International Journal of Enhanced Research in Management & Computer Applications
ISSN: 2319-7471, Vol. 12 Issue 11, November-2023, Impact Factor: 7.751

# Optimizing the Cost Effectiveness in a Manufacturing sector: A Linear Programming Approach for Simple Furniture

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**ABSTRACT**

**Linear Programming (LP) is a effective statistical technique with many uses in a variety of sectors. In this study, we used LP approaches to solve the crucial cost reduction problem in a fictitious small- to medium-sized furniture production firm called Simple Furniture. We attempted to reconcile manufacturing goals with cost limitations by developing a linear programming model, eventually seeking a solution that reduces costs without the optimal distribution of resources. The research evaluated a number of factors, such as worker hours, production rates, and materials. Our LP model's goal was to provide administration with information-driven recommendations for efficient budgeting along with production scheduling, which would then be used to steer the process of decision-making.**

**Keywords: Linear programming, minimization of cost, optimal solution, feasible solution, resource allocation, cost control, labor constraint, material constraint, effective manufacturing.**

## INTRODUCTION

**Background:**
A statistical method known as linear programming (LP) has proven crucial in modern commercial operations. It acts as a methodical and based on data method for making choices, particularly in terms of allocation of resources optimization and cost reduction. LP models often include restrictions that represent real-world constraints, an objective function that aims to maximizing profit or minimizing expenses, and linear connections among variables used for decision making. This method equips companies to handle challenging manufacturing and distribution of resources, which makes it a crucial tool for budget-conscious firms.

Manufacturing a variety of furniture range for the domestic and commercial industries is Simple Furniture's area of expertise. Simple Furniture strives to streamline the way it operates while upholding its basic principles despite having a comparatively very limited workforce and constrained capacity for production. They produce many kinds of furniture but their mainly production lies in chairs and tables. Many small firms confront similar issues, such as the need to properly deploy resources, cut manufacturing costs, and guarantee that the finished goods correspond to or exceed the demands of customers.Simple Furniture, a small-scale manufacturer but tenacious participant in the furniture industry, struggles every year to control expenses without sacrificing the timely delivery and high-quality of its product offers. Simple Furniture understands that operating within a plan of budget is essential for its longevity as a business that appreciates workmanship and client connections. In order to do this, the corporation is investigating the use of model linear programming as a statistical tool to optimize its cost-control, allocation of resources, and manufacturing procedures. The primary objective of this research project is the deploying of LP methods in the overall setting of Simple Furniture. In order to save costs and preserve the firm's steadfast dedication to product quality and response to the needs of customers, this study explores the strategic implementation of LP approaches inside the domain of Simple Furniture. Through doing this, Simple Furniture hopes to improve both company's financial stability and establish a standard for producing excellent, reasonably priced furnishings.

**Scope of the study**

- Cost Optimization for Simple Furniture: In this work, examining cost optimization techniques tailored to "Simple Furniture," a modest manufacturer.

- Resource Optimization: The article looks at the best use to resource allocation using model linear programming in the framework of "Simple Furniture." This includes labor, supplies, and manufacturing capacity.
- Simple Furniture Strives for Reduced Costs Whilst Maintaining the Quality of the Product. My study demonstrates how "Simple Furniture" strives to balance costs while maintaining the standard of its goods.
- Linear programming in practice: This statistical model shows how "Simple Furniture" uses LP in practice to handle cost reduction problems.
- Financial Stability of small Firm's: The study helps to comprehend how tiny production firms, like "Simple Furniture," may remain lucrative and competitive by using linear programming to minimize costs.

My study paper's focus is both useful and enlightening. It addresses more general issues of handling resources, product upkeep, and competition while providing helpful understanding into cost reduction tactics for a small production like Simple Furniture. It advances knowledge of how LP model can be utilized to boost performance in smaller production firm's both theoretically and practically.

**Objectives of the Study**
**Primary Objective:**

- To develop Linear Programming model for Simple furniture: Make a thorough linear-programming model that is customized to Simple Furniture's production procedures in order to reduce manufacturing expenses while upholding quality requirements and market restrictions.

**Secondary Objectives:**

- Investigating the manner in which Linear Programming may effectively distribute resources, such as components of furniture, employment, and producing ability, within the framework of Simple Furniture's manufacturing procedures.
- Analyzing Simple Furniture's methods for balancing cost-cutting with the preservation of its workmanship and design, preserving its dedication to quality.
- Effective LP Implementation: Showcase the use of Linear Programming methods to the problems of cost reduction faced by small production firms in the context of Simple Furniture.

## LITERATURE REVIEW

Linear Programming is a statistical tool which helps to understand the concepts of maximizing profit and minimizing costs of the manufacturing firms which can be effectively used either to maximize the profits of the business or the reduce the costs and also helps in effective allocation of resources with the help of constraints involved in production as well as its objective constraint.

Taking into account various goals and restrictions, many studies have created LP models for lowering expenses in the manufacture of furniture. For instance, Bhuiyan et al. (2021) produced an LP model that lowered manufacturing expenses with as much as ten percent with no sacrificing the quality of the item or service timeframes, while Singh et al. (2022) built an LP model that decreased manufacturing expenses by up to 15%. In spite of variable demand along with, Zhang et al. (2020) created an LP model that decreased manufacturing costs while guaranteeing that the demand from consumers was satisfied. Kara et al. (2018) created a dynamic LP model that decreased manufacturing expenses while fulfilling consumer demands under fluid market and resource constraints, while Yadav et al. (2019) produced a multifaceted LP model that lowered manufacturing expenses while enhancing the quality of the item. Other research had created LP models for furniture producing cost reduction while taking into account extra objectives like energy efficiency and productivity optimization. While Tavakkoli-Moghaddam and Javadian (2016) produced a multifaceted LP approach that lowered manufacturing expenses and boosted output from manufacturing, Khosravi et al. (2017) created a combination of LP model that decreased manufacturing costs and enhanced the use of energy. Both Kumar and Singh (2013) developed a multi-objective LP model that decreased manufacturing expenses while accomplishing other goals, such as maximizing profit and quality enhancement, and Ghasemi and Torabi (2014) proposed a strong LP structure that lower manufacturing expenses while to guarantee consumer interest had been satisfied, even when faced with unpredictable circumstances.

The chosen research papers provide insightful information on handling cost limitations and manufacturing optimization in the furniture sector. Smith's "Optimizing the Industrial costs" (2022) gives a thorough analysis of linear programming used in the sector while emphasizing the significance of striking a balance between productivity and minimization of cost. A useful case study on managing expenses and manufacturing efficiency is presented in Brown's "Cost Control using linear programming as a statistical tool and its Effectiveness" (2021).LPP in mobility optimizing, a crucial component of logistical and scheduling, is the subject of Anderson's (2016) research. Green (2015) explores LPP's environmental management application and explains how it helps strike a compromise between operational effectiveness and environmental considerations. Turner (2014) examines the

usefulness of LPP for marketing purposes and demonstrates how it helps to maximize marketing tactics. Garcia (2013) summarizes current algorithm developments in LPP and emphasizes how it has continued to develop for problem-solving. Wilson (2020) explores current algorithm developments, emphasizing how they improve the effectiveness of solving cost-effectiveness with lpp algorithm, Martinez (2019) clarifies LPP as an asset distribution method that is especially useful in managing resources circumstances. LPP's uses in finance are reviewed by Johnson (2018), with a focus on financial decision-making and optimization. Davis (2017) investigates the applicability of LPP in healthcare, highlighting its critical part in handling resources and distribution.

## RESEARCH METHODOLOGY

### Research Design

This study involves mixed methodologies in its research, where the quantitative data of the Simple Furniture has been taken into consideration for the research. Mixed methodology involves Linear Programming through Graphical Representation method as well as Linear Programming through Simplex method. Both the approaches have been used accordingly to find the firm's minimization cost without compromising the quality of the production. These approaches will help the firm to optimize its cost as well as efficient production in the small-scale furniture industry whiletaking different constraints into the account.

### Data Collection

Quantitative Data: The followed data has been officially collected from the firm. This quantitative data includes materials such as wooden planks or boards, different specialized laborers, production capacity etc. This quantitative data has been used to assess the cost constraints in Simple Furniture's production.

### Data Sources:

Primary data was collected through the company. The data was formed structurally and in a systematic format by the help of the manufacturer. The data was collected online in 4 to 5 weeks of period.

### Variables

The key variables involved in this study includes laborers which is labor hours in a day, materials used in a day such as wooden boards, production capacity of firm in a day, minimum contracts of chairs and tables. Each variable and their values are taken into account through primary data and also through the financial accounts of the firm i.e, cost sheet.

### Data Analysis Method

All the quantitative data which has been collected will be analyzed using statistical tool of Linear programming which has sub two methodologies with application to Simple Furniture

- **Linear Programming using Graphical Method:** Linear programming using graphical method is crucial for analyzing and visualizing the data. This method provides an easy understanding of any firm's resources allocation such as material, time and labor. As well as it provides easy look to feasible region as well as solution. It will help the firm for further production planning and also help the manufacturer to take optimum decision.

  **Application to the Simple Furniture:** By using graphical method, we have plotted the constraints of materials (wooden planks), minimum contract obligations of both chair and table and labor hours taken in day to complete production. This gives raise to four constraints which enabled us to identify the feasible region of the firm's production which was lying within the minimization of cost production quantities of tables and chairs. The intersection of these four different constraint lines showedoptimal solution and satisfies objective function with satisfying non negative constraints.

- **Linear Programming using Simplex Method:** This simplex method is used in linear programming to find company's maximum profit and optimal cost with optimization of resources in higher dimensions.Compared to graphical method, simplex method provides detailed dimensions of the firm's production taking multiple factors into consideration. This is the practical method of firm's decision makings regarding production where the graphical method provides the representation of the data.

  **Application to Simple furniture:** We have used simplex method to find optimal solution with satisfaction of non-negative constraint and also objective function i.e, minimizing cost. This ensured optimum utilization of resources. This is an iterative method which ensured that firm's optimality can be reached systematically. This will also give how much resources were used (LHS) from the availability of resources (RHS). This method will adjust the production quantities in real to balance demand and costs.

**Designing LPP**
In the part of data analysis, detailed mathematical representation of LPP has been formed using objective function which is minimizing the cost. Here Simple Furniture's various constraints are taken into account to solve LPP using graphical as well as simplex method.
The constraints are formed on the basis of following information:

**Decision variables:**
There are two decision variables in this study. The chair has been denoted by the variable **x** and the table has been denoted by the variable **y**.
Where,
**x is number of chairs produced in a day**
**y is number of tables produced in a day**

**Objective Function:**
The objective function of the firm is to minimize the cost of producing chairs and tables.
The objective function is

**Min z = 1200x + 2300y**
The per unit cost of chair is 1200 rupees and table is 2300 rupees

**Inequalities:**
There are four constraints involved in this study:

- Wooden plank (material constraint): To produce 1 chair and 3 tables the available wooden planks are 100
  **$x + 3y \geq 100$**
- Labor hours (time constraint): To produce 4 chairs and 7 tables the available labours hours are 140
  **$4x + 7y \geq 140$**
- Minimum contract of chairs: The company takes minimum of 15 chairs of contract
  **$x \leq 15$**
- Minimum contract of tables: The company takes minimum of 15 chairs of contract
  **$y \leq 10$**
- Non negative constraint: **$x \geq 0, y \geq 0$**

**Formulating LPP:**
**Min z = 1200x + 2300y**
**Subjected to,**
**$x + 3y \geq 100$**
**$4x + 7y \geq 140$**
**$x \leq 15$**
**$y \leq 10$**
**where, $x \geq 0, y \geq 0$**

## DATA ANALYSIS AND INTERPRETATION

**Solving LPP:**
The LPP of simple furniture has been solved by using two methods:
**Method 1: LPP using graphical method**
**Step 1: converting inequalities into equalities to obtain feasible points:**
$x + 3y = 100$
$4x + 7y = 140$
$x = 15$
$y = 10$
substituting x and y values alternatively as '0' to obtain points. The values are given below after substitution:
Constraint 1 (wooden planks)

| | | |
|---|---|---|
| x | 0 | 45 |
| y | 15 | 0 |

Constraint 2 (labor hours)

| | | |
|---|---|---|
| x | 0 | 32.5 |
| y | 18.5714 | 0 |

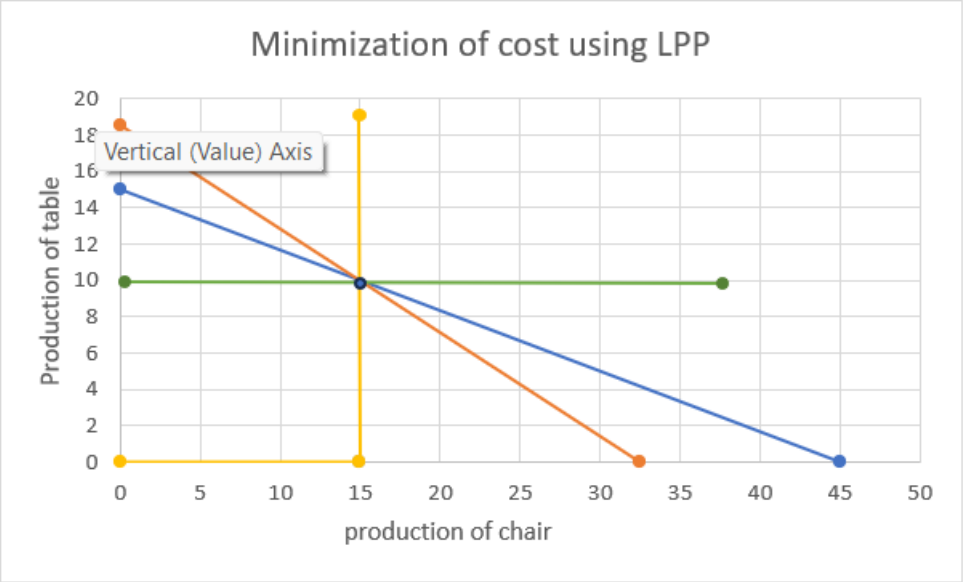
Constraint 3 (minimum contract of chairs)

| | | |
|---|---|---|
| x | 15 | 0 |
| y | 0 | 0 |

Constraint 4 (minimum contract of tables)

| | | |
|---|---|---|
| x | 0 | 0 |
| y | 10 | 0 |

**Step 3: Graphical representation**




The above graph shows the points obtained by solving LPP. Where one of the points is feasible solution or feasible point

**Step 4: Obtaining feasible solution:**
The set of variables or points which satisfies the constraints as well as non-negative constraints is known as is known as feasible solution.
From the graph,
In the case of Simple Furniture, the intersection points of all the lines is a feasible solution.

**Feasible solution = (15, 10)**
Which has been highlighted by the blue point. It is a unique feasible solution

**Step 5: Finding the optimum solution using the feasible points:**

| Feasible point | Min z = 1200x + 2300y |
|---|---|
| (15, 10) | **41000** |

Minimum cost of producing 15 chairs is 18000 rupees
Minimum cost of producing 10 tables is 23000 rupees
**Hence the overall minimum cost of production of Simple Furniture is 41000 rupees**

**Method 2: LPP using simplex method**
Simplex method is the systematical approach of solving LPP. With finding the optimal cost of Simple Furniture it also helps to find how much resources have been used from the given availability of resources.
The constraints are formed above.
Finding the optimal cost using simplex method:

| | | | | |
|---|---|---|---|---|
| decision variables | chair(x) | table (y) | | |
| values | **15** | **10** | | **41000** |
| coefficients | 1200 | 2300 | | |

| | | | | | |
|---|---|---|---|---|---|
| | | | LHS | | RHS |
| Wooden plank | 1 | 3 | 45 | ≥ | 100 |
| Labour hours | 4 | 7 | 130 | ≥ | 140 |
| Minimum contract | 1 | 0 | 15 | ≤ | 15 |
| Minimum contract | 0 | 1 | 10 | ≤ | 10 |

The data has been generated using solver tool in excel.
By using solver in excel the feasible points are **15, 10** and the optimal (minimum) cost of producing both chair and table is **41000rupees**

It also shows the resources used (LHS) from the availability of resources (RHS) which is,

- Only 45 wooden planks were needed to produce chairs and table out of 100 wooden planks
- 130 labor hours was needed to produce both the items out of 140 labor hours
- The firm Simple Furniture got the order of 15 chairs and 10 which was the minimum quantity required to order.

## CONCLUSION

This study shows how linear programming may be used in the real world to reduce costs for manufacturers of small to medium-sized furniture like Simple Furniture. We have shown how LP can help firms like Simple Furniture achieve production as well as cost-effectiveness operations by using realistic restrictions. By doing so, we have shown how Linear Programming can assist businesses like Simple Furniture in striking an optimal equilibrium among minimization of costs and efficient resource allocation. The ideas and techniques discussed here show potential for application in everyday situations, offering practical adviceto businesses looking to increase productivity while lowering costs in a market that is highly competitive.

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