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Dual-objective Programming Model and Optimization Based on Factor Analysis

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Abstract: *In this paper, through the establishment of factor analysis, multiple linear regression, and objective programming models, the optimal task pricing plan is given by analyzing the problem of meeting production requirements. Specifically, by using the R-type factor analysis method, using MATLAB to calculate the selected factor data. Import SPSS to calculate the KMO test, through factor analysis and comprehensive evaluation model, use the formula to calculate the total score of the comprehensive evaluation of suppliers, and select the top 50. In addition, we use the objective programming model to select from 131 companies, so as to obtain the plan with the least loss, the most economical, and meet the production needs of the enterprise. Further, the dual goal programming model is used to obtain the plan with the least loss. The transfer process in the objective planning problem is optimized.*

Keywords: *factor analysis, dual objective programming model, objective function, comprehensive evaluation, optimization*

1. Introduction

Combining the times, society, people's livelihood, etc., explain the background of the problem in your own language. As the competition between enterprises has increasingly evolved into the competition between supply chains, reducing cost management and improving the status of enterprises in the supply chain have become the competition between enterprises An important pillar for gaining advantages in the market. In the fierce market competition and changing market demand, there are new requirements for the development of enterprises. Common competition mode; how to apply new science and technology, adopt scientific management methods, improve production efficiency and reduce production costs have become the key issues that modern enterprises need to consider.

However, through quantitative analysis of the supply characteristics of 402 suppliers, a mathematical model is established to reflect the importance of ensuring the production of enterprises, and the 50 most important suppliers are determined on the basis of this model. For these suppliers, the company formulates an ordering plan for the most economical raw materials every week for the next 24 weeks, and formulates a transshipment plan with the least loss accordingly, and analyzes the actual effect of this ordering plan and transshipment plan. The company aims to compress production cost, plan to purchase as many Class A raw materials as possible and as little as possible to purchase Class C raw materials, and reduce the cost of transshipment and storage, and at the same time hope that the amount of transshipment loss during transshipment is small. Making a new ordering plan and transshipment plan, and analyze the implementation of the plan effect. The company already has the potential to increase production capacity through technology upgrades. According to the actual situation of existing raw material suppliers and forwarders, determine how much the company can increase its weekly production capacity, and give the ordering and forwarding plan for the next 24 weeks.

2. Model Establishment

2.1. Evaluation model based on factor analysis

We establish an evaluation model based on factor analysis according to the new indicators [5].

The average weekly supply refers to the situation that the average weekly supply can visually express the supply, which can be expressed as:

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$$\alpha = \frac{\sum_{i=1}^{240} w_i}{240} \tag{1}$$

The difference between the supplier's supply and the company's order, expressed by the difference between the supply and the order, can be expressed as:

$$\beta = \sum_{i=1}^{n} w_i - \sum_{i=1}^{n} W_i \tag{2}$$

The weekly supply range is the difference between the maximum and minimum supply, which can represent the variation range and dispersion degree of the variable distribution, and can be expressed as:

$$\gamma = \max\{w_i\} - \min\{w_i\} \tag{3}$$

Weekly supply variance is the weekly supply minus the square of the mean divided by the total number of weeks, reflecting the degree of deviation between the random variable and the mean, and can be expressed as:

$$\sigma = \frac{(w_i \frac{\sum_{i=1}^{n} w_i}{240})^2}{n-1} \tag{4}$$

The ratio of supply to order is:

$$\varphi = \frac{i=i+1\ (w_i \neq 0)}{j=j+1 (W_i \neq 0)} \tag{5}$$

The order percentage refers to the number of times the order places an order in the total number of weeks, and the supply percentage refers to the number of times the supplier delivers in the total number of weeks, which can be expressed as:

$$\eta = \frac{i=i+1\ (w_i \neq 0)}{240} \tag{6}$$

$$\mu = \frac{i=i+1\ (W_i \neq 0)}{240} \tag{7}$$

After the above results are calculated by MATLAB, factor analysis method is used, and KMO (Kaiser-Meyer-Olkin) coefficient and variance contribution rate are calculated by SPSS. Influence factors were used to analyze the 50 excellent raw material factories by the comprehensive evaluation method [3].

2.2. Models based on goal programming

The objective function is to select the smallest number of suppliers [4], let i, j traverse the matrix to find the number of weeks and times that are not 0, which can be expressed as:

$$f_A = (\sum_{i=1}^{24}(C_A)) + (\sum_{i=1}^{24}(C_B)) + (\sum_{i=1}^{24}(C_C)) \tag{8}$$

The objective function should be changed to the minimum cost. According to the model assumption, the company purchases all the raw materials provided by the supplier, so the cost calculation should be determined according to the supply quantity, so the objective function is:

$$g_{(x)} = 1.2 \times H_A + 1.1 \times H_B + 1.0 \times H_C \tag{9}$$

Combining with the loss rate of the forwarder, the final result is:

$$h_1 = \rho \times X_A \times \begin{pmatrix} H_A \\ H_B \\ H_C \end{pmatrix} \tag{10}$$

2.3. Multiple linear regression model

Assuming that a dependent variable y is affected by k independent variables $x_1, \dots, x_k$. Then, the structure of the multiple linear regression model is:

$$y_a = p_0 + Bx_0 + p_0 Bx_{1a} + p_k Bx_{ka} + \varepsilon a \tag{11}$$

where $p_0, p_1, \dots, p_k$ is the pending parameters, ε is a random variable.

If $b_0, b_1, \dots, b_k$ are the fitted values of $p_0, p_1, \dots, p_k$, respectively, the regression equation is:

$$\mathrm{y} = b_0 + b_1 x_1 + \cdots + b_k x_k \tag{12}$$

where b_0 is a constant, $b_0, b_1, \dots, b_k$ is called the partial regression coefficient.

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2.4. A model for dual-objective programming

A dual-objective programming model is established to solve the most economical and at the same time the least loss rate scheme. Now we plan to purchase as many A products as possible and use B and C products as little as possible. By consulting the literature, we can see that we can assign weights to A, B, and C raw materials through the priority factors and weight coefficients in the target optimization model. Therefore, the objective function is calculated [2]. The requirement of the minimum number of suppliers is missing, and the objective function has also changed at this time, but the decision variables and constraints are roughly the same. Through the analysis of the results, the total daily supply volume is generally in the situation. It is less than the maximum range of transportation that can be transported. Under the assumption that we do not take into account the cost caused by the number of transportations, we only need to reduce the loss rate to a minimum.

3. Model Solution

Use MATLAB for fitting, and then use the minimum curvature for local fitting to remove the more abnormal data. The data reduction processing uses sample reduction [1]. The weekly average supply, supply and order quantity can be calculated. The data of seven factors, such as the difference, the weekly supply range, the weekly supply variance, the ratio of the supply to the order, the order percentage, and the supply percentage. After calculating the data of the above seven factors, 3-5 calculated KMO coefficients are randomly selected. Using the weekly average supply, the difference between the supply and the order, the extreme difference in the weekly supply, the variance of the weekly supply, and the average supply-to-order ratio, the KMO coefficient is calculated to be 78.1%, and the result is shown in Fig. 1.

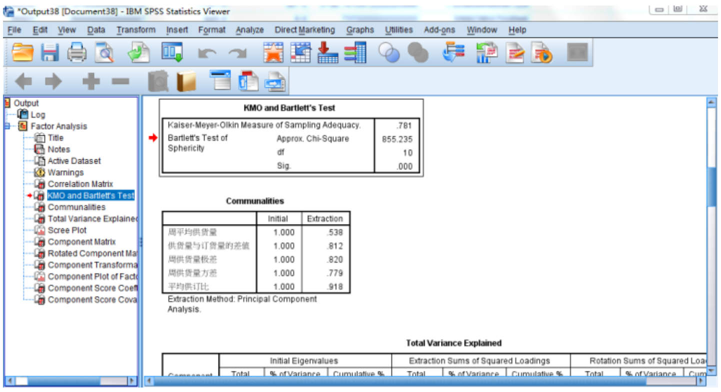

Figure 1: KMO coefficient derived from five factors

Four factors were selected to calculate the KMO coefficient: the difference between the supply quantity and the order quantity, the weekly supply difference, the weekly supply variance, and the average supply-to-order ratio, and the result was 73.4%, as shown in Fig. 2.

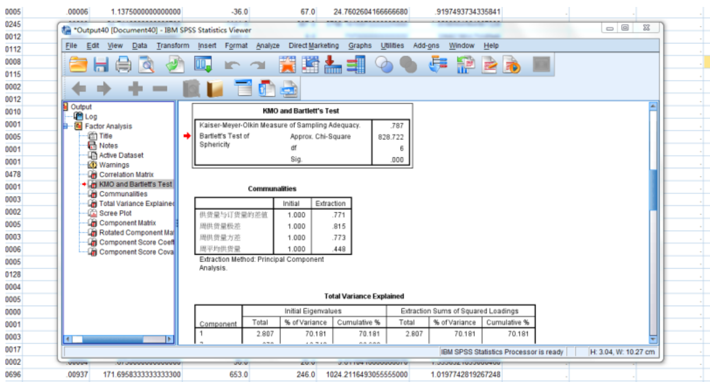

Figure 2: KMO coefficients derived from four factors

The KMO coefficient is 78.7% calculated by using four factors, the difference between the supply and the order, the extreme difference in the weekly supply, the variance of the weekly supply, and the average weekly supply, as shown in Fig. 3.

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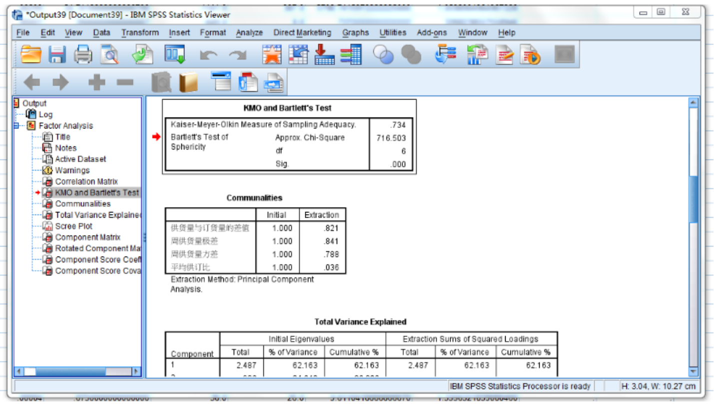

Figure 3: KMO coefficients derived from four factors

The KMO coefficient is calculated to be 67% using the four factors of the weekly supply range, the weekly supply variance, the weekly average supply and the average supply-to-order ratio, as shown in Fig. 4.

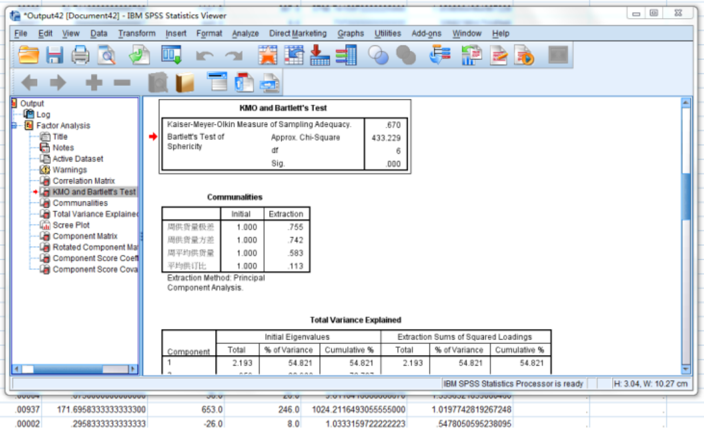

Figure 4: KMO coefficients derived from four factors

According to the above four results, the largest KMO coefficient is 78.7%. The selected factors include the difference between the supply quantity and the order quantity, the extremely poor weekly supply quantity, the variance of the weekly supply quantity, and the weekly average supply quantity. The four factors are comprehensively evaluated, the variance contribution rate of each factor is used as a weight, the score of each factor is weighted, and then the total factor score of each supplier is obtained:

$$\mathrm{f}=\frac{V_1}{\sum_{i=1}^{4} V_i} f_1+\frac{V_2}{\sum_{i=1}^{4} V_i} f_2+\frac{V_3}{\sum_{i=1}^{4} V_i} f_3+\frac{V_4}{\sum_{i=1}^{4} V_i} f_4 \tag{13}$$

The serial numbers of the top 50 suppliers after the total factor score is obtained, as shown in table 1.

Table 1: Top 50 Suppliers

Top 50

S229	**S361**	**S108**	**S340**	**S282**
S275	S329	S131	S268	S356
S306	S151	S139	S330	S194
S140	S308	S352	S143	S247
S307	S284	S395	S365	S031
S037	S374	S040	S364	S367
S338	S346	S080	S294	S055
S218	S244	S003	S189	S273
S114	S292	S086	S266	S005
S078	S007	S123	S154	S208

By calculating and then inputting it into MATLAB for calculation, it is finally calculated that at least 131 suppliers should be selected to supply raw materials to meet the production needs, as shown in Fig.

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5.

1	**2**	**3**	**4**	**5**	6	**7**	8	**9**	**10**	11	12	13	14	15	16	17	18	19	20
21	22	**23**	24	**25**	26	27	**28**	29	**30**	31	32	33	34	35	36	**37**	38	39	**40**
41	**42**	43	44	45	46	47	48	49	50	51	**52**	53	**54**	**55**	56	57	58	59	60
61	62	63	64	**65**	**66**	67	**68**	69	70	71	72	73	74	75	**76**	**77**	**78**	**79**	80
81	82	83	**84**	85	**86**	**87**	**88**	**89**	90	91	92	**93**	**94**	95	**96**	**97**	**98**	**99**	100
101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	**120**
121	122	**123**	124	**125**	126	127	128	129	130	**131**	**132**	**133**	134	135	136	137	**138**	139	140
141	142	143	**144**	145	**146**	147	148	**149**	150	151	152	153	154	**155**	156	157	158	159	160
161	162	163	164	165	166	167	168	169	**170**	**171**	172	173	174	175	176	**177**	178	**179**	180
181	182	183	184	**185**	186	**187**	**188**	189	190	191	**192**	193	194	195	196	197	198	199	**200**
201	**202**	**203**	**204**	205	206	207	208	209	210	211	**212**	213	**214**	215	216	217	**218**	219	**220**
221	**222**	223	224	225	226	227	228	229	**230**	231	**232**	233	234	235	236	**237**	238	**239**	240
241	242	243	**244**	**245**	246	247	**248**	**249**	250	251	252	253	254	**255**	**256**	257	258	259	**260**
261	262	263	264	265	**266**	**267**	268	269	270	271	**272**	273	274	**275**	276	277	278	**279**	280
281	**282**	**283**	284	285	286	287	**288**	289	290	291	292	**293**	294	295	296	**297**	**298**	299	300
301	**302**	**303**	304	305	**306**	**307**	308	309	**310**	311	**312**	313	314	**315**	316	317	318	319	**320**
321	322	323	324	**325**	**326**	**327**	328	**329**	330	331	332	333	**334**	335	**336**	337	338	339	**340**
341	**342**	**343**	344	345	346	347	**348**	349	**350**	**351**	352	353	354	355	356	**357**	358	**359**	360
361	**362**	363	**364**	365	366	367	368	369	370	371	372	**373**	374	375	376	377	**378**	379	380
381	382	383	384	385	386	387	388	**389**	390	391	392	393	394	395	396	397	398	399	400
401	**402**																		

Figure 5: Screened 131 suppliers

Let $a_{i,j}$ represent the supply quantity of the ith supplier in the jth week, $0 \leq \mathrm{i} \leq 200, 0 \leq \mathrm{j} \leq 240$, fix i, and the sum of j from 1 to 240 weeks, that is, the supply quantity of the ith supplier in the 240th week, the requirement is not less than to meet the production needs of the enterprise for two weeks, the average inventory is:

$$\mathrm{w} = \frac{\sum_{j=1}^{240} a_{i,j}}{Sum\ of\ times\ of\ non\text{-}zero\ weeks} \tag{14}$$

Considering the effect of the average attrition rate, the following formula needs to be satisfied in the first week:

$$\left(\frac{S_A}{0.6} + \frac{S_B}{0.66} + \frac{S_C}{0.72}\right) \times (1 - \varphi) \geq 5.64 \times 10^4 \tag{15}$$

$$\left(\frac{S_A}{0.6} + \frac{S_B}{0.66} + \frac{S_C}{0.72}\right) \times (1 - \varphi) \geq 2.68 \times 10^4 \tag{16}$$

Need to meet the 24-week production needs of the enterprise, the total cost = raw material cost + transportation cost:

$$T_i = p_i + t_i \tag{17}$$

Solving the raw material cost of each company, set the unit price of C material as "1", then the cost of B material is "1.1", and the raw material cost of A is "1.2", because it is necessary to purchase A as much as possible, and as little as possible purchase C, and because in the second question, it is found that B of B is the least cost-effective material, the unit price is high, and the required quantity is also large, so we add a weight to A, B, and C, and purchase A, B , the ratio of C is 20:0.1:0.9. In the second question, we find the production demand of not less than two weeks. After the third week, we only need to consider the production demand of each week [6], which can be expressed as:

$$\left(\frac{S_A}{0.6} \times 20 + \frac{S_B}{0.66} \times 0.1 + \frac{S_C}{0.72} \times 0.9\right) \times (1 - \varphi) \geq 2.84 \times 10^4 \tag{18}$$

Weekly raw material cost:

$$p_i = 1.2 \times A_i + 1.1 \times B_i + 1 \times C_i \tag{19}$$

Finding outmin$\{\sum_{i=1}^{24} T_{i\,,} \sum_{i=2}^{25} T_i\ , \ldots , \sum_{i=217}^{240} T_{i\,,}\}$, we can get the most economical plan for the next 24 weeks.

Through our calculation, we found that, under normal circumstances, the total maximum supply per day is less than the maximum range that can be transported by transportation, which is 6,000 cubic meters per week. When we do not calculate the cost caused by the number of shipments, we transport all the supply almost every day, and all 8 forwarders use them at the same time. In this case, we only need to reduce the loss rate to the minimum [7].

Based on the genetic algorithm, we formulate the following steps:

Step 1: Initialization: Randomly formulate a transport plan

Step 2: Individual evaluation: Calculating the fitness of each program in the group.

Step 3: Selection operation: Usin the roulette strategy to determine the suitability of the transshipment plan, judge whether it meets the optimization criteria, if so, output the best plan and its optimal solution, end, otherwise, go to the next step, and select according to the fitness The regeneration scheme, the

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scheme with high fitness has a high probability of being selected, and the scheme with low fitness is eliminated.

Step 4: Crossover operation: Generating a new scheme according to a certain crossover probability and crossover method

Step 5: Mutation operation: Generating a new generation transport scheme by crossover and mutation, return to step 2

Step 6: Judgment of termination conditions: Taking the solution with the maximum fitness obtained in the evolution process as the output of the optimal solution, and terminating the calculation.

Through the above dual-objective planning model, we can see that the company's ordering plan and transshipment plan for the next 24 weeks.

4. Conclusion

In this paper, we analyze the problem of meeting production demand by establishing factor analysis, multiple linear regression and objective programming models, and give the optimal task pricing scheme. We can use the objective programming model, from the objective function, decision variables The objective function is the operation plan with the least loss, and it is calculated that at least 131 suppliers need to be selected, and then selected from 131 to obtain the plan with the least loss, the most economical, and meet the production needs of the enterprise.

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