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A Goal Programming Approach for Frozen Food Production Planning

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HIGHLIGHTS

- Lexicographic Goal Programming was used to develop models for food production planning in small and medium enterprise (SME).
- The result was obtained using LINGO software.
- The result was compared using available and other findings were reviewed.

ABSTRACT

This paper examines the Goal Programming (GP) approach in food production planning in order to further enhance and find better solutions. The objective of this paper is to determine the optimum level of frozen food production for small and medium enterprise (SME). Azali Frozen Food, a small and medium enterprise located in Penang was selected as it can produce a range of frozen foods throughout the country. The problem is handled through Lexicographic Goal Programming. The results are compared to the available data that was given and other findings were reviewed. The findings of this paper are expected to assist community small and medium enterprise and other decision makers involved in production planning. The developed method will also be of use for those who are interested in the model of goal programming to solve complex planning issues involving uncertain parameters.

Keywords: *goal programming, small and medium enterprise, production planning*

INTRODUCTION

A small and medium enterprise (SME) is defined as a company with fewer than 150 employees (Hassan & Ayop, 2012). It is considered as a business tool, as well as a source of employment and income. It is the biggest contributor to accomplishing the fundamental goals of any national economy, as well as an innovative and competitive power (Herman, 2012). A plan for determining production goals and estimating resources is known as production planning. To achieve these objectives, production planning is required in organisation's process in order to get optimize production. Production planning is an essential activity in any manufacturing system. It also entails allocating available resources to the required operations (Saidi-Mehrabad, Paydar & Aalaei, 2013). Furthermore, it allows to create a detailed plan for achieving production goals in a cost-effective, efficient, and timely manner. Still, it also discovered that production planning is a difficult task. For this reason, close collaboration between all units in any organisation is required (Hassan, Idris and Razman, 2013). The problem that companies frequently face when conducting production planning is optimizing more than one goal, so proper planning and a solution method to combine optimal solutions from incompatible factors are required. Georgios, Luis, and Micheal (2011).

LITERATURE REVIEW

According to Silva et al. (2013), GP is a multi-objective optimization technique. This technique is used by decision-makers to solve complex problems, as well as those committed to finding solutions that meet the multiple objectives (Shrivastava, Verma, and Sharman, 2013). Many recent research ideas for production planning using goal programming have been developed. Previously Setiawati and Arisya, 2018 optimized amount of three types of chocolate product in order to maximize the profit of the chocolate factory using goal programming. Kumar 2019 created pre-emptive priory weighted goal programming for a small-scale industry in Hyderabad that produces five bakery products. Meanwhile for clothing production, Anggraeni et al., (2015) used the goal programming method to determine how many clothing productions should be produced in order to achieve the best possible production results that are in line with the company's goals. In fact, according to (Hassan & Ayop, 2012) SME's can use the GP model to determine their production planning in order to meet the expanding demands of their markets. There is evidence stated that small and medium enterprise require the goal programming model to calculate their profits based on the use of their labour, machinery, and raw materials (Hassan et al., 2013).

METHODOLOGY

Goal Programming Approach

GP can be used in solving multiple objectives. According to Chang and Lee, (2010) , it can be used to design the best overall optimal performance in a multi objective decision problem. The general GP as defined by Ignizio (1976) can be presented as

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

subject to

$$\sum_{j=1}^{n} a_{ij} x_j + d_i^- - d_i^+ = b_i$$

$x_j , d_i^- , d_i^+ \geq 0$ for all i and j

P_i represents the priority level assigned to each relevant goal in rank order. For example $P_1 > P_2 > ... > P_n$ and w_i are nonnegative constants representing the numerical weights associated with deviational variables, d_i^- and d_i^+ corresponding goal, b_i. The x_j represents the decision variables for the items while a_{ij} represents the decision variables coefficients.

Steps for Formulating Goal Programming Model

There are a few important steps in order to create a GP model. The step can be concluded as follows (Ahmad et al., 2005):

Step 1: Determine decision variables.
Step 2: Determine the aspirational levels of each objective.
Step 3: Determine the deviational variables of each objective and each of the constraint.
Step 4: Rank the goals of importance.
Step 5: Setting the achievement functions.

Proposed Method

The proposed method is based on pre-emptive goal programming. The aim of this study is to construct a goal programming model that can be used in a real-life production situation in a small-medium industry. The data is collected from Azali Frozen Food in Penang. The optimization aim is to maximize its daily sale profit of RM 330 per day, minimise overtime and staff, and maximizing machine utility. The procedure for a goal programming approach for frozen food production planning is summarized as in Figure 1.

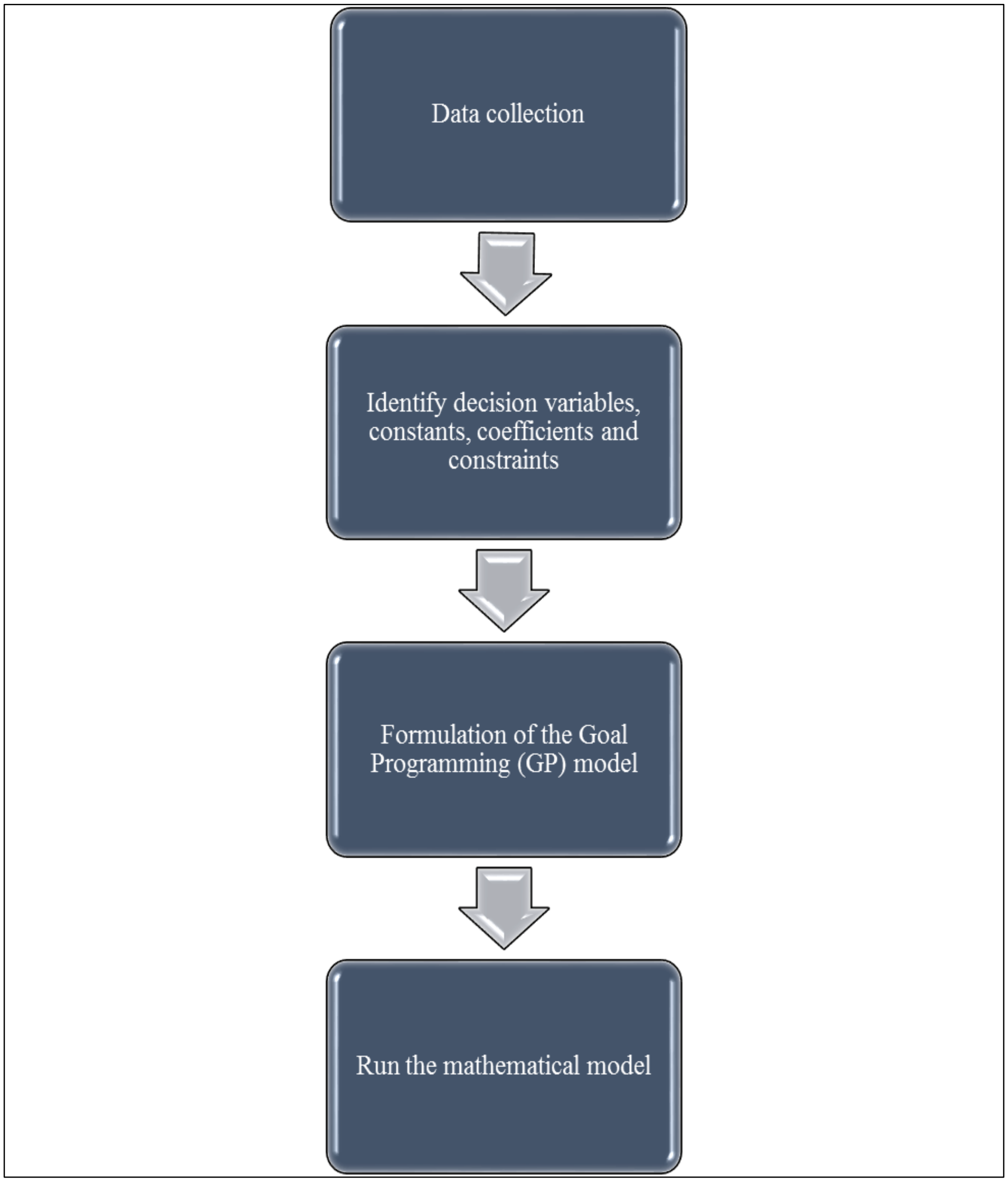

Figure 1: Flowchart of Goal Programming Approach for Frozen Food Production Planning

IMPLEMENTATION

There are a few things that need to be considered before build the model depend on the steps taken in the goal programming formulation. Thus, this model is developed with three decision variables, 17 hard constraints, three goals, three aspirational levels and two priorities. All these factors need to be considered. The data were collected from person in charge at Azali Frozen Food which located in Penang.

Table 1: Decision Variables

Notation	Decision variable
Q_1	Number of murtabak
Q_2	Number of samosa
Q_3	Number of cucur badak

Table 2: Ingredient for Each Product

Symbol	Data	Value (gram)
δ_1	Quantities of flour to murtabak	20
δ_2	Quantities of flour to cucur badak	4.6
β_1	Quantities of onion to murtabak	37.5
β_2	Quantities of onion to samosa	2.3
A_1	Quantities of eggs to murtabak	25
O_1	Quantities of meat to murtabak	8
ω_1	Quantities of chicken to murtabak	8
B_1	Quantities of potatoes to murtabak	10
B_2	Quantities of potatoes to samosa	6.5
B_3	Quantities of potatoes to cucur badak	8
H_1	Quantities of sugar to murtabak	5

H_2	Quantities of sugar to samosa	4.7
H_3	Quantities of sugar to cucur badak	1.5
E_1	Quantities of carrot to samosa	0.6
I_1	Quantities of coconut to cucur badak	4.4
N_1	Quantities of prawn to cucur badak	0.37
P_1	Quantities of spice to murtabak	6.25
P_2	Quantities of spice to samosa	5.9
P_3	Quantities of spice to cucur badak	1.8
T_1	Quantities of spring roll pastry to samosa	4.2
X_1	Quantities of oil to cucur badak	2.2
Y_1	Quantities of salt to murtabak	1.25
Y_2	Quantities of salt to samosa	1.25
Y_3	Quantities of salt to cucur badak	1.25

Table 3: Profit of Each Product

Symbol	Total profit	Profit (RM)
λ_1	Murtabak	0.20
λ_2	Samosa	0.10
λ_3	Cucur badak	0.10

Table 4: Raw Materials Per Day

Symbol	Data	Total available per day (gram)
θ_1	Flour	45000
θ_2	Onion	60000
θ_3	Eggs	2500
θ_5	Meat	6400
θ_6	Potatoes	31500
θ_7	Carrot	1000
θ_8	Sugar	16000
θ_9	Coconut	12000
θ_{10}	Prawn	1000
θ_{11}	Spice	25000
θ_{12}	Spring roll pastry	3500
θ_{13}	Oil	6000
θ_{14}	Salt	4000

Table 5: Time Taken to Produce for Each Product

Symbol	Data	Minutes
α_1	Time taken for labour to produce murtabak	0.125
α_2	Time taken for labour to produce samosa	0.5
α_3	Time taken for labour to produce cucur badak	0.13
ε_1	Time taken for machine to produce murtabak	0.175
ε_2	Time taken for machine to produce samosa	0.006
ε_3	Time taken for machine to produce cucur badak	0.044

Hard Constraints

1) Total quantities of flour to murtabak and flour to cucur badak are not less than 45000g.

$$\sum_{i=1}^{2} \delta_i Q_i \leq \theta_1$$

$$\delta_1 Q_1 + \delta_2 Q_2 \leq 45000 \qquad (1)$$

2) Total quantities of onion to murtabak and onion to samosa are not less than 60000g.

$$\sum_{i=1}^{2} \beta_i Q_i \leq \theta_2$$

$$\beta_1 Q_1 + \beta_2 Q_2 \leq 60000 \qquad (2)$$

3) Total quantities of eggs to murtabak are not less than 2500g

$$A_1 Q_1 \leq 2500 \qquad (3)$$

4) Total quantities of chicken to murtabak are not less than 6400g.

$$\omega_1 Q_1 \leq 6400 \qquad (4)$$

5) Total quantities of meat to murtabak are not less than 6400g.

$$O_1 Q_1 \leq 6400 \qquad (5)$$

6) Total quantities of potatoes to murtabak, potatoes to samosa and potatoes to cucur badak are not less than 31500g.

$$\sum_{i=1}^{3} B_i Q_i \leq \theta_6$$

$$B_1 Q_1 + B_2 Q_2 + B_3 Q_3 \leq 31500 \qquad (6)$$

7) Total quantities of carrot to samosa are not less than 1000g.

$$E_1 Q_2 \leq 1000 \qquad (7)$$

8) Total quantities of sugar to murtabak, sugar to samosa and sugar to cucur badak are not less than 16000g.

$$\sum_{i=1}^{3} H_i Q_i \leq \theta_8$$

$$H_1 Q_1 + H_2 Q_2 + H_3 Q_3 \leq 16000 \qquad (8)$$

9) Total quantities of coconut to cucur badak are not less than 12000g.

$$I_1 Q_3 \leq 12000 \qquad (9)$$

10) Total quantities of prawn to cucur badak are not less than 1000g.

$$N_1 Q_3 \leq 1000 \qquad (10)$$

11) Total quantities of spice to murtabak, spice to samosa and spice to cucur badak are not less than 25000g.

$$\sum_{i=1}^{3} P_i Q_i \leq \theta_{11}$$

$$P_1Q_1 + P_2Q_2 + P_3Q_3 \leq 25000 \quad (11)$$

12) Total quantities of spring roll pastry to samosa are not less than 3500g.

$$T_1Q_2 \leq 3500 \quad (12)$$

13) Total quantity of oil to cucur badak are not less than 6000g.

$$X_1Q_3 \leq 6000 \quad (13)$$

14) Total quantity of salt to murtabak, salt to samosa and salt to cucur badak are not less than 4000g.

$$\sum_{i=1}^{3} Y_i Q_i \leq \theta_{14}$$

$$Y_1Q_1 + Y_2Q_2 + Y_3Q_3 \leq 4000 \quad (14)$$

15) The amount of murtabak required must be at least 74 pieces.

$$Q_1 \geq 74 \quad (15)$$

16) The amount of samosa required must be at least 500 pieces.

$$Q_2 \geq 500 \quad (16)$$

17) The amount of cucur badak required must be at least 2600 pieces.

$$Q_3 \geq 2600 \quad (17)$$

The Goals

There are three goals in this problem. The purpose of these goals are to present the decision maker's requirement.

1) Total profit desired in this company are RM330 per day.

   The total profits are taken from profit of murtabak, samosa and cucur badak gained per day is RM330.

$$\sum_{i=1}^{3} \lambda_i Q_i \geq 330$$

$$\lambda_1Q_1 + \lambda_2Q_2 + \lambda_3Q_3 \geq 330 \quad (18)$$

2) Minimize the overtime per staff per day is 601 minutes. There are eight staff who work in this company.

$$\sum_{i=1}^{3} \alpha_i Q_i \leq 601$$

$$\alpha_1Q_1 + \alpha_2Q_2 + \alpha_3Q_3 \leq 601 \quad (19)$$

3) Maximize the usage of machine per day is 134 minutes. This is the time taken of the usage of machine for murtabak, samosa and cucur badak.

$$\sum_{i=1}^{3} \varepsilon_i Q_i \geq 134$$

$$\varepsilon_1 Q_1 + \varepsilon_2 Q_2 + \varepsilon_3 Q_3 \geq 134 \tag{20}$$

Aspirational Levels

In this problem, aspirational levels are determined based on the frozen food's company requirement. It should be combined with the objective functions to develop the goals.
There are three aspirational levels as follows:

1) First aspirational level
The total profit desired in this company is RM330. In this research, first aspirational level is based on the first objective which is as follow:

$$\sum_{i=1}^{3} \lambda_i Q_i \geq 330$$

2) Second aspirational level
The overtime per staff per day is 601 minutes. Therefore, in this research, the second aspirational level is based on the second objective which is as follow:

$$\sum_{i=1}^{3} \alpha_i Q_i \leq 601$$

3) Third aspirational level
The usage of machine per day is 134 minutes. In this research, third aspirational level is based on third objective which is as follow:

$$\sum_{i=1}^{3} \varepsilon_i Q_i \geq 134$$

Priority Structures

The priority structures:

1) First priorities (P_1)
In this research, the first priority is based on the first goal and this will result in the achievement function. It can be obtained as follow:

Minimum $P_1 = n_1$

2) Second priorities (P_2)
In this research, the second priorities are based on the second goals and third goals and this will result in the achievement function. It can be obtained as follow:

Minimum $P_2 = p_2 + n_3$

Achievement Function

Goals are formed from combination of objective function and the aspirational level and will conclude into achievement function.
The achievement function is:

Minimization = [$P_1(n_1), P_2(p_2 + n_3)$]

RESULTS AND DISCUSSION

Results Discussion

Based on the result obtained using LINGO 13.0, all the objectives and goals are achieved. A goal that is met will depend on the deviational variables. If the value of deviational variable or priority level gives zero value and meet the prescribed deviational variable, thus the goal is met. To obtain the goal, all the deviational variables must be reviewed on each of the objectives. Table 6 below shows the result.

Table 6: Summary of the Complete Results

Results of deviational variables	Deviational variables	Priorities	Goal achievement
Q_1 =100	n_1 =0	P_1 =0	Fully achieved
Q_2 =500	n_2 =0.5	P_2 =0	Fully achieved
Q_3 =2600	n_3 =0		
	p_1 =0		
	p_2 =0		
	p_3 =0.9		

In the first priority level, negative and positive deviational variables represented symbols n_1 and p_1 in computer programming. The goal for the first priority level is to obtain at least RM330. From the table 6, the objective function for the first priority is zero which is $n_1 = 0$. Thus, the first priority, P_1 is achieved and the first objective is met. For the second priority, there are two deviational variable for negative deviation variable and two positive deviation variables which represent n_2 , n_3, p_2 and p_3. There are two goals for the second objective which are minimizing overtime and maximizing the utility of machines used in the frozen food production planning. Both goals are placed in the same level because it based on the decision maker and it also has the same unit measure which is in minutes. The objective functions show that the value for p_2 and n_3 are zero as shown in the table above. The negative variable, n_2 give the value 0.5 minutes. The value stated shown that it is less about 0.5 minutes in order to achieve the goal. The variable that should be minimized in this objective function is p_2. While the positive variable for p_3 is 0.9 minutes and the result obtained is more than 0.9 minutes in achieving the desired goal. In addition, n_3 is the variable that should be minimized in order to achieve the goals. As a result, it is shown that both goals have been achieved. In overall, the results obtained are fully achieved for first and second priorities. Thus, the objectives and the goals of this research are achieved in order to get the optimum solution.

Comparison Results

Table 7: Comparison Results

Symbol	Type of variable	Original data	Optimum value
Q_1	Number of murtabak	150	100
Q_2	Number of samosa	840	500
Q_3	Number of cucur badak	2600	2600

Table 7 shows that the comparison result between the original data and the optimum value calculated from LINGO 13.0. The solution shows that the number of murtabak and the number of samosa are exceed the optimum level which are 50 pieces for the number of murtabak and 340 pieces for the number of samosa whereas the number of cucur badak is in the optimum level which is 2600 pieces. This solution can be expected to help in the planning of frozen food production in order to achieve the necessary target.

CONCLUSION

In conclusion, goal programming is a suitable technique used in optimizing food production planning. Sinha and Sen (2011) concluded that the goal programming model (GP) is a powerful tool that draws upon highly developed and tested approaches in linear programming, whereas Babic and Peric (2011) argued that the GP has demonstrated as an useful procedure in finding the optimal solution. Furthermore, based on available resources, this model can help increase food production for small and medium enterprise. A similar methodology could be utilized by other SMEs or industries for future planning.

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CONFLICT OF INTEREST DISCLOSURE

All authors declared that they have no conflicts of interest to disclose.

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