Quantitative Management Modelling

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Question 1

Type	Collegiate	Mini
Material	3	2
Labor	45	40
Sales	1000	1200
Profit	$32	$24

a. Decision variables:

The decision variables represent the number of each backpack model to produce.

Let

Variable	Definition
x_1	Collegiate backpacks produced per week
x_2	Mini backpacks produced each week

x_1 represent the number of collegiate backpacks produced each week.

x_2 represent the number of Mini backpacks produced each week

b. Objective Function

The objective is to maximize the total profit.

Profit for each Collegiate = $32

Profit for each Mini = $24

$$\text{Maximize } Z = 32x_1 + 24x_2$$

Z is the total weekly profit.

Constraints: There are three types of constraints:

Material Constraint:

5000 square feet of nylon every week to make backpacks.

Each Collegiate backpack uses 3 square feet, so for x_1 backpacks, it would be $3x_1$. Each Mini backpack uses 2 square feet, so for x_2 backpacks, it would be $2x_2$

$$3x_1 + 2x_2 \leq 5000$$

Work Constraint:

The company has 35 workers, each working 40 hours a week, work a total of 1400 labor hours or 84000 minutes in a week.
one Collegiate backpack takes 45 minutes, and one Mini backpack takes 40 minutes.
45 minutes for each Collegiate is $45x_1$,

- 40 minutes for each Mini is $40x_2$
The total time spent is 84000 minutes.

$$45x_1 + 40x_2 \leq 84000$$

- Sell at most 1000 collegiates and 1200 minis

Sale constraint:

The sales constraint is based on number about backpacks you're expected to sell. The predictions show you can't sell more than a certain number each week.

X1 ≤ 1000 (you can't sell more than 1000 Collegiate backpacks.)

X2 ≤ 1200 (you can't sell more than 1200 Mini backpacks.

Non negativity constraint: The number of backpacks produced cannot be negative.

The Full Mathematical Formulation:

Functions	**Formula**

Components	Maximize z =$32x_1$+$24x_2$
Constraints	$3x_1$+$2x_2$≤5000 $45x_1$+$40x_2$ ≤ 84000 X1 ≤ 1000 X2 ≤ 1200
Non- Negativity	$x_1 \geq 0,\ \ x_2 \geq 0$

Summary: The linear programming model for Back Savers helps figure out the best number of Collegiate and Mini backpacks to make each week to get the most profit. It looks at how much nylon, labor time, and sales limits are available to make sure production stays within these limits and maximizes profit.

Questions:2

Types	Plant 1	Plant 2	Plant 3
Sizes	L1, M2, S3	L2, M2, S2	L3, M3, S3
Profits	$420	$360	$300
Capacity	750	900	450
Storage	13000	12000	5000
Unit area	20	15	12
Sales	900	1200	750

The Decision Variables: Represent the number of large, medium and small products produced at plant 1, 2 and 3

Variables	Definition
X_{L1}	Number of large units produced at Plant 1
X_{M1}	Number of medium units produced at Plant 1
X_{S1}	Number of small units produced at Plant 1
X_{L2}	Number of large units produced at Plant 2
X_{M2}	Number of large units produced at Plant 2
X_{S2}	Number of large units produced at Plant 2
X_{L3}	Number of large units produced at Plant 3
X_{M3}	Number of large units produced at Plant 3
X_{S3}	Number of large units produced at Plant 3

Objective Function:

The purpose of maximize the profit from producing large, medium and small units across all three plants.

Sizes	Units
Large	$420 per unit
Medium	$360 per unit
Small	$300 per unit

Maximize Z = 420(X_{L1} + X_{L2} + X_{L3}) + 360(X_{M1}+ X_{M2} + X_{M3}) + 300(X_{S1}+ X_{S2} + X_{S3})

Constraints:

1. **Production Capacity Constraint:**

Maximum Capacity to produce each plants units per day.

Plant	**Capacity Constraint**
Plant 1	$X_{L1} + X_{M1} + X_{S1} \leq 750$
Plant 2	$X_{L2} + X_{M2} + X_{S2} \leq 900$
Plant 3	$X_{L3} + X_{M2} + X_{S3} \leq 450$

2. Storage Space Constraint:

Every plant has fixed amount of storage space for production. Its size 20 square feet for large units, 15 square feet for medium and 12 square feet for small units.

Plant	**Storage Constraint**
Plant 1	$20X_{L1} + 15X_{M1} + 12X_{S1} \leq 13000$
Plant 2	$20X_{L2} + 15X_{M2} + 12X_{S2} \leq 12000$
Plant 3	$20X_{L3} + 15X_{M3} + 12\,X_{S3} \leq 5000$

3. **Sales Forecast Constraint:** The company has estimated the maximum number of units each size. The total number of large, medium, and small units produced all plants cannot exceed the forecast.

Size	**Sales Constraint**
Large	$X_{L1} + X_{L2} + X_{L3} \leq 900$
Medium	$X_{M1} + X_{M2} + X_{M3} \leq 1200$
Small	$X_{S1} + X_{S2} + X_{S3} \leq 750$

4. **Equal Percentage Capacity utilization:** The same percentage of production capacity must be used at all plants.

   X_{L1} + X_{M1} + X_{S1}/ 750 = X_{L2} + X_{M2} + X_{S2} / 900= X_{L3} + X_{M3} + X_{S3} / 450

5. **Non negativity constraint:** The number of backpacks produced cannot be negative.

   $X_{L1}, X_{M1}, X_{S1}, X_{L2}, X_{M2}, X_{S2}, X_{L3}, X_{M2}, X_{S3} \geq 0$

Summary: The Linear Programming Model helps the company decide large, medium, and small products to make at each plant to maximize profit. It also takes amount limits in storage capacity, storage space, and sale. The company use its resources wisely and avoid layoffs, making the best possible decisions for profit.