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Transportation and ordering of raw materials for building and decoration plates

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Abstract: Aiming at the optimal cost planning problem in the raw material supply process of production enterprises, on the basis of supply planning demand, considering the relationship between supply and demand, economy, risk and the development of enterprises, this paper obtains the solution of each problem through the specific analysis of the four problems and appropriate and reasonable assumptions. Firstly, the supply characteristics of raw materials are quantitatively analyzed, the TOPSIS Model Based on entropy method is established, and the 50 most important suppliers are calculated and selected. Secondly, according to the enterprise's capacity demand, establish a 0-1 planning model, screen suppliers, and formulate the most economical ordering scheme and the transshipment scheme with the least loss. Considering the tendency and requirements of enterprises for different raw materials, a multi-objective programming model is established to further screen the optimal ordering and transportation scheme. Finally, according to the material supply of the supplier, the production capacity that the enterprise can improve every week is predicted, and the improvement plan of the enterprise production capacity is formulated.

Keywords: Quantitative analysis, TOPSIS Model Based on entropy weight method, order and transportation decision, multi-objective programming.

1. Introduction

The raw materials used by a manufacturer of building and decorative plates are mainly wood fiber and other vegetable fiber materials, which can be divided into three types: A, B and C. The enterprise arranges production 48 weeks a year and needs to formulate a 24 week raw material ordering and transportation plan in advance, that is, determine the raw material suppliers to be ordered (called "suppliers") and the corresponding weekly raw material ordering quantity (called "ordering quantity") according to the capacity requirements, Determine the third-party logistics company (called "forwarder") and entrust it to transfer the supplier's weekly supply quantity of raw materials (called "supply quantity") to the enterprise warehouse. The weekly production capacity of the enterprise is 28200 cubic meters, and each cubic meter of products needs to consume 0.6 cubic meters of class raw materials, 0.66 cubic meters of class B raw materials, or 0.72 cubic meters of class C raw materials. Due to the particularity of raw materials, the supplier cannot guarantee to supply goods in strict accordance with the order quantity, and the actual supply quantity may be more or less than the order quantity. In order to ensure the needs of normal production, the enterprise should keep the inventory of raw materials that meet the production needs of two weeks as much as possible. Therefore, the enterprise always purchases all the raw materials actually provided by the supplier. In the actual transfer process, raw materials will be subject to certain loss (the percentage of loss in supply is called "loss rate"), and the quantity of raw materials actually transported by the forwarder to the enterprise warehouse is called "received quantity". The transportation capacity of each forwarder is 6000 m3 / week. Generally, raw materials supplied by one supplier every week shall be transported by one forwarder as far as possible.

The purchase cost of raw materials directly affects the production efficiency of enterprises. In fact, the purchase unit price of class A and class B raw materials is 20% and 10% higher than that of class C raw materials respectively. The unit cost of transportation and storage of three types of raw materials is the same.

We study the following problems: quantitatively analyze the supply characteristics of 402 suppliers, establish a mathematical model reflecting the importance of ensuring enterprise production, and determine the 50 most important suppliers on this basis. How many suppliers should the enterprise choose to supply raw materials to meet the production demand? For these suppliers, formulate the most economical raw material ordering scheme for the enterprise every week in the next 24 weeks, and formulate the transshipment scheme with the least loss accordingly. Try to analyze the implementation effect of ordering scheme and transshipment scheme.

In order to reduce the production cost, the enterprise plans to purchase more class A and less class C raw materials as much as possible, so as to reduce the cost of transshipment and storage. At the same time, it is hoped that the transshipment loss rate of the transshiper will be minimized. Please formulate a new ordering scheme and transshipment scheme, and analyze the implementation effect of the scheme.

If the enterprise has the potential to increase production capacity through technological transformation. According to the actual situation of existing raw material suppliers and forwarders, determine how much the weekly production capacity of the enterprise can be increased, and give the ordering and transshipment plan for the next 24 weeks.

This is a selection and optimization analysis problem. According to the weekly supply capacity of raw material suppliers, select suppliers that are more in line with the capacity needs of the enterprise; Select the forwarder with less loss rate according to the ability of the forwarder in transit; According to the difference of purchase unit price of different materials, the proportion more suitable for enterprise ordering is selected to reduce the cost of transshipment and storage. The difficulty lies in the selection of limiting conditions. Considering the above conditions, the enterprise will formulate different supplier selection schemes, raw material ordering and transportation schemes in the next 24 weeks, optimize the model after selecting these conditions, and analyze the implementation effect of each scheme.

2. Establishment and solution of the mathematical mode

2.1 The mathematical model for problem one.

Firstly, the data is preprocessed. According to the raw materials consumed by the enterprise in one week and the total supply provided by each supplier for the enterprise in 240 weeks, a small number of worthless suppliers who are far from being able to supply the enterprise's production capacity are screened and removed. Visualize the data, draw the statistical chart of ordering and supply, and the histogram of the difference between ordering and supply.

The supply characteristics of 402 suppliers are quantitatively analyzed, and three characteristics of supplier supply stability, supply risk and supply quantity are selected to establish characteristic indexes. Supply stability: use the variation coefficient of annual supply to reflect the stability of supplier supply capacity $\mathrm{CV} = \frac{s}{\bar{X}}$; Supply risk: considering the relationship between supply and supply, we designed a function

$$f(x) = Q - s - Q^1,$$

where Q is the supply quantity, Q^1 is the difference between the supply quantity and the order quantity, and S is the variance of the supply quantity; Supply quantity: the weekly average supply quantity, and the optimal supplier shall be greater than the weekly average supply quantity. After determining the supply indexes of 402 suppliers, TOPSIS Model Based on entropy weight method is established, which is weighted according to the difference degree of each index mark value, calculates the degree of approaching the ideal solution, evaluates the good and bad grades of each sample, and comprehensively evaluates the suppliers.

In problem one, among the 402 suppliers, it is necessary to determine the 50 most important suppliers according to the supply characteristics to ensure that the production capacity of the enterprise can meet the demand as much as possible every week. Using the above model, combined with the subject requirements, the worthless suppliers are removed through jupyter notebook screening, the supply and ordering statistical chart is drawn, and the annual supply variation coefficient CV, user-defined risk function and weekly average supply of each supplier are calculated.

Finally, it is sorted according to the size of the C_i. The larger C_i it is, the closer it is to the optimal value. The results are shown in Table 1 below.

Table 1: 50 most important suppliers

supplier	supplier	supplier	supplier	supplier	supplier	supplier	supplier	supplier	supplier
S229	S282	S356	S284	S330	S310	S025	S149	S253	S128
S140	S139	S306	S395	S348	S092	S175	S379	S046	S036
S108	S340	S268	S308	S324	S221	S169	S213	S178	S386
S361	S275	S307	S194	S141	S113	S174	S067	S030	S193
S151	S329	S374	S131	S392	S076	S318	S342	S336	S270

2.2 The mathematical model for problem two

Selection of the least supplier: that is, further analysis based on the selection of 50 suppliers in question 1. If it is necessary to meet the enterprise's production capacity, the total supply volume of all suppliers in five years is 240 * 28200 cubic meters. First, sort the total production capacity of 50 important suppliers in five years, and eliminate some suppliers that have little impact on the total supply volume of suppliers in the process, and then set corresponding constraints, so as to turn the problem into NP hard problem, The 0-1 programming model is established.

Suppose v_i、v_j、v_k respectively represent the selection of suppliers of raw materials of category A, B and C. when v_i =0 or v_j =0 or v_k =0, it means that the supplier of such raw materials is not selected; Otherwise, it means that the supplier of such raw materials is selected. For each supplier, there are and only two choices, that is, select it to supply raw materials for the enterprise or not. Thus, the constraint conditions and objective function are established:

$$\min(\sum w_i v_i + \sum w_i v_j + \sum w_i v_k)$$

S.t., $0.6\sum x_i v_i + 0.66\sum y_j v_j + 0.72\sum z_k v_k \geq 2\bullet\sum w_i(x_i + y_j + z_k), v_i、v_j、v_k \in \{0,1\}$

Among them, $\sum x_i$, $\sum y_j$, $\sum z_k$ is the supply quantity to meet the two-week production demand of the enterprise, and w_i is the weekly supply quantity of each supplier.

After selecting the least suppliers in the previous step, it is necessary to judge the credit and supply-demand relationship of each supplier, so as to design the transshipment scheme and ordering scheme.

About ordering scheme design: after selecting the least suppliers, it is necessary to judge the credit and supply-demand relationship of each supplier and evaluate the ordering risk. First, calculate the absolute value of the difference μ_{nm} between the weekly supply of each supplier to the enterprise and the weekly order of the enterprise in each supplier. N supplier ID and m are weekly times, then

$$\mu_{nm} = |\text{Supply quantity-Order quantity}|$$

Average the difference between two consecutive weeks $\bar{\mu}_{nm}$, that is

$$\bar{\mu}_{nm} = \frac{1}{2}(\mu_{nm} + \mu_{n(m+1)}),$$

as the risk coefficient of the ordering scheme μ, the higher the risk coefficient, the less ideal the ordering scheme is.

2.3 The mathematical model for problem three

Combined with the goal of purchasing A as much as possible and C as little as possible to reduce the storage cost and the loss of transshipment raw materials, we establish a dual objective programming model to reduce the storage cost and reduce the transshipment loss, and use the priority method to convert each objective into a single objective model according to the priority of different importance, so as to finally obtain the order transshipment scheme.

Assumptions v_i , v_j , v_k respectively represent the selection of suppliers of raw materials of category A, B and C; Two flexible objective constraints are set, and the constraint deviation of objective planning is d_i^+ , d_i^- , which $d_i^+ = \max\{f_i - d_i^0, 0\}$ represents the part where the decision value exceeds the target value and $d_i^- = -\min\{f_i - d_i^0, 0\}$ the part where the decision value does not reach the target value; Set two priority levels, namely P_1 , P_2 , to establish the objective function and constraints:

$$\min_z = P_1 d_1^- + P_2(d_2^+ + d_2^-)$$

$$\sigma \sum y_j + \sum z_k - \sum x_i + d_2^- - d_2^+ = 0, \sigma > 1$$

$$\text{s.t.} \quad \sum w_m + d_1^- - d_1^+ = w_n, m = 1, 2...402, n = 1, 2...8$$

$$w_n + d_1^- - d_1^+ = 6000$$

$$d_i^-, d_i^+ \geq 0, i = 1, 2$$

Where σ refers to the scale factor, w_m refers to the raw material supply of the m-th supplier, and w_n refers to the transshipment volume of n transhipper's.

Selection of suppliers: 402 suppliers are classified according to the category of raw materials supplied, combined with the model of problem one. Type, calculate the most important 50 suppliers, and divide these suppliers into three categories: A, B and C; Solve the established dual objective programming model, and finally select 32 suppliers to supply raw materials for the enterprise.

About the design of ordering scheme: after 32 suppliers have been selected, the absolute value μ_{nm} of the difference between the weekly supply of each supplier to the enterprise and the weekly order of the enterprise in each supplier is calculated by using the solution of the second ordering scheme. N supplier ID and m are weeks, then

$$\mu_{nm} = |\text{Supply quantity-Order quantity}|.$$

Average $\bar{\mu}_{nm}$ the difference between two consecutive weeks, that is $\bar{\mu}_{nm} = \frac{1}{2}(\mu_{nm} + \mu_{n(m+1)})$,

as the risk coefficient of the ordering scheme. The higher the risk coefficient, the less ideal the ordering scheme is.

Design of transfer scheme: after formulating the transfer scheme, rank according to the effective average loss rate. Considering the weekly transfer limit, calculate the number of transfer merchants required per week for 24 weeks, and obtain the corresponding raw material ordering scheme. Using the method in question 2 to establish the transfer rate index ∂ and analyze the data of the results, it can be seen that the transfer rate in all weeks can be maintained at more than 72%, indicating that the transfer rate can meet the basic needs of the production enterprise. The above designed transfer scheme is reasonable and effective.

2.4 The mathematical model for problem four

We assume that the potential of enterprises to increase production capacity depends on the supply volume of each supplier, that is, the supply ceiling of each supplier needs to be calculated. We take θ_i the ratio of the number of times the supplier's weekly supply rate $\alpha = \frac{w_p}{w_o}$ is greater than 1 to the actual supply weeks as the stability factor of the supplier's supply, where w_p is the weekly supply of a supplier and w_o the weekly order of the enterprise. Therefore, the new capacity of the enterprise every week is the difference between the maximum supply quantity stably provided by the supplier every week and the loss during transportation. Therefore, a planning model for improving the capacity is established, that is

$$\max_z(\sum w_i')$$

$$\sum w_i' \leq \sum w_p \theta_i (1-\bar{\varphi}), \bar{\varphi} \in [0,1]$$

Where, w_i' refers to the production capacity of raw materials consumed by the i-th supplier, θ_i represents the supply stability factor, and $\bar{\varphi}$ refers to the effective average loss rate of transshipment.

About the enterprise's weekly capacity improvement: preprocess the data of each supplier, eliminate some abnormal data, and solve the above model. Finally, the enterprise's weekly capacity is 36700 cubic meters, an increase of 8500 cubic meters.

On the design of ordering scheme: Based on the selection of 50 most important suppliers in the first question and the solution of the second question ordering scheme, the average value of the difference for two consecutive weeks is calculated as the risk coefficient. The lower the risk coefficient, the more ideal the ordering scheme is.

About the design of transshipment scheme: rank the above-mentioned ordering schemes according to the effective average loss rate, consider the transshipment limit of 6000 cubic meters per week of each transshiper, calculate the number of transshipment merchants required per week in the next 24 weeks, and then select the corresponding number of transshipers in order to formulate the transshipment scheme with the least loss of raw materials.

3. Conclusion

This paper studies in detail the selection and planning of raw materials required by production enterprises in the process of ordering and transportation, comprehensively considers the influencing factors of production enterprises in the actual ordering and transportation decision-making, puts forward reasonable assumptions, establishes a mathematical model that meets the production needs of enterprises, and selects suppliers that meet the production capacity needs of enterprises, The most stable and economical ordering scheme and the transportation scheme with the least loss for the production enterprise in the next 24 weeks are formulated, and the production capacity that the enterprise can improve every week is predicted. Therefore, it has a certain reference significance for the actual decision-making of the enterprise, and can provide some help for the ordering and transportation decision-making of raw materials for the production enterprise.

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