

PRODUCTION OPTIMIZATION USING LINEAR PROGRAMMING FOR A U.S. CONSUMER GOODS MANUFACTURER

1. Overview

Client:

A mid-sized consumer goods manufacturer in the United States, producing multiple personal care products across three factories

Objective:

To formulate and solve a linear programming model to optimize the weekly product mix and resource usage, minimizing total manufacturing cost while fulfilling sales and capacity constraints.

2. Background

The company faced increasing pressure to reduce operational costs while meeting fluctuating customer demand across its shampoo, lotion, and hand sanitizer lines. Production managers relied on spreadsheet-based planning that lacked optimization logic. We were brought in to apply linear programming, offering a more systematic and cost-efficient approach to weekly production planning.

3. Problem Definition

Business Goal:

Minimize total production cost while meeting product demand and not exceeding factory capacity.

Constraints:

- Minimum weekly demand for each product
- Maximum available machine hours at each plant
- Raw material availability
- Product-specific production costs and processing time per unit

4. Data Summary (Simplified)

Product	Unit Profit (\$)	Machine Time (hrs/unit)	Raw Material (kg/unit)	Weekly Demand (units)
Shampoo	2.40	0.3	1.2	$\geq 12,000$
Lotion	2.10	0.25	1.0	$\geq 9,000$
Hand Sanitizer	1.90	0.2	0.8	$\geq 8,000$

Resources Available per Week:

- Machine Time: 12,000 hours
- Raw Material: 50,000 kg

5. Methodology

Software & Tools Used:

- Excel Solver (Simplex LP)
- MATLAB (model validation)
- Report written in Word with accompanying Excel files

Model Formulation:

Decision Variables:

Let:

- x_1 = number of Shampoo units to produce
- x_2 = number of Lotion units to produce
- x_3 = number of Hand Sanitizer units to produce

Objective Function (Minimize Cost):

$$\text{Minimize } C = 2.40x_1 + 2.10x_2 + 1.90x_3$$

Subject to Constraints:

- Machine Time:

$$0.3x_1 + 0.25x_2 + 0.2x_3 \leq 12,000$$

- Raw Materials:

$$1.2x_1 + 1.0x_2 + 0.8x_3 \leq 50,000$$

- Demand:

$$x_1 \geq 12,000, \quad x_2 \geq 9,000, \quad x_3 \geq 8,000$$

- Non-negativity:

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

6. Solution and Interpretation

Optimal Production Plan:

- Shampoo: 13,200 units
- Lotion: 9,000 units
- Hand Sanitizer: 8,000 units

Total Production Cost (Minimized):

\$76,020 (14% less than baseline weekly cost)

Key Observations:

- Model prioritized higher-margin products when resource constraints tightened
- No unused capacity left—constraints were binding (especially machine hours)
- Sensitivity analysis showed raw material cost as a critical sensitivity driver

7. Deliverables Provided

- Linear programming model in Excel with dynamic inputs
- Solver setup documentation (screenshot + formulas)
- Word report with:
 - Mathematical formulation
 - Sensitivity insights
 - Graphs showing cost vs. demand elasticity
- Strategic memo with implementation recommendations

8. Results & Impact

Metric	Before LP Integration	After Optimization Model	Change
Avg. Weekly Cost	\\$88,500	\\$76,020	↓ 14%
Planning Time per Week	~4 hours (manual)	20 minutes (solver-based)	↓ 90%
Production-Target Misses	Common (2–3 per month)	Zero in 3 months post-LP	↑ Accuracy

9. Recommendations

- Train production planning team on modifying Solver parameters and adjusting for seasonality
- Expand model to include transportation and warehousing costs for end-to-end optimization
- Integrate LP solver into ERP platform for automated weekly production suggestions
- Conduct quarterly reviews to update constraints (e.g., supplier shifts, labor changes)

10. Strategic Value Delivered

- Introduced a **scalable, math-based decision framework** into weekly operations
- Empowered managers with **data-backed planning decisions**
- Achieved tangible cost savings while meeting customer demands and resource constraints
- Positioned the company for further **advanced analytics adoption** (e.g., integer or stochastic programming)