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Applying Linear Programming for Profit Maximization in Furniture Production

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Abstract

Linear programming can be effectively applied to solve practical business problems, including maximizing profits in furniture production. This paper aims to use the simplex method of linear programming to find the optimal production mix of dining tables, chairs, sofa sets, dressing tables, shoe racks, and beds that maximizes profit while adhering to limitations on materials like wood, fabric, paint, Sun mica, stuffing, accessories and labor cost per unit.

The goal is to achieve maximum profit with minimal investment. This method is highly effective in optimizing linear objectives, making it ideal for profit maximization.

Key findings indicate the production levels needed to achieve maximum profitability, offering actionable insights for balancing material usage with revenue goals.

The conclusions emphasize the importance of linear programming in operational decision-making, demonstrating its potential to enhance profit margins in retail and manufacturing sectors facing similar resource limitations.

Keywords

Linear programming, Simplex method, Decision variables, Optimization, Profit maximization.

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Introduction

A linear objective function subject to linear constraints can be maximized or minimized using linear programming, a potent mathematical technique for optimization issues.

The concept was developed by George B. Dantzig in 1947, and it has since become integral to operations research and economics, especially in resource allocation and scheduling.

One of the significant advantages of LP is its adaptability, as exemplified by the Simplex algorithm, which efficiently solves linear programming problems even in complex scenarios and extensive applications

In this study, we apply linear programming for furniture production, where the focus is on determining the optimal quantities of dining tables, chairs, sofa sets, dressing tables, shoe racks and beds to produce for maximum profit. The furniture production operates under various constraints, including demand, material quantity & labor availability.

General Form of a Linear Programming Model

The linear programming problem is generally expressed as:

Maximize (or Minimize) $Z = c_1x_1 + c_2x_2 + \ldots + c_nx_n$ (objective function) (1.1)

Subject to the constraints:

$$a_{11}x_1 + a_{12}x_2 + \ldots + a_{1n}x_n \ (<,=,>)\ b_1$$
$$a_{21}x1 + a_{22}x_2 + \ldots + a_{2n}x_n \ (<,=,>)\ b_2$$
$$\ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots$$
$$a_{m1}x_1 + a_{m2}x_2 + \ldots + a_{mn}x_n \ (<,=,>) b_m \qquad (1.2)$$

And non-negative restrictions: $x_j \geq 0$ for $j = 1, 2, \ldots, n$

Where aij's, bi, s, and cj's are constants and xj's are variables.

Any of the 3 indications <,=, and > may be present in the circumstances specified by (1.2).

The standard form of a linear programming problem for the simplex technique is as follows:

(a) All constraints are expressed as equations using excess and slack variables.

(b) For each constraints all bi > 0, if any bi is negative then multiply the corresponding constraint by − 1.

(c) Always remember, the problem must be of maximization type, if not, convert it in maximization type by multiplying the objective function by −1.

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This is one way to formulate the linear programming problem of n variables and m constraints using slack and excess variables:

Optimize

$Z = c_1 x_1 + c_2 x_2 + \ldots + c_n x_n + 0.s_1 + 0.s_2 + \ldots + 0.s_m$ (Objective function) (1.3)

Subject to the constraints

$$a_{11}x_1 + a_{12}x_2 + \ldots + a_{1n}x_n + s_1 = b_1$$

$$a_{21}x_1 + a_{22}x_2 + \ldots + a_2n_{xn} + s_2 = b_2$$

$$\ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots$$

$$\ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots$$

$$a_{m1}x_1 + a_{m2}x_2 + \ldots + a_{mn}x_n + s_m = b_m \qquad (1.4)$$

and non – negative restrictions

$$x_j > 0,\ s_i > 0,\ j = 1, 2 \ldots n,\ i = 1, 2 \ldots, m$$

Where a_{ij}'s, b_i's and c_j's are constants and x_j's and s_i's are variables

Review of Literature

Linear programming (LP) has been extensively used in optimization problems across industries. Dantzig's pioneering work on the Simplex Method laid the foundation for LP applications in real-world resource allocation and profit maximization. Research by Sherali and Yao (2007) highlighted the role of LP in supply chain design for profit maximization, while Patidar and Choudhary emphasized its utility in small-scale industries for optimizing resource use. The application of LP in furniture production remains underexplored but offers significant potential, as suggested by Schulze's works on operational efficiency. Studies have demonstrated that LP not only aids decision-making but also ensures sustainable use of resources.

Research Methodology

This study employs linear programming to develop an optimal plan for furniture production. Using the Simplex Method, the problem is modeled with an objective function to maximize profit while considering constraints such as material availability and labor capacity. Data on production requirements for six furniture types—dining tables, chairs, sofa sets, dressing tables, shoe racks, and beds—were collected from a furniture maker's operational records.

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The model formulation involved defining decision variables for each furniture type and constructing the objective function based on profit contributions.

Constraints were introduced for resources like wood, fabric, paint, sun mica, stuffing, accessories, and labor hours. Non-negativity constraints ensured feasibility. The model was solved using Excel to derive the optimal production mix.

The research design is quantitative, focusing on numerical optimization. Results are interpreted to provide actionable insights for efficient resource utilization and profit maximization. The methodology ensures reliability through precise mathematical modeling and validation using real data.

Problem Assumption

Six main types of furniture to be produced are as follows:

- Dining tables, chairs, sofa sets, dressing tables, shoe racks and beds.
- There is limited availability of key materials like wood, fabric, paint, sun mica, stuffing, accessories, and labor.
- The production of each item requires specific amounts of these materials.
- The goal is to allocate resources efficiently to maximize profit while meeting all material and production constraints.

Table

	PRODUCTS						
	Dining Table (unit)	Chairs (unit)	Sofa Set (unit)	Dressing Table (unit)	Shoe Rack (unit)	Bed (unit)	Total Availability
Wood (cubic feet)	15	6	12	8	10	20	1200 cubic feet
Fabric (square feet)	0	8	40	25	15	20	1800 square feet
Paint (liters)	4	2	3	3	2	5	250 liters
Sun mica (sheets)	3	1	2	2	1	3	350 sheets
Stuffing (kilograms)	8	3	4	5	2	6	600 kilograms
Accessories (units)	5	2	3	4	3	2	400 units
Labor Cost per Unit (hours)	10	4	8	6	5	12	1500 hours

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Profit per Unit (Rupees)	1500	600	2500	3000	2000	3500	

Model Formulation

Let:
x_1 = Number of dining tables produced
x_2 = Number of chairs produced
x_3 = Number of sofa sets produced
x_4 = Number of dressing tables produced
x_5 = Number of shoe racks produced
x_6 = Number of beds produced

Objective Function:

Maximize $\mathbf{Z = 1500x_1 + 600x_2 + 2500x_3 + 3000x_4 + 2000x_5 + 3500x_6}$

Subject to Constraints:

1. Wood Constraint:
$15x_1 + 6x_2 + 12x_3 + 8x_4 + 10x_5 + 20x_6 \leq 1200$

2. Fabric Constraint:
$0\ x_1 + 8x_2 + 40x_3 + 25x_4 + 15x_5 + 20x_6 \leq 1800$

3. Paint Constraint:
$4x_1 + 2x_2 + 3x_3 + 3x_4 + 2x_5 + 5x_6 \leq 250$

4. Sun mica Constraint:
$3x_1 + x_2 + 2x_3 + 2x_4 + x_5 + 3x_6 \leq 350$

5. Stuffing Constraint:
$8x_1 + 3x_2 + 4x_3 + 5x_4 + 2x_5 + 6x_6 \leq 600$

6. Accessories Constraint:
$5x_1 + 2x_2 + 3x_3 + 4x_4 + 3x_5 + 2x_6 \leq 400$

7. Labor Cost Constraint:
$10x_1 + 4x_2 + 8x_3 + 6x_4 + 5x_5 + 12x_6 \leq 1500$

8. Non-Negativity Constraints:

$$x_1, x_2, x_3, x_4 \geq 0$$

Interpretation of Results

The optimal production mix derived from the model indicates the quantities of each product that should be produced to maximize profits while staying within material constraints. The results will guide the furniture production in resource allocation, ensuring profitability and efficient use of materials.

Research Findings

The above linear programming model was solved by EXCEL, which gives an optimal solution of $x_1 = 0, x_2 = 0, x_3 = 0, x_4 = 3.703704, x_5 = 107.4074, x_6 = 4.814815$ and maximum **Z = *850007407.4.*** This solution indicates that prioritizing the production of shoe racks, dressing tables, and beds maximizes profitability while adhering to the given constraints.

Conclusion

The linear programming model, solved using Excel, demonstrates the effectiveness of optimization techniques in maximizing profitability in furniture production. The optimal solution highlights that focusing on the production of **shoe racks, dressing tables, and beds** yields the highest profit, with a maximum value of **₹850,007,407.4** while adhering to material and labour constraints.

This study confirms that linear programming is a practical and powerful tool for resource allocation and decision-making in manufacturing. The results emphasize the importance of strategic production planning to achieve profitability and provide a framework for further optimization in similar industries.

Suggestions/Future Scope

Future research can explore dynamic models incorporating market demand fluctuations and seasonal variations. Expanding the scope to include cost analysis for material procurement and logistics can enhance the model's applicability.

Automating LP implementation in production processes could further optimize resource use and improve efficiency. The methodology can also be adapted for other industries facing similar challenges.

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