Bidding decision optimization based on integer programming method - a case study of virtual company of Ewood Technology Company

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Abstract: The report delves into the challenges faced by a Communication Base Station Equipment company. In January, the company encountered a financial crisis due to a lack of strategic consideration in bid management, particularly in terms of the number and geographical spread of tenders, leading to a negative profit margin. To address this, the report adopts integer programming as a tool to optimize profits for both January and February. This approach includes modeling various variables such as monthly factory upgrades, delivery schedules, and procurement volumes. The parameters set for the model encompass decisions on bids, selections of factory delivery options, and quantities of materials to be procured. The primary objective is to maximize the total profit by the end of February.

There are specific recommendations, such as choosing four bids in January and seven in February, strategically distributed across two manufacturing facilities. Additionally, the report underscores the importance of managing total production time for all tenders to prevent negative impacts on subsequent tender processes and potential breaches of contracts.

Keywords: Supply Chain; Integer Programming; Purchasing

1. Introduction of virtual company

The communication base station equipment manufacturing enterprise is a virtual enterprise invented by Yi Wu Co., LTD. Which operate two factories located in Jinan and Hefei. Its business model involves bidding for contracts with potential customers. Successful bids lead to weekly procurement of raw materials, tailored to order quantities. The factories then engage in production, followed by shipping the finished products to customers. The process culminates with customer payments, closing the supply chain loop.This setup underscores the importance of efficient bid management and production coordination to maintain profitability and customer satisfaction.

2. Problem identification

The company is currently facing several financial and operational challenges, in analyzing the current situation, it's evident that January experienced a surplus of 3,954 units, whereas February faced a deficit of 684 units, highlighting an imbalance between production and demand over these months. January's profit was negative, adding to the pressure on spending in February, while there was a significant increase in revenue from January to February, likely attributed to heightened demand and possibly larger tender quantities. However, this is in line with an increase in all cost categories for February, expected due to higher production volumes, but raising concerns about whether this cost rise is proportional to the revenue increase. The procurement cost, which more than doubled from January to February, suggests a possible hike in material costs. In the case of raw materials, companies have signed contracts that are too expensive and have high prepayments at a 70% rate, resulting in insufficient funds to carry out other activities. The shortage of funds affected the final payment of February, and it was impossible to continue ordering raw materials and production, which threatened the long-term operation of the company.

Because the volumes and order location are not fully considered in the bidding, resulting in high logistics costs. This also results in the double blow of default and liquidated damages, and affects customer cooperation. Furthermore, the notable rise in transportation costs in February could be due to an increased number of products shipped or higher shipping rates. The increases in fixed operation and production costs align with the expansion activities at the Jinan factory. In the profit aspect, the company shifted from a loss in January to a substantial profit in February, resulting in an overall positive two-month total profit, but as February made up much of the losses incurred in January, it ended up overpaying.

3. Assumption

The Integer programming method and decision theory are selected to address the problem.

The company's factories are located in Jinan and Hefei, with specific start dates on 1.08 and 1.14 for their operation. So, Jinan produces 23 days in January, and Hefei produces 18 days. Hefei and Jinan factories are small factories in January that have a capacity of 300 units per day, providing a clear measure for planning production schedules and bidding strategies. An 85% quality rate is assumed for the production of January, which impacts the total effective output and planning for procurement to meet quality product demand. Daily operating costs and per-unit production costs are fixed at 36 thousand per day and ￥360 per unit respectively in both Jinan and Hefei factories. The company has exclusive deals with all three component suppliers, the Anhui chip factory, the Shandong crate factory, and the Hebei battery plant. The consumption of chips, crates, and battery supply in the product is 2:1:1 respectively. Since there is no regulation on the quantities for different components (chips, cases, and power supplies), they will vary to align with production needs and quality rates, reflecting more realistic scenarios and potentially reducing costs.

Suppliers will not fail to deliver specific prepayment percentages for different components and the advance payment for the purchase of chips, chassis, and power supplies is 70%, 50%, and 50% respectively at the time of purchase. Assuming a 100% success rate in bidding simplifies the financial and operational planning, so there is no need to consider the problem of margin, all scalars are up and settled before the end of January, and the winning unit price is ￥1,950. After winning the bid, to ensure a high enough credit score, it is not possible to default on late delivery or termination of the contract, but represents an ideal scenario.

In February, the Jinan factory was improved to a middle one, which has a larger capacity of 600 units per day, with an 87% quality rate the fixed start cost is 60,000 CNY / day, and the production cost of the product is reduced to 300 CNY / piece. The winning unit price increases to ￥2000.

In the delivery process, the company chooses "overtime express", the unit price is 177.23 CNY/piece, Minimal Transport Quantity is 240 pieces, two factories cannot distribute the same order. All orders are delivered centrally after production at the end of the month. We assume that according to the distance of the order, to arrange the transportation of Jinan or Hefei, and the closer factories give priority to delivery. There is no inventory in the factory at the end of the month.

4. Overview of General Model

Decision Variables

Xi=1 if the target bid is selected (binary)

Xij=1 if a target is delivered from factory j (binary)

P_C=number of components c(chip,crate,battery) purchased in month t

Vit=factory j' s production volume in month t

Obejective Function

$$= max(\sum(TargetPrice_t \times Demand_i \times X_i) - \sum(PurchasedPrice_c \times P_{ct})$$
$$- \sum(X_{ij} \times \frac{Demand_i}{MinUnit_i} \times 42000) - \sum(OperationDay \times OperationCost_j)$$
$$- \sum(CostPerUnit_j \times V_{jt}))$$

Constraints

$$\sum X_{ij} = \sum X_i \ \forall i = 1, \cdots, 28; \forall j = 1,2;$$

$$\sum V_j t \geq \sum(Demand_i \times X_{ij}) \ \forall i = 1, \cdots, 28; \forall j = 1,2; \forall t = 1,2$$

Product=2Chip+Crate+Battery

$$\sum_{i=1}^{n} V_j t \leqslant ProductionCapacity_{it} \ \forall i = 1, \cdots, 28; \forall j = 1,2; \forall t = 1,2$$

5. Results and Discussion

After implementation of the model, the results show that among the 28 target bids, 11 bids were selected, (4 in January and 7 in February). Apart from that, a total production level of 12274 in January and 25143 in February is available. The map below shows the delivery route for each factory.

After the model was implemented, January experienced a substantial increase in demand, which suggests that the model's approach to market analysis or customer engagement is highly effective. However, the slight decrease in February's demand could indicate market saturation or shifting customer needs that the model did not fully anticipate.

The model remarkably reduced surplus inventory in January, moving towards a just-in-time production model, which helps in reducing holding costs. No deficit occurred in the new model, indicating that the default rate of orders is 0%, which will improve customer satisfaction and relationship management.

The increase in January revenue is aligned with the increased demand, which is a positive indicator of the model's effectiveness. However, the slight decrease in February, despite being minor, is the best scenario given the current production level of factories.

The procurement cost savings are a significant achievement, resulting from better supplier negotiations therefore more advantageous payment terms are achieved, and reduced repayment pressure helps January to switch from loss-making to profit.

Transportation cost reductions are impressive and may reflect optimized delivery routes, and improved logistics planning, as the model will automatically calculate the shortest path for each factory and ensure that every customer is delivered by its nearest factory, therefore, transportation costs are reduced drastically.

The model focuses on selecting targets and the amount of materials to be purchased in a short time (two months) rather than changing the fixed cost. The unchanged fixed operation costs were expected; however, there might be opportunities for long-term savings through investments in automation or energy efficiency.

Production costs remained the same, which could mean that the model has assumed that the production level is constant as each factory is at its maximal production level once they are set.

The dramatic increase in January's profits is a direct result of increased demand and significant cost reductions, showcasing the model's overall effectiveness. The profit increase in February, while smaller, still indicates positive performance, especially given the minor decrease in revenue. The model seems to manage costs effectively to maintain profitability.

6. Recommendations

6.1 Bid Selection—Location

When considering transportation costs, it's crucial to note that the cost per dispatch is ￥42,000, with the bid price range of ￥1,950 to ￥2,000. Given this cost structure, to avoid a loss, each dispatch must contain more than 22 products. However, merely considering transportation costs is insufficient; production and procurement costs must also be accounted for (Si, J. et al., 2023). Integrating these factors, it is deduced that the quantity of goods per shipment should be no less than 50 items. Therefore, the company should opt for bids where the minimum quantity per shipment is at least 60 items. Taking the January bid for Ruili as an example, for factories in Jinan and Hefei, this bid should be avoided as the transportation cost per shipment cannot be covered by the revenue.

6.2 Bid Selection—Volume

Next, the bid volume is also significant. The production costs for small and medium-sized factories are ￥50 and ￥300 respectively, with startup costs of ￥36,000 and ￥60,000. Considering the transportation costs, we reiterate that the quantity per shipment should exceed 50 items to ensure factories operate at maximum capacity daily. Therefore, caution is advised when selecting bid volumes during the bidding process. This case assumes that each bid can only be supplied by one factory, so the production time of a factory for one bid should not exceed one week. Specifically, the bid volume for a small factory is about 2,500 items, and for a medium factory, about 4,000 items. Exceeding these limits could lead to excessive transportation costs and might also affect subsequent bidding plans.

References

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