QMM assignment1

2023-09-10

Problem 1

Back Savers is a company that produces backpacks primarily for students. They areconsidering offering some combination of two different models—the Collegiate and the Mini. Both are made out of the same rip-resistant nylon fabric. Back Savers has a long-term contract with a supplier of the nylon and receives a 5000 square-foot shipment of the material each week. Each Collegiate requires 3 square feet while each Mini requires 2square feet. The sales forecasts indicate that at most 1000 Collegiates and 1200 Minis can be sold per week. Each Collegiate requires 45 minutes of labor to produce and generates a unit profit of $32. Each Mini requires 40 minutes of labor and generates a unit profit of $24. Back Savers has 35 laborers that each provides 40 hours of labor per week.Management wishes to know what quantity of each type of backpack to produce per week. a. Clearly define the decision variables b. What is the objective function? c. What are the constraints? d. Write down the full mathematical formulation for this LP problem.

LP Model

Create table

```
a = c(3, 1000, 45, '$32')

b = c(2, 1200, 40, '$24')

Z = matrix(c(a, b), byrow= TRUE, nrow= 2)

colnames(Z)=c('sq.feet','Sales', 'time ', 'profit')

rownames(Z)= c('collegiate', 'mini')

Result= as.table(Z)

Result
```

```
##            sq.feet Sales time  profit
## collegiate 3       1000  45    $32
## mini       2       1200  40    $24
```

1.Define the decision variables

Let, Number of collegiate Bags = a Number of mini Bags = b a,b are the decision variables for Back savers company

Let,

Number of Collegiate Bags = a

Number of Mini Bags = b

2. Objective function

In making of collegiate bag there will be a profit of 32dollars, while in making of mini bag there will be a profit of 24dollars.

$$MaxY = 32a + 24b$$

3. Constraints

Material constraint

The back saver company receives 5000 square-foot of nylon on weekly basis,and per collegiate require 3 square-feet and per mini require 2 square-feet respectively.

$$3a + 2b <= 5000$$

Sales constraint

As of sales projections, a maximum of 1000 collegiate bags and 1200 mini bags can be sold each week.

$$a <= 1000$$

$$b <= 1200$$

Labor constraint

As mentioned in the question that 40 min of labor needed to produce one unit of mini bag and 45min of labor is needed to produce one unit of collegiate bag.

(45 minutes = 0.75hours, 40 minutes = 0.67 hours)

$$0.75a + 0.67b <= 35 * 40$$

=> $0.75a + 0.67b <= 1400$

Non negativity of decision Variables

a>=0 , b>=0

4.Mathematical formulation for the LP problem

$$MaxY = 32a + 24b$$

Decision Variables = a, b

Material constraint = $3a + 2b <= 5000$

Sales constraint = $a <= 1000, b <= 1200$

Labor constraint = $0.75a + 0.67b <= 1400$

Non-negativity of decision Variables = a>=0 , b>=0

Problem 2

2.The Weigelt Corporation has three branch plants with excess production capacity.Fortunately, the corporation has a new product ready to begin production, and all three plants have this capability, so some of the excess capacity can be used in this way. This product can be made in three sizes–large, medium, and small–that yield a net unit profit of $420, $360, and $300, respectively. Plants 1, 2, and 3 have the excess capacity to produce 750, 900, and 450 units per day of this product, respectively, regardless of the size or combination of sizes involved. The amount of available in-process storage space also imposes a limitation on the production rates of the new product. Plants 1, 2, and 3 have 13,000, 12,000, and 5,000 square feet, respectively, of in-process storage space available for a day's production of this product. Each unit of the large, medium, and small sizes produced per day requires 20, 15, and 12 square feet, respectively. Sales forecasts indicate that if available, 900, 1,200, and 750 units of the large, medium, and small sizes,respectively, would be sold per day. At each plant, some employees will need to be laid off unless most of the plant's excess production capacity can be used to produce the new product. To avoid layoffs if possible, management has decided that the plants should use the same percentage of their excess capacity to produce the new product. Management wishes to know how much of each of the sizes should be produced by each of the plants to maximize profit. a. Define the decision variables b. Formulate a linear programming model for this problem.

LP Model

Create table

```
Industries = matrix(c(750, 13000, 900, 12000, 450, 5000), byrow = TRUE, nrow
=3)

colnames(Industries) = c("Capacity", "Square_feet")

rownames(Industries) = c("Plant1", "Plant2", "Plant3")

Result1= as.table(Industries)

Result1

##        Capacity Square_feet
## Plant1      750       13000
## Plant2      900       12000
## Plant3      450        5000
```

```
Z = matrix(c( 20, 900, "$420", 15, 1200, "$360", 12, 750, "$900"), byrow=
TRUE, nrow = 3)

colnames(Z) = c("Square_feet", "Sales", "Profit")

rownames(Z) = c("Large", "Medium", "Small")

Result2 = as.table(Z)

Result2

##        Square_feet Sales Profit
## Large  20          900   $420
## Medium 15          1200  $360
## Small  12          750   $900
```

Define the decision variables

The Weigelt Corporation has three types of plant.

The dimensions for the products are Large, Medium and Small that are produced in respective plants.

Considering that, the no.of Large size products in plant 1 = $F1_L$

Assume number of Medium size products in plant 1 = $F1_M$

Assume number of Small size products in plant 1 = $F1_S$

Assume number of Large size products in plant 2 = $F2_L$

Assume number of Medium size products in plant 2 = $F2_M$

Assume number of Small size products in plant 2 = $F2_S$

Assume number of Large size products in plant 3 = $F3_L$

Assume number of Medium size products in plant 3 = $F3_M$

Assume number of Small size products in plant 3 = $F3_S$

The Decision Variable are: $F1_L, F1_M, F1_S, F2_L, F2_M, F2_S, F3_L, F3_M, F3_S$

Objective Function

The maximum quantity of each size to be produced by the individual plants to increase revenue:

$$MaxZ = 420(F1_L + F2_L + F3_L) + 360(F1_M + F2_M + F3_M) + 900(F1_S + F2_S + F3_S)$$

Constraints

Capacity Constraints

Capacity constraint for plant1 :

$$F1_L + F1_M + F1_S <= 750$$

Capacity constraint for plant2 :

$$F2_L + F2_M + F2_S <= 900$$

Capacity constraint for plant3 :

$$F3_L + F3_M + F3_S <= 450$$

Storage Constraints

Storage constraint for plant1 :

$$20F1_L + 15F1_M + 12F1_S <= 13000$$

Storage constraint for plant2 :

$$20F2_L + 15F2_M + 12F2_S <= 12000$$

Storage constraint for plant3 :

$$20F3_L + 15F3_M + 12F3_S <= 5000$$

Sales Constraint

Sales constraint of product produced in Large size :

$$F1_L + F2_L + F3_L <= 900$$

Sales constraint of product produced in Medium size :

$$F1_M + F2_M + F3_M <= 1200$$

Sales constraint of product produced in Small size :

$$F1_S + F2_S + F3_S <= 750$$

Same capacity constraints

To generate the new product,the plants should utilize the same proportion of their surplus capacity according to the management:

$$F1_L + F1_M + F1_S/750 = F2_L + F2_M + F2_S/900 = F3_L + F3_M + F3_S/450$$

Non negativity of variable

$$F1_L, F1_M, F1_S, F2_L, F2_M, F2_S, F3_L, F3_M, F3_S >= 0$$

Mathematical Model for the LP problem

$$MaxZ = 420(F1_L + F2_L + F3_L) + 360(F1_M + F2_M + F3_M) + 900(F1_S + F2_S + F3_S)$$

Decision variable

$$F1_L, F1_M, F1_S, F2_L, F2_M, F2_S, F3_L, F3_M, F3_S$$

Capacity Constraints

$$F1_L + F1_M + F1_S <= 750$$

$$F2_L + F2_M + F2_S <= 900$$

$$F3_L + F3_M + F3_S <= 450$$

Storage Constraints

$$20F1_L + 15F1_M + 12F1_S <= 13000$$

$$20F2_L + 15F2_M + 12F2_S <= 12000$$

$$20F3_L + 15F3_M + 12F3_S <= 5000$$

Sales Constraint

$$F1_L + F2_L + F3_L <= 900$$

$$F1_M + F2_M + F3_M <= 1200$$

$$F1_S + F2_S + F3_S <= 750$$

Same capacity constraint

$$F1_L + F1_M + F1_S/750 = F2_L + F2_M + F2_S/900 = F3_L + F3_M + F3_S/450$$

Non negativity of variable

$$F1_L, F1_M, F1_S, F2_L, F2_M, F2_S, F3_L, F3_M, F3_S >= 0$$