127	147	167	187	207	227	**247**	**267**	287	**307**	327	347	**367**	387
8	**28**	48	68	**88**	**108**	128	148	168	188	**208**	**228**	248	**268**	288	**308**	328	**348**	368	388
9	29	49	**69**	**89**	109	**129**	149	**169**	**189**	209	**229**	249	269	289	309	**329**	349	**369**	389
10	**30**	50	70	**90**	**110**	130	**150**	170	190	**210**	230	250	**270**	290	**310**	**330**	350	370	390
11	**31**	51	71	91	111	**131**	**151**	171	**191**	211	231	251	271	**291**	311	**331**	351	371	391
12	32	52	72	**92**	112	132	**152**	**172**	192	212	**232**	252	272	**292**	312	332	**352**	372	392
13	33	53	73	93	**113**	133	**153**	173	193	**213**	**233**	253	**273**	293	**313**	**333**	353	373	393
14	34	**54**	**74**	94	**114**	134	**154**	**174**	**194**	**214**	234	**254**	274	**294**	**314**	334	354	**374**	394
15	35	**55**	**75**	95	**115**	135	155	**175**	195	215	235	255	**275**	295	315	335	355	375	**395**
16	36	56	**76**	96	116	136	156	176	196	**216**	236	**256**	276	296	316	336	**356**	376	396
17	**37**	57	**77**	97	**117**	137	**157**	177	**197**	217	237	257	277	297	317	337	357	377	397
18	38	58	78	**98**	118	**138**	158	178	198	**218**	238	**258**	278	298	318	**338**	358	378	398
19	39	59	79	99	119	**139**	159	179	**199**	219	**239**	259	279	299	319	339	359	379	399
20	**40**	60	**80**	100	120	**140**	160	**180**	200	220	240	260	**280**	**300**	320	**340**	**360**	380	400

7. Conclusion

This paper first establishes a comprehensive index system of supplier importance and then establishes the optimal planning situation which meets the production demand based on the fuzzy comprehensive evaluation method. The whole process of supplier is divided into two stages: ordering and transportation, and the least supplier scheme, the most economical raw material and the model of minimum transportation loss are studied respectively. A genetic algorithm is used to optimize the scheme, and the simulation results show that the effect of the scheme is good.

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