

Ordering and Transportation of Raw Materials

The raw materials used by a production enterprise are mainly wood fiber and other plant fiber materials, which can be divided into three types, A, B, and C. The enterprise arranges production for 48 weeks annually, and draw up 24-week ordering plan of raw materials in advance. The ordering plan is to determine the raw material supplier (called “supplier”) and the corresponding weekly ordering quantity of raw materials (called “order quantity”). The transshipment plan is to decide the third-party logistics company (called “forwarder”) to transfer the weekly quantity of raw materials supplied by the suppliers (called “supply quantity”) to the enterprise warehouse.

The weekly production capacity of the enterprise is $28,200 \text{ m}^3$, and the raw material consumption of per m^3 product is 0.6 m^3 of Type A, or 0.66 m^3 of Type B, or 0.72 m^3 of Type C. Due to the particularity of the raw materials, the suppliers cannot guarantee to supply in strict accordance with the ordered quantity, and the actual supply quantity may be more or less than the ordered quantity. In order to guarantee its normal production, the enterprise always maintains the inventory of raw materials required for two weeks’ production at least, so that the enterprise always receives all the raw materials actually provided by the suppliers.

In the actual transshipment process, there is a certain loss (the percentage of loss in the supply quantity is called “loss rate”), and the actual quantity of raw materials transported by the forwarder to the enterprise warehouse is called “received quantity”. The transportation capacity of each forwarder is $6,000 \text{ m}^3$ per week. Generally, the most convenient way is that the weekly raw materials supplied by a supplier are transported by one forwarder.

The purchase cost of raw materials directly affects the production efficiency of the enterprise. In fact, the purchase prices per unit of Type A and Type B raw materials are 20% and 10% higher than that of Type C raw materials, respectively, while the transportation and storage costs per m^3 of the three types of raw materials are the same.

Appendix 1 gives the order quantity and supply quantity data of 402 raw material suppliers of the production enterprise in the past 5 years. Appendix 2 shows the transportation loss rate of 8 forwarders. Based on the actual problems, your team needs to conduct a deep analysis of relevant data, and solve the following problems:

1. According to Appendix 1, please analyze the supply characteristics of 402 suppliers quantitatively, and establish a mathematical model reflecting the importance of ensuring enterprise production. Then determine 50 most important suppliers, and list the results in the paper.
2. Referring to Problem 1, how many suppliers should the enterprise choose at least to

supply raw materials to meet the production demand? For these suppliers, draw up the most economical ordering plan of raw materials for the enterprise every week in the next 24 weeks, and for this ordering plan, formulate the transshipment scheme with the least loss. Try to analyze the implementation effect of the orderings scheme and the transshipment scheme separately.

3. In order to reduce the production cost, the enterprise plans to purchase as many Type A raw materials and as few Type C raw materials as possible, so as to reduce the cost of transshipment and storage, and also hope to minimize the transshipment loss rate of the forwarders. Please formulate new ordering scheme and transshipment scheme, and analyze the implementation effect of the scheme.

4. The enterprise has the potential to increase production capacity after its technological transformation. According to the actual situation of existing suppliers and forwarders of raw materials, how much can the weekly production capacity of the enterprise be increased? And corresponding to the increased production, please give the ordering and transshipment schemes for the next 24 weeks.

Note: Please fill in the numerical results of the ordering scheme for Problem 2, Problem 3 and Problem 4 in Appendix A, and the numerical results of the transshipment scheme in Appendix B. These two files (do not change their names and formats) should be submitted as support materials of your solution paper.

Data description in Appendix 1:

1. The order quantity of the enterprise: the suppliers' names are listed in the first column; the category of raw materials supplied by the suppliers is listed in the second column; for the next 240 columns, the data in each column is the weekly order quantity (unit: m³) of the enterprise from each supplier; the value of 0 indicates that there is no order with the supplier (at the corresponding row) in the corresponding week (at the corresponding column).

2. The supply quantity of suppliers: the suppliers' names are listed in the first column; the category of raw materials supplied by the suppliers is listed in the second column; for the next 240 columns, the data in each column is the weekly supply quantity (unit: m³) of each supplier. The value of 0 indicates that there is no supply of the supplier (at the corresponding row) in the corresponding week (at the corresponding column).

Data description in Appendix 2:

The names of the forwarders are listed in the first column; the weekly transportation loss rate (%) of each forwarder is listed in the 240 columns next to the second column, which is

$$\text{Loss Rate} = \frac{\text{Supply Quantity} - \text{Received Quantity}}{\text{Supply Quantity}} \times 100\%,$$

the value of 0 indicates no delivery.