Using Linear Programming Technique

to Measure Minimum Total Cost

[Case study]

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Abstract

The main objective of this study is to calculate the Minimum total Cost and Minimum cost for each product by using linear programming Technique, in one of the ready-to-wear factories. This factory is producing 10 different types of products (5 types of Pants, 2 types of shirts, 1type of long Jacket, 1 type of suit and 1 type of premium suit). This Technique usually used to solve complicated problems in different fields by formulating or changing the problem to Linear Programming model and then solve this model by using Simplex Method. We will use Simplex method which is simple and powerful tool for solving linear programming Model to calculate the Minimum Cost, because calculating cost is not easy problem. The present study ascertained that there is a significant powerful technique in Quantitative Methods called Linear programming Method that can be used in Optimization cases.

This study will provide this Factory and other Factories, particularly in Iraq, an exposure of linear programming Technique in making decisions to determine the minimum total cost and minimum cost for different products.

The result of Statistical analysis exhibited or shows that:

1.The Minimum total cost Z = 3249,745000 IQ.D per year

2. The products which reduce costs within the restrictions are [X2 = suit, X4 = shirt 2), X8 = pants 4 and X10 = premium suit]

3. The number of units that can be produced from 4 variables as follows:

X2 = 153,333 suits, X4 = 49,465 shirt 2, X8 = 486,666 pants 4 and X10 = 150,000 premium suits

Keywords: Formulation, Model Building, Linear Programming, Optimization, Simplex Method and Cost Accounting.

1.1 Introduction

Accounting is no longer limited to recording the accounting operations of the facility and determining the financial position, and to determine the results of these operations in an aggregate form. In the last century, accounting science has touched on many other areas. Cost accounting has emerged as one of the accounting branches used to serve enterprise management in planning, implementation and oversight. Cost accounting is defined as a science that includes a set of accounting principles and foundations for estimating, compiling, analyzing and tabulation cost of the unit produced, whether a commodity or service, controlling it, assisting management in the development of productive and marketing policies, and choosing among the alternatives available to solve administrative problems (assisting management in carrying out its functions of planning, coordinating, controlling and making decisions). Minimum or optimal cost is the main objective to be satisfied in any factory or manufacture, and can be determined or calculated by using Linear Programming Technique. Linear Programming Technique is a scientific application to managerial decision-making.

The successful use of this Technique would help the organization in solving complex problems on time greater accuracy and in the most economical way. Due to the importance of this method, this method is required to be guided by the use of the "Simplex method".

1.2. Research problem:

In view of the inability to set standard costs under achievable criteria in addition to the absence of a specialized team to estimate the costs necessary for production, we can use one of the quantitative methods, namely the method of Linear programming in order to calculate minimum or optimal cost.

1.3. Research Importance

The importance of this research is to try to apply one of the important statistical methods, which is the method of linear programming in order to find the optimal costs. This method is precise method where it is characterized by accurate analysis

to serve management in decision-making and to determine the relationship between standard costs and optimal costs in future studies.

1.4. Research Objectives.

The Objectives of this research are:

14.1 To Create or Build Linear Programming Model.

1.4.1 to calculate the Minimum total Cost.

1.4.2 To calculate the Minimum cost for each product.

1.4.3 To show that Linear Programming Technique is powerful in calculating minimum cost using Simplex method.

2.1 Literature Review

2.1.1 Concept of Linear Programming

Linear programming (LP) is a mathematical technique that aimed in optimizing performance in terms of combinations of resources (Yahya, Garba, & Ige, 2012) to achieve profit maximization or cost minimization in a mathematical model whose requirements are represented by linear relationship among variables (Gunasekaran et al., 2015). According to Sharma (2016), linear programming is useful for the allocation of limited resources to several competing activities on the basis of given criterion of optimality. Linear programming is a mathematical technique that widely used in operation research or management science, in finding solutions to complex managerial decision problems that allows options between alternative courses of action. If there is some changes on the conditions whether decision variables or constraints, the model can be controlled by changing or altering the conditions for the optimal results (Ezema & Amakom, 2012). Linear programming can also be applied in other areas such as agricultural planning, farm management, selecting air weapon system, education, hospital administration and capital budgeting (Sharma, 2009).

2.1.2 The methodology adopted in solving L. P. Problems are as follows:

1. **Formulating the problem**
2. **Defining decision variables and restrictions.**

3. **Developing a suitable model**
4. **Acquiring the Input Data**
5. **Solving the model**
6. **Validating the model**
7. **Implementing the results**

2.2 Literature Review of Simplex Methods

The simplex method solves the linear programming problem in iterations to improve the value of the objective function. The simplex approach not only yields the optimal solution but also other valuable information to perform economic. There are diverse opinions on application of simplex method to make decision in management in different sectors. These opinions developed by George Dantzig (American Mathematician) planned to solve the business problems and economic development after the World War II. During the world war he worked on planning methods for the US Air Force. After that he planned for solving the industrial and business problems. Initially, Dantzig didn't include objectives in formulation so that huge number of feasible solution found, therefore more rules were required to choose a best solution among all feasible solution. In Mid 1947 Dantzig included objectives in his formulation. Afterwards, he developed a "Simplex Method" to solve linear programming problems.

3. Application of Linear Programming Technique

3.1 Data Sources

This study is conducted in one of the ready-to-wear factories (small Factory) which is located in Baghdad, Iraq. This Factory produces 10 types of Products using 8 types of

Machines. All details of data are described in Table 1 and Table 2 bellow.

We will focus on:

1. **Ten Types of main products in this factory which are: 5 types of Pants, 2 types of shirts, 1type of long Jacket, 1 type of suit and 1 type of premium suit and Ten types of Materials that can be used in the Production Processes. Table 1**

Table (1)

Types of products and materials entered, available quantities and unit cost

Product / Material	Premium suit X10	Pants 1 X9	Pants 2 X8	Pants 3 X7	Pants 4 X6	Pants 5 X5	Shirt 2 X4	Shirt 1 X3	Suit X2	Long jacket X1	Quantitie available
Regular fabrics	1250	230	215	170	180	210	280	200	370	425	6000000
Wool Cloth	1.8	0	0	0	0	0	0	0	1.5	1.5	500000
Canvas bags	0	0	1.5	0	0	0	0	0	0	0	730000
Cotton cloth	3.1	2.35	0	1.85	0	0	3.74	2.17	0	0	650000
Cotton	2	0	0	0	0	0	0	0	0	0	300000
Rope	35	25	24	15	22	25	0	0	0	0	420000
Ordinary filament	30	18	18	16	14	10	10	10	15	20	900000
Zips	0	0	1	0	0	0	1	1	0	1	40000
Saddle filaments	0	0	0	0	0	0	15	25	50	60	1500000
Buttons	8	5	4	0	0	0	5	5	8	8	1400000
Cost per Unit	10280	1720	1610	1425	1560	1840	2410	2520	5250	5890	

2. **Eight different Machines with different Production Capacity that can be used in the Production Processes.**

Table (2)

Annual production capacity for machinery and production works

Products / Machines	Premium suit X10	Pants 1 X9	Pants 2 X8	Pants 3 X7	Pants 4 X6	Pants 5 X5	Shirt 2 X4	Shirt 1 X3	Suit X2	Long jacket X1	Production capacity
Separation	5	4	3	2	2	3	4	4	5	5	2038850
Measurements	8	5	5	4	4	5	5	5	10	10	245250
Sewing machine	95	60	55	50	50	50	25	25	90	90	8583725
Join Machine	0	0	0	30	35	30	25	45	80	90	6521000
Buttons Machine	1	0.45	0.4	0	0	0	0.45	0.45	0.55	0.55	272500
Saddle	0	0	0	0	0	0	18	20	30	35	1400000
Iren	5	4.5	4	3	2	3	1	1	5	0	938000
Packaging	8	6	4.5	3.5	3	3.5	4	4	8	8	2605250

3.2 Constructing L P. Model and Data Analysis

3.2.1 Formulating and Building Linear Programming Model

From the information in table (1) and table (2) above, the required mathematical model can be formulated as follows:

Step 1: We define decision variables. Each product is represented by the variable X_i. We have ten types of products (X1, X2,X3, … X10) during the available quantities, production quantities and production capacity .

Or

X1 = Long jacket X4 = Shirt 2 X7 = Pants 3 X10 = Premium suit

X2 = Suit X5 = Pants 5 X8 = Pants 2

X3 = Shirt 1 X6 = Pants 4 X9 = Pants 1

We assume that:

the number of units to be produced from product 1 is X_1,

the number of units to be produced from product 2 is X_2 ,

the number of units to be produced from product 3 is X_3,

the number of units to be produced from product 4 is X_4,

the number of units to be produced from product 5 is X_5,

the number of units to be produced from product 6 is X_6,

the number of units to be produced from product 7 is X_7,

the number of units to be produced from product 8 is X_8,

the number of units to be produced from product 9 is X_9,

and the number of units that will be produced from product 10 is X_{10}.

Step 2: The Objective function for this study is to minimize the total cost (Z), where:

$$Z = 5890\,X_1 + 5250\,X_2 + 2520\,X_3 + 2410\,X_4 + 1840\,X_5 + 1560\,X_6 + 1425\,X_7 + 1610\,X_8 + 1720\,X_9 + 10280\,X_{10}$$

It is clear that the mathematical model of this problem achieves all the following conditions of the written programming model

Step 3: There are eighteen Restrictions or Constraints identified in this study (Eight Machines) and (ten types of Material) as described below:

A) Restrictions on raw material(10 Inequalities)

$$425 X_1 + 370 X_2 + 200 X_3 + 280 X_4 + 210 X_5 + 180 X_6 + 170 X_7 + 215 X_8 + 230X_9 + 1250 X_{10} \geq 6000000$$

$$1.5 X_1 + 1.5 X_2 + 1.8 X_{10} \geq 500000$$

$$1.5 X_8 \geq 730000$$

$$2.17 X_3 + 3.74X_4 + 85 X_7 + 2.35X_9 + 3.1X_{10} \geq 650000$$

$$2 X_{10} \geq 300000$$

$$25X_5 + 22X_6 + 15 X_7 + 24 X_8 + 25X_9 + 35 X_{10} \geq 420000$$

$$20 X_1 + 15 X_2 + 10 X_3 + 10 X_4 + 10 X_5 + 14 X_6 + 16 X_7 + 18 X_8 + 18 X_9 + 30 X_{10} \geq 900000$$

$$X_1 + X_3 + X_4 + X_8 \geq 40000$$

$$60X_1 + 50 X_2 + 25 X_3 + 15 X_4 \geq 1500000$$

$$8X_1 + 5 X_2 + 5 X_3 + 4 X_8 + 5 X_9 + 8 X_{10} \geq 1400000$$

B) Production Capacity Constraints:

$$5 X_1 + 5X_2 + 4 X_3 + 4 X_4 + 3 X_5 + 2 X_6 + 2 X_7 + 3 X_8 + 4 X_9 + 5 X_{10} \geq 2038850$$

$$10 X_1 + 10 X_2 + 5 X_3 + 5 X_4 + 5 X_5 + 4 X_6 + 4 X_7 + 5 X_8 + 5 X_9 + 8 X_{10} \geq 2454250$$

$$90X_1 + 90 X_2 + 25 X_3 + 25 X_4 + 50 X_5 + 50 X_6 + 50 X_7 + 4 X_8 + 4.5 X_9 + 5 X_{10} \geq 938000$$

$$8 X_1 + 8 X_2 + 4 X_3 + 4 X_4 + 3.5 X_5 + 3 X_6 + 3.5 X_7 + 4.5 X_8 + 6 X_9 + 8 X_{10} \geq 2605250$$

Step 4: Non-negativity constraint

X1, X2, X3, …, X10 cannot be negative because it represents the number of units to be produced, so the condition of non-negativity is placed as follows:

$$X1, X2, \ldots, X10 \geq 0$$

3.2.2 Solving the above L.P.Model by Simplex Method.

To solve the previos L.P Model, we used Q.S. Package.

All results are described in Table 3 belwo:

Table 3

Cost per unit , reduced cost, total cost and number of unit to be produced

No.	Decision Variables	Solution Value	Unit Cost	Total Contribution	Reduced Cost	Allowable Min.	Allowable Max.
1	X1	0	5890	0	640.0000	5250.0000	
2	X2	153333.300	5250	805000100	0	0	5890.0000
3	X3	0	2520	0	1121.6840	1398.3160	
4	X4	49465.2500	2410	119211200.	0	0	2737.3620
5	X5	0	1840	0	1840.0000	0.0000	
6	X6	0	1560	0	1560.0000	0	
7	X7	0	1425	0	232.8877	1192.1120	
8	X8	486666.7000	1610	783533300	0	0	
9	X9	0	1720	0	205.6953	1514.3050	
10	X10	150000.0000	10280	1542000000	0	8297.5940	
	Objective	Function=Z	Min =	3249745000			

4. Conclusions:

This study focused on a small Factory as a case study with the aim of Constructing Linear Programming Model by identifying the objective function, decision variables, and restrictions through understanding of the current cost production of the Factory which is fulfilled the objectives, and applying this linear programming Model for Calculating Minimum Cost. We developed a linear programming model in this study and solved this model by Q.S. Package. The results that summarized in Table 3 are suggested the following:

4.1.The essential Variables (product X2 = suit) , X4 = shirt 2), X8 = pants 4) and X10 = premium suit) that can be rely on in the production process to reduce costs within the restrictions.

4.2. The number of units that can be produced, from:

X2 = 153333 units, X4 = 49465 units,

X8 = 486666 units and X10 = 150,000 units.

4.3. Cost Reduction:

The costs were reduced for product X1 (Long jacket) from:

5890 dinars to 5250 dinars by 640 dinars.

The costs were reduced for product X3 (Shirt 1) from:

2520 dinars to 1398 dinars by1122 dinars.

The costs were reduced for product X9 (Pants 1) from 1720 dinars to 1514 dinars by 206 dinars and so on.

4.4. Total Cost and Cost per Unit

4.4. 1. the Optimal Total cost production is: Z = 3249745000

4.4. 2. The minimum cost of product X2 = 805000100

4.4. 3. The minimum cost of product X4 = 119211200

4.4. 4. The minimum cost of product X8 = 783533300

4.4. 5 The minimum cost of product X10 = 1542000000

4.5. The new Objective Function (Minimum Total Cost) is:

Recommendations: The Manager of this Factory should constraint on producing the products X2, X4, X8 and X10. For future studies, we suggest to use Multiple Linear Regression Analysis to find or estimate the Standard Cost and make proper Comparison between Standard Cost and Optimal Cost (Minimum Cost) that has been computed by using Linear Programming Technique.

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