Advances in Environmental Biology, 6(2): 510-513, 2012
ISSN 1995-0756

This is a refereed journal and all articles are professionally screened and reviewed **ORIGINAL ARTICLE**

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

Nasruddin Hassan and Zuraini Ayop

School of Mathematical Sciences, Faculty of Science and Technology, Universiti Kebangsaan Malaysia 43600 UKM Bangi Selangor D.E., MALAYSIA

Nasruddin Hassan and Zuraini Ayop: A Goal Programming Approach for Food Product Distribution of Small and Medium Enterprises

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.

Introduction

Small and Medium Enterprise (SME) is defined as a manufacturing industry having full-time staffs employed numbering not more than 150 people. In Malaysia, SME's received full support from the government. Based on the 2005 Associations and Enterprise Census, the numbers of registered SME's numbered 33113 contributing 29 per cent to the number in the manufacturing sector, 31 per cent to value-added as well as 44 per cent to total employment [5]. Merzifonluogly and Geunes [6] stated that product manufacturing planning is to fulfill the demands with minimum costs. Planning is to be done based on varying perspectives and assuming the demands as a decision variable. Their study determined the optimum level of demand, supply and inventories for every planning schedule using the heuristic dual method. Hausman *et al*. [1] used the heuristic approach to study the probability of demands being optimally met. The study considered various inventory systems which are represented by the multivariate normal distribution to satisfy 'the early bird gets the worm' rule. Jomalnia and Soukhakian [4] used the non-linear fuzzy hybrid planning method to plan the production of goods. Yucel *et al*. [7] studied product optimization and inventory planning based on customers' demands. Cunha and Mutarelli [1] proposed a mixed linear integer planning model to optimize the number of productions and distribution of weekend news magazines in Brazil reportedly reducing the costs by 7 per cent.

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.

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 = minimum G_1
P_2 = minimum G_2
.
.
.
P_n = minimum G_n

Corresponding Author

Nasruddin Hassan, School of Mathematical Sciences,Faculty of Science and Technology Universiti Kebangsaan Malaysia 43600 UKM Bangi Selangor D.E., MALAYSIA

with $P_1, P_2, ..., P_n$ as the priority level for every goal arranged according to its priority, that is $G_1 \geq G_2 \geq ... \geq G_n$

In general , the GP model is written as

$$\text{minimum } z = \sum_{i=1}^{m} P_i (w_i d_i^- + w_i d_i^+)$$

subject to

$$\sum_{j=1}^{n} a_{ij} x_{ij} + d_i^- - d_i^+ = b_i \qquad (i = 1, 2, ..., m)$$

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

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-thgoal*

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*

$$x_{ij} = D_{ij} \qquad i = 1, 2, ..., 5 \;,\; j = 1, 2, 3 \tag{1}$$

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

$$x_{ij} + d_k^- - d_k^+ = D_{ij} \qquad i = 1, 2, ..., 5 \,,\; j = 1, 2, 3 \,,\; k = 1, 2, ..., 15 \tag{2}$$

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

$$\left(\sum_{i=1}^{5} a_i x_{i1} - \alpha_K \right) + \left(\sum_{i=1}^{5} a_i x_{i2} - \alpha_A \right) + \left(\sum_{i=1}^{5} a_i x_{i3} - \alpha_L \right) \geq 0.3B \tag{3}$$

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:

$$\left(\sum_{i=1}^{5} a_i x_{i1} - \alpha_K \right) + \left(\sum_{i=1}^{5} a_i x_{i2} - \alpha_A \right) + \left(\sum_{i=1}^{5} a_i x_{i3} - \alpha_L \right) + d_{16}^- - d_{16}^+ = 0.3B \tag{4}$$

and rewritten as

$$\sum_{i=1}^{5} a_i x_{i1} + \sum_{i=1}^{5} a_i x_{i2} + \sum_{i=1}^{5} a_i x_{i3} + d_{16}^- - d_{16}^+ = 0.3B + \alpha_K + \alpha_A + \alpha_L \tag{5}$$

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

$$\sum_{i=1}^{5} \sum_{j=1}^{3} c_i x_{ij} \leq B \tag{6}$$

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

$$\sum_{i=1}^{5} \sum_{j=1}^{3} c_i x_{ij} + d_{17}^- - d_{17}^+ = B \tag{7}$$

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

$$d_k^-, d_k^+ \geq 0 \qquad k = 1, 2, ..., 17 \tag{8}$$

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

$$S_i^l \leq \sum_{j=1}^{3} x_{ij} \leq S_i^u \qquad i = 1, 2, ..., 5 \tag{9}$$

5) Supply of each product must be at least 1

$$x_{ij} \geq 1 \qquad i = 1, 2, ..., 5\,,\; j = 1, 2, 3 \qquad (10)$$

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.

P_3 : the manufacturing costs does not exceed the allocated monthly 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

i	Food product	Cost per kg	Sales per kg
1	Kerang beku	4.50	7.00
2	Bebola ketam	6.00	8.00
3	Bebola sotong	6.00	8.00
4	Bebola udang	6.00	8.00
5	Nuget ikan	6.00	8.00

Table 2: Supply and demand of products

Food product	Supply		Demand		
	Minimum	Maximum	Kulai	Ampang	Kuala Lumpur
Kerang beku	2000	3000	2000	700	500
Bebola ketam	400	500	300	200	200
Bebola sotong	400	500	300	200	200
Bebola udang	400	500	300	200	200
Nuget ikan	400	500	300	200	200

Table 3: Delivery costs

Location	Kulai	Ampang	Kuala Lumpur
Delivery	400	200	200

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 $d_2^-, d_3^-, d_4^-, d_5^-$ dan 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 RM2500 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 lossof customers' faith in the supply of food products while ensuring that there is sufficient supply to every location.

Acknowledgement

We are indebted to Universiti Kebangsaan Malaysia for funding this research under the grant UKM-GUP-2011-159. We would also like to thank our understudy Nik Nur Hamizah Nik Ibrahim for her cooperation.

References

1. Cunha, C.B. & F. Mutarelli, 2007. A spreadsheet-based optimization model for the integrated problem of producing and distributing a major weekly newsmagazine. European Journal of Operational Research, 176(2): 925-940.
2. Hausman, W.H., H.L. Lee, & A.X. Zhang, 1998. Joint demand fulfilment probability in a multi-item inventory system with independent order-up-to-policy. European Journal of Operational Research, 109(3): 646-659.
3. Ignizio, J.P., 1976. *Goal Programming and Extensions.* Lexington: Lexington Books.
4. Jomalnia, A. & M.A. Soukhakian, 2009. A hybrid fuzzy goal programming approach with different goal priorities to aggregate production

planning.*Computers and Industrial Engineering*, 56 : 1474-1486.
5. Malaysia, 2006. *Ninth Malaysian Plan* 2006-2010. Economic Planning Unit, Prime Minister Department.
6. Merzifonluogly, Y. & J. Geunes, 2006. Uncapacitated production and location planning models with demand fulfillment flexibility. International Journal of Production Economics, 102(2): 199-216.
7. Yucel, E., F. Karaesman, F.S. Salman, & M. Turkay, 2009.Optimizing product assortment under customer-driven demand substitution. European Journal of Operational Research, 199(3): 759-768.