A Goal Programming Approach for Food Product Distribution of Small and Medium Enterprises

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ABSTRACT

Small and Medium Enterprise (SME) is now an emerging industry in Malaysia. Frozen food products are in high demand but not all demands can be met due to certain limiting factors. This study is undertaken to develop a goal programming model in order to optimize the customers’ demands of a SME company producing frozen foods. A pre-emptive goal programming model is formulated with three objectives. These are maximizing the total distribution of five products of frozen foods to three different locations, maximizing total profits and minimizing the total manufacturing costs using LINDO 6.1 as the optimizer solver. The first objective was achieved, albeit not fully. Nonetheless, the second and third objectives were fully achieved.

Key words: Frozen foods; goal programming; small and medium enterprise.

Methodology:

Goal Programming (GP) was introduced by Charnes and Cooper in the early 1960s to solve multi-objective mathematical programming model [3]. The objective function of a GP model with \( n \) goals can be written as

\[
P_1 = \text{minimum } G_1 \\
P_2 = \text{minimum } G_2 \\
\vdots \\
P_n = \text{minimum } G_n
\]

In this study, a pre-emptive goal programming model with three primary objectives is formulated. The objectives are maximizing the total distribution of five products of frozen foods to three different locations, maximizing total profits and minimizing the total manufacturing costs. LINDO 6.1 is used as the optimizer solver. A case study involving a SME company, a frozen food enterprise which is based on seafood products in the Kuala Selangor district, is undertaken. The products of this company under consideration are frozen cockle fills, crab balls, squid balls, shrimp balls and fish nuggets. Demands exceed supply but the company has to make sure that only the demands that are profitable should be fulfilled.
with $P_1, P_2, \ldots, P_n$ as the priority level for every goal arranged according to its priority, that is $G_1 \geq G_2 \geq \ldots \geq G_n$.

In general, the GP model is written as

$$\text{minimum } z = \sum_{i=1}^{n} P_i(d^-_i + w_i d^+_i)$$

subject to

$$\sum_{j=1}^{m} a_{ij} x_{ij} + d^-_i - d^+_i = b_i \quad (i = 1, 2, \ldots, m)$$

$x_{ij}, d^-_i, d^+_i \geq 0$

The above model is defined as follows:

$P_i$: priority level for each goal

$w_i$: weight for each decision variable.

$b_i$: aspiration level for the $i$-th goal

$d^-_i$: underachievement variable for the $i$-th goal

$d^+_i$: overachievement variable for the $i$-th goal

There are three main demand location, namely Kulai, Ampang and Kuala Lumpur. The demand from every location differs according to customer needs. The delivery costs are also different due to the varying distance. A few assumptions are made:

1) Demand from each location is the average monthly demand of that location.

2) The delivery costs are borne equally by both supplier and buyer.

3) The gross profit is calculated as the difference between total sales and production cost of each product.

4) The monthly net profit must be at least 30% of the allocated budget.

5) All types of the $i$-th food product sent to all three locations must not be nil.

Model Development:

1) Demand of the $i$-th product from location $j$

$$x_{ij} = D_{ij} \quad i = 1, 2, 3 \quad j = 1, 2, 3$$

(1)

Overachievement and underachievement variables are added to this constraint to minimize underachievement

$$x_{ij} + d^-_k - d^+_k = D_{ij} \quad i = 1, 2, 3 \quad j = 1, 2, 3 \quad k = 1, 2, \ldots, 15$$

(2)

2) The net profit must be at least 30% of the budget allocation

$$\left(\sum_{i=1}^{3} a_{i1} x_{i1} - a_K\right) + \left(\sum_{i=1}^{3} a_{i2} x_{i2} - a_A\right) + \left(\sum_{i=1}^{3} a_{i3} x_{i3} - a_L\right) \geq 0.3B$$

(3)

The first part of the above inequality is the net profit from Kulai, followed by Ampang and Kuala Lumpur respectively. The net profit is the difference between the gross profit and the delivery cost to every location.

Overachievement and underachievement variables are added to this constraint to minimize the underachievement variable $d^-_{16}$ forming the soft constraint:

$$\left(\sum_{i=1}^{3} a_{i1} x_{i1} - a_K\right) + \left(\sum_{i=1}^{3} a_{i2} x_{i2} - a_A\right) + \left(\sum_{i=1}^{3} a_{i3} x_{i3} - a_L\right) + d^-_{16} - d^+_{16} = 0.3B$$

(4)

and rewritten as

$$\sum_{i=1}^{3} a_{i1} x_{i1} + \sum_{i=1}^{3} a_{i2} x_{i2} + \sum_{i=1}^{3} a_{i3} x_{i3} + d^-_{16} - d^+_{16} = 0.3B + \alpha_K + \alpha_A + \alpha_L$$

(5)

3) The manufacturing costs should not exceed the monthly allocated budget.

$$\sum_{i=1}^{3} \sum_{j=1}^{3} c_{ij} x_{ij} \leq B$$

(6)

Overachievement and underachievement variables are added to this constraint to minimize the overachievement variable $d^+_{17}$

$$\sum_{i=1}^{3} \sum_{j=1}^{3} c_{ij} x_{ij} + d^+_{17} - d^-_{17} = B$$

(7)

All overachievement and underachievement variables are not allowed to be negative.

$$d^-_k, d^+_k \geq 0 \quad k = 1, 2, \ldots, 17$$

(8)

4) The monthly supply to each location must be within the minimum and maximum demands.

$$S_i \leq \sum_{j=1}^{3} x_{ij} \leq S^u_i \quad i = 1, 2, 3$$

(9)
5) Supply of each product must be at least 1
\[ x_{ij} \geq 1 \quad i = 1, 2, \ldots, 5, \quad j = 1, 2, 3 \]  
\( (10) \)  
The priority level of the GP model is as follows:
- \( P_1: \) demand of products are to be fulfilled.
- \( P_2: \) the net profit is to be at least 30 percent of the total budget.

The list of data are listed in Table 1, Table 2, and Table 3

Table 1: Costs and selling price for each food product

<table>
<thead>
<tr>
<th>( i )</th>
<th>Food product</th>
<th>Cost per kg</th>
<th>Sales per kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Kerang beku</td>
<td>4.50</td>
<td>7.00</td>
</tr>
<tr>
<td>2</td>
<td>Bebola kuttle</td>
<td>6.00</td>
<td>8.00</td>
</tr>
<tr>
<td>3</td>
<td>Bebola sotong</td>
<td>6.00</td>
<td>8.00</td>
</tr>
<tr>
<td>4</td>
<td>Bebola udang</td>
<td>6.00</td>
<td>8.00</td>
</tr>
<tr>
<td>5</td>
<td>Nuget ikan</td>
<td>6.00</td>
<td>8.00</td>
</tr>
</tbody>
</table>

Table 2: Supply and demand of products

<table>
<thead>
<tr>
<th>Food product</th>
<th>Supply</th>
<th>Demand</th>
<th>Kulai</th>
<th>Ampang</th>
<th>Kuala Lumpur</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kerang beku</td>
<td>2000</td>
<td>3000</td>
<td>2000</td>
<td>700</td>
<td>500</td>
</tr>
<tr>
<td>Bebola kuttle</td>
<td>400</td>
<td>500</td>
<td>300</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>Bebola sotong</td>
<td>400</td>
<td>500</td>
<td>300</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>Bebola udang</td>
<td>400</td>
<td>500</td>
<td>300</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>Nuget ikan</td>
<td>400</td>
<td>500</td>
<td>300</td>
<td>200</td>
<td>200</td>
</tr>
</tbody>
</table>

Table 3: Delivery costs

<table>
<thead>
<tr>
<th>Location</th>
<th>Kulai</th>
<th>Ampang</th>
<th>Kuala Lumpur</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delivery</td>
<td>400</td>
<td>200</td>
<td>200</td>
</tr>
</tbody>
</table>

Every month, the company allocates RM 28, 000 as a budget to produce frozen foods. The net profit is to be at least 30 percent of this budget.

Results And Discussion

This model is solved using the LINDO version 6.1 software. The value of the objective function obtained from this model is 1000 with values of \( P_1, P_2 \) and \( P_3 \) are 1000, 0 and 0 respectively. This implies that the first objective is not fully achieved whereas the second and the third objectives are fully achieved.

The first objective is to determine the number of food products delivered based on the demands of each location. All the underachievement variables have zero values, except for \( d_2, d_3, d_4, d_5 \) and \( d_6 \) valued at 200 each. These suggest that 200 kilograms request for crab balls, squid balls, shrimp balls and fish nuggets in Kulai cannot be fulfilled. The same goes for 200 kilograms of frozen cockles request in Ampang. Hence, the supplier must increase the production of these items accordingly. The second objective of increasing the net profit of the food products sold is fully achieved with \( d_{16} \) valued at zero. The net profit increased by RM 2300 and can be seen from the value of \( d_{16}^+ \). The last objective to reduce the production cost is also fully achieved with \( d_{17}^+ \) valued at zero. In fact, the production cost can be saved as much as RM 2500 as indicated by the value \( d_{17}^- \).

It can be seen that the GP model is a useful tool for SME’s to determine their production planning to satisfy the growing demands of their markets. Proper planning will ensure that all the demands will be met to avoid loss of customers’ faith in the supply of food products while ensuring that there is sufficient supply to every location.

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References

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