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Research Article

Optimal Multi-Criteria Decision Model For The Production And Supply Of Ball Valve By Utilizing Recycled Plastic In Green Manufacturing Company

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Abstract: In the current scenario industrialization is placing a huge impact on developing nations such as India especially the production sector. Due to the rapid growth of the country, creating a huge demand in the production of food grains which is resulting in the Green revolution. As raining is seasonal in India, farming is majorly depending on the irrigation system. In this paper, we considered a Green manufacturing private company established under Make in India Project with the mission and vision of Swatch Bharath Abhiyan, which produces ball-valve using recycled plastic which helps to control the flow of water. The company is producing different varieties of ball valves as per the need of farmers. Thus, the company needs to achieve multiple goals such as minimizing production cost, maximizing profit, increasing the sales, minimizing the raw material cost, optimum utilization of human resources, matching up to the farmers demand, minimizing the transportation cost, marketing and advertisement cost, investment in research and development, cost of quality checking, minimizing losses during production, optimum usage of where house capacity, minimization of lost sales, minimizing of damage during packing and transportation. Keeping all these constraints in mind we developed an Optimal Multi-Criteria Decision Model [MCDM] using Goal Programming [GP] technique to achieve all the goals according to priorities of the manufacturer up to a satisfactory level based on the obtained deviation.

Keyword: Goal Programming, MCDM, Production and Supply, Under achievement, Over achievement

1. Introduction

Industrialization and farming are back bone of every growing nation. Especially after green revolution and industrial revolution everyone is significantly giving extra attention toward the production sectors. Due to these revolutions solid waste management is also becoming predominate problem especially plastic wastes. To avoid these many of green manufacturing is companies been established. Here we took one such company which helps the farmers in irrigation system by producing all kinds of option in ball vales. As some standard companies does not concentrate on local problems in irrigation, this company is showing lot of promise towards addressing problems of the farmers. Also, company is intended in reutilizing the waste plastic which is also a great step toward improving environmental health. The company is concentrating on production of ball valve using these plastics which helps farmers in the irrigation which helps to control irrigation system.

Currently company is producing different varieties of ball vale which is helping the local farmers to control the irrigation system providing water supply in required direction. For this purpose company want to help the local farmers hence they want to optimise this problem as they are exclusively want to do the work for the social cause along with other manufacturing parts they want to produce ball vales. For this production company want to optimize several goals such as minimizing production cost, maximizing profit, increasing the sales, minimizing the raw material cost, optimum utilization of human resources, matching up to the farmers demand, maintaining the quality standard of materials, minimizing the transportation cost, marketing and advertisement cost, investment in research and development, cost of quality checking, minimizing losses during production, optimum usage of where house capacity, minimization of lost sales, minimizing of damage during packing and transportation. Thus, we have developed a multi criteria decision model using goal programming to optimize the problem according to the priorities given the officials of the company so that they can manage this in a better manner.

Review of literature

Wang and Liang has given fuzzy multi-objective linear programming model in the multi-product aggregate production planning problem. To demonstrate the feasibility of applying the model to APP problem they have given numerical example. The proposed model compromise solution and the decision maker's overall levels of satisfaction to achieve the goals. Also, several significant characteristics of the proposed model were presented for APP problem. Leung and Ng developed a pre-emptive goal programming model to solve APP problem for perishable items. The Hong Kong data was applied to determine the ability of the proposed model. Results displayed that the decision-makers can find the flexibility of the proposed model. Mirzapur Al-e-hashem et al. took a supply chain problem by considering multiple aspects such as multi-site, multi- period, multi-product aggregate production planning (APP) problem. Here the mathematical model was solved as a single-objective mixed integer programming model applying the LP-metrics method is applied deal with APP including two conflicting objectives simultaneously. The results showed the proposed model can achieve an efficient result. Ramezanian et al. praposed a mixed integer linear programming (MILP) model for two-phase APP systems. A genetic algorithm and tabu search was applied for solving this problem. The outcomes showed that these proposed algorithms would give good quality solutions for APP. Zhang et al. applied a MILP model to the problem of APP with capacity expansion in a manufacturing system for multiple activity centres. It used the heuristic based on capacity shifting with linear relaxation to solve the problem. The results showed that the heuristic based on the capacity shifting with CLR is very quick but results in the low-quality solution whereas the capacity shifting with PLR provides good solutions but at the cost of considerable amount of computational time.

2. Materials & methods

Multi criteria decision making (MCDM) methodology is widely applied when we have to achieve multiple goals simultaneously with different variety of constraints. Goal programming is a tool facilitates us to achieve the goals up to most satisfactory level according to priorities by minimising the deviations. Here we may not achieve every goal but higher priority goals are achieved at the cost of lower priority goals. General Goal Programming model is as follows

Objective function: $Minimize\ Z = \sum_{i=1}^{m}\sum_{k=1}^{K} P_k(w_{i,k}^{+}d_i^{+} + w_{i,k}^{-}d_i^{-})$

Subjected to

Soft constraints $\sum_{j=1}^{n} a_{ij}x_j + d_i^{-} - d_i^{+} = b_i,\ for\ \ i = 1,2,\dots,m$

Hard constraints $\sum_{j=1}^{n} a_{ij}x_j(\leq = \geq)b_i,\ for\ \ i = m+1,\dots,m+p$

Non negativity conditions$x_j, d_i^{-}, d_i^{+} \geq 0 \qquad \forall\ i = 1,2,\dots,m\ \ \&\ \ j = 1,2,\dots,n$

Where m goals are expressed by an m component column b_i,

a_{ij} = coefficient for the j^{th} decision variable in the i^{th} constraint.

x_j = decision variable.

w_i = weights of each goal.

d_i^{-} = deviational variable representing the amount of under achievement of i^{th} goal.

d_i^{+} = deviational variable representing the amount of over achievement of i^{th} goal.

P_k = priority coefficient for the k^{th} priority level.

$w_{i,k}^{+}$ = is the relative weight of the d_i^{+} variable in the k^{th} priority level.

$w_{i,k}^{-}$= the relative weight of the d_i^{-} variable in the k^{th} priority level.

3. Result & discusion

The company's main intention was to find how many number of ball valve i to be produced, based on the demand, how many number of ball valve i can be kept as inventory in Wearhouse, how many units of ball valve i went into lost sales, also company desires to know how many employees are required for the production of each ball valve. Based on this we decided the decision variables as follows. Also, company had some restrictions with fixed production capacity, fixed cost for analysis of quality check and demand are considered as hard constraints. Also company had several goals to be achieved such as minimizing production cost, maximizing profit, increasing the sales, minimizing the raw material cost, optimum utilization of human resources, matching up to the farmers demand, maintaining the quality standard of materials, minimizing the transportation cost, marketing and advertisement cost, investment in research and development, cost of quality checking, minimizing losses during production, optimum usage of where house capacity, minimization of lost sales, minimizing of damage during packing and transportation are considered as soft constraints and deviation variables also be introduced along with the target values. Also, company gave us three different priorities of goals. Based on which we created three different objective function to achieve the goals in desired order. The goal programming model is as follows

Decision variable

X_i =Number of units of ball valve i produced.

S_i =Number of units of ball valve i in lost in sales.

I_I = Number of units of ball valve i in inventory

H_i = Number of employees required to produce ball valve i.
Where $i = 1,2,\dots,10$ represents different types of ball valve.

Deviation variable
U_j = Under achievement.
O_j = Over achievement.
Where $j = 1,2,\dots,12$ represents the goal constraints.
Target values
Q_i = number of units of ball valve i can be produced.
A = Total cost for quality check.
B = Total Production cost.
C = Total sales
D_i = Demand of ball valve i.
E = Total raw material cost.
F = Total number of employee available for production.
G = Total transportation cost.
H = Total investment for research and development.
K = Total cost of production losses.
L = Total available space in warehouse.
M = Total cost of lost sales.
N = Total cost of loss during packing and transportation.
Coefficients
a_i = cost per unit for quality check of ball valve i.
b_i = Production cost per unit of ball valve i.
c_i = Sales per unit of ball valve i.
e_i = raw material cost per unit of ball valve i.
g_i = Total transportation cost required to transport per unit of ball valve i.
h_i = Investment toward per unit of ball valve i.
k_i = Cost of losses during production per unit of ball valve i.
l_i = Space required per unit of ball valve i.
m_i = Cost of lost sales per unit of ball valve i.
n_i = Cost of losses during packing and transportation per unit of ball valve i.
Hard Constraints
Production capacity: $\sum_{i=1}^{n} X_i \le Q_i$
Demand constraint: $\sum_{i=1}^{n} X_i + \sum_{i=1}^{n} I_{i-1} + \sum_{i=1}^{n} S_i = \sum_{i=1}^{n} D_i + \sum_{i=1}^{n} I_i$
Cost of quality checking. $\sum_{i=1}^{n} a_i X_i = A$
Soft Constraint or Goal Constraints
Minimization of production cost $\sum_{i=1}^{n} b_i X_i + U_1 - O_1 = B$
Maximizing profit $\sum_{i=1}^{n} b_i X_i + U_2 - O_2 = B$
Increasing the sales $\sum_{i=1}^{n} c_i I_i + U_3 - O_3 = C$
Minimizing the raw material cost $\sum_{i=1}^{n} e_i X_i + U_4 - O_4 = E$
Optimum utilization of human resources $\sum_{i=1}^{n} H_i + U_5 = F$
Minimizing the transportation cost $\sum_{i=1}^{n} g_i X_i + U_6 - O_6 = G$
Maximum utilization of investment in research and development $\sum_{i=1}^{n} h_i X_i + U_7 = H$
Minimizing losses during production $\sum_{i=1}^{n} k_i X_i + U_8 - O_8 = K$
Optimum usage of warehouse capacity, $\sum_{i=1}^{n} l_i I_i + U_9 = L$
Minimization of lost sales $\sum_{i=1}^{n} m_i S_i + U_{10} - O_{10} = M$
Minimizing of damage during packing and transportation $\sum_{i=1}^{n} n_i X_i + U_{11} - O_{11} = N$
Minimizing marketing and advertisement cost $\sum_{i=1}^{n} n_i X_i + U_{12} - O_{12} = N$

Case I: Priorities

Goals	**Priority I**
Production cost	4
Profit	12
Sales	8
Raw material cost	1

Utilization of human resources	2
Transportation cost	3
Investment in research and development	5
Losses during production,	6
Optimum usage of where house capacity,	7
Lost sales	9
Damage during packing and transportation.	10
Marketing and advertisement cost	11

Objective function:

$$MINZ = P_1O_4 + P_2U_5 + P_3O_6 + P_4O_1 + P_5U_7 + P_6U_6 + P_7U_9 + P_8U_3 + P_9O_{10} + P_{10}O_{11} + P_{11}O_{12} + P_{12}U_2$$

Case II: Priorities

Goals	**Priority II**
Production cost	5
Profit	12
Sales	1
Raw material cost	3
Utilization of human resources	2
Transportation cost	4
Investment in research and development	6
Losses during production,	7
Optimum usage of where house capacity,	8
Lost sales	9
Damage during packing and transportation.	10
Marketing and advertisement cost	11

Objective function:

$$MINZ = P_1U_3 + P_2U_5 + P_3O_4 + P_4O_6 + P_5U_1 + P_6U_7 + P_7U_6 + P_8U_9 + P_9O_{10} + P_{10}O_{11} + P_{11}O_{12} + P_{12}U_2$$

Case III: Priorities

Goals	**Priority III**
Production cost	3
Profit	1
Sales	4
Raw material cost	5
Utilization of human resources	2
Transportation cost	6
Investment in research and development	11
Losses during production,	9
Optimum usage of where house capacity,	8
Lost sales	10
Damage during packing and transportation.	7
Marketing and advertisement cost	12

Objective function:

$$MINZ = P_1U_2 + P_2U_5 + P_3O_1 + P_4U_3 + P_5O_4 + P_6O_6 + P_7O_{11} + P_8U_9 + P_9U_6 + P_{10}O_{10} + P_{11}U_7 + P_{12}O_{12}$$

4. Conclusion

Here we developed an Optimal Multi-Criteria Decision Model [MCDM] using Goal Programming [GP] technique to achieve all the goals according to priorities of the manufacturer up to a satisfactory level based on the obtained deviation. Here we obtained optimum solution by minimizing production cost, maximizing profit, increasing the sales, minimizing the raw material cost, optimum utilization of human resources, matching up to the farmers demand, maintaining the quality standard of materials, minimizing the transportation cost, marketing and advertisement cost, investment in research and development, cost of quality checking, minimizing inventory cost, optimum usage of where house capacity, minimization of lost sales, minimizing of damage during packing and transportation. As per the different priorities given by the company model been executed using the software like Lindo, Lingo, CPLEX we have got most satisfactory result by achieving nearly ten different goals in first case 1, eight goals in case 2 and seven in the case of 3.

5. Future scope

The current study gives several managerial insights for decision makers working in production sector. Based on the product produced the given mathematical model can be changed according to the need of decision maker. It also helps the new entrepreneurs in manufacturing field to take proper decision even before establishing the company. Also, with different priorities they can get different solution and can take proper discission for the establishment of the production setup.

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