Cost Estimation of Bandage Production Using Simplex Method

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ABSTRACT

A key problem faced by managers is how to allocate scarce resources among activities or projects. Linear programming, or LP, is a method of allocating resources in an optimal way. It is one of the most widely used Operations Research (OR) tools. Using LP, the system helps the management to decide how to allocate the limited resources to maximize profits. This paper will support the bandage production for a factory by using simplex method, sensitivity analysis and dual simplex method. To get maximum profit and minimum cost, the paper uses the simplex method, which is one of multidimensional unconstrained optimization without derivative methods to search for optimal parameters in product and process design. Options are available which can provide additional information and analysis on problems by using sensitivity analysis. And then calculate by using dual simplex method to get post-optimal solution.

1. Introduction

To be successful in market competitions for any businesses, especially in manufacturing plant, it is essential that both productivity and quality must be accomplished while the cost reduction is satisfied. Thus, most industrial factories focus on quality improvement and cost reduction which will also affect the productivity. One method that they use to improve the quality with cost reduction is to aim at the design phase where they attempt to find the estimated function that represents the output or response of their processes or systems and search for optimal parameters.

Linear programming (LP) is the general techniques of optimum allocation of "Limited" resources, such as labour, material, machine, capital, energy, etc. to several competing activities, such as products, services, jobs, new equipment, products, etc. on the basic of a given criterion of during planning period. Linear programming is a widely used operations research tool in economics and business [1]. It is used to answer such business questions as how to maximize profits from products produced or how to minimize costs of certain business activities given certain constraints.

The linear programming model has been applied in a large number of areas [3] including military applications, transportation and distribution, scheduling, production and inventory management, telecommunication, agriculture and more. Many problems simply lend themselves to a linear programming solution but in many cases some ingenuity is required for the modeling. Linear programming also has interesting theoretical applications in combinatorial optimization and complexity theory.

The purpose of this paper is to estimate the cost estimation of bandage production. If the system computes the maximum profit and minimum cost of the product by using simplex method, the formula used in the system are described in equation 1 of section 3.2 and equation 2 of section 3.3, then compare the simplex method's profit and expense and sensitivity's profit and expense and then to problems involving the collection for scare resources decision makers to arrive at the optimal solution. The system estimates the profit of the product and the expense of it.

The remainder of this paper is structured as follows: Section 2 describes the related works. Section 3 represented the background theory and section 4 explains the system architecture. The conclusion and further extension is discussed in the section 5.

2. Related Word

Kantorovich [5], who as early as 1939 formulated and solved a linear programming problem (LPs) dealing with the organization and planning of production. It's known that, historically, the initial mathematic statement, the basic theoretical results of the general problem of LP were first made, developed and applied in 1947 by George B. Dantzig, Marshall Wood, and their associates of the U.S. Department of the Air Force along with the simplex method. The Air Force organized a research group under the title of Project SCOOP (Scientific Computation of Optimum Programs) whose the most important contribution was the formal development and application of the LP model.

Emre Alper Yıldırım [1] presented the study concerned with sensitivity analysis on perturbations of the right-handside and the cost parameters in linear programming (LP) and semidefinite programming (SDP).

Zoran Bosnic [4] discusses the reliability estimation of individual regression predictions in the field of supervised learning. In contrast to the average measures for the evaluation of model accuracy (e.g. mean squared error), the reliability estimates for individual predictions can provide additional information which is beneficial for evaluating the usefulness of the predictions.

A moderately sized LP with 10 products and 10 resource constraints would involve nearly 200,000 corners [2]. An LP problem 10 times this size would have more than trillion corners. In the real world, computer software is used to solve LP problems using the simplex method.

3. Methods

3.1. Simplex Method

Simplex is a mathematical term. In one dimension, a simplex is a line segment connecting two points. In two dimensions, a simplex is a triangle formed by joining the points. A three-dimensional simplex is a four sided pyramid having four corners [2]. The underlying concepts are geometrical, but the solution algorithm, developed by George Dantzig in 1947, is an algebraic procedure.

As with the graphical method, the simplex method finds the most attractive corner of the feasible region to solve the LP problem. Any LP problem having a solution must have an optimal solution that corresponds to a corner, although there may be multiple or alternative optimal solutions.

Simplex usually starts at the corner that represents doing nothing. It moves to the neighboring corner that best improves the solution. It does this over and over again, making the greatest possible improvement each time. When no more improvements can be made, the most attractive corner corresponding to the optimal solution has been found.

3.2. Simplex algorithm

In mathematical optimization theory, the simplex algorithm is a popular algorithm for numerical solution of the linear programming problem. The simplex algorithm requires the linear programming problem to be in augmented form [7]. The problem can then be written as follows in matrix form:

Maximize Z in:

$$\begin{bmatrix} 1 & -\mathbf{c}^T & 0 \\ 0 & \mathbf{A} & \mathbf{I} \end{bmatrix} \begin{bmatrix} Z \\ \mathbf{x} \\ \mathbf{x}_s \end{bmatrix} = \begin{bmatrix} 0 \\ \mathbf{b} \end{bmatrix}$$

Equation (1)

where x are the variables from the standard form, xs are the introduced slack variables from the augmentation process, c contains the optimization coefficients, A and b describe the system of constraint equations, and Z is the variable to be maximized.

The simplex algorithm begins by finding a basic feasible solution. At each step, one basic and one nonbasic variable are chosen according to the pivot rule, and their roles are switched.

3.3. Matrix Form of the Simplex algorithm

At any iteration of the simplex algorithm, the tableau will be of this form:

$$\begin{bmatrix} 1 & -\mathbf{c}^T & 0 \\ 0 & \mathbf{A} & \mathbf{I} \end{bmatrix} \begin{bmatrix} Z \\ \mathbf{x} \\ \mathbf{x}_s \end{bmatrix} = \begin{bmatrix} 0 \\ \mathbf{b} \end{bmatrix}$$

Equation (2)

where are the coefficients of basic variables in the c-matrix; and B consists of the columns of corresponding to the basic variables [7].

It is worth noting that B and are the only variables in this equation (except Z and x of course). Everything else is constant throughout the algorithm.

3.4 Sensitivity

Sensitivity analysis (or post-optimality analysis) is the study of the behavior of the optimal solution of an optimization problem with respect to changes in the data of the original problem [7]. Apart from being an interesting theoretical question in itself, sensitivity analysis is often very important in practice. Typically, the numerical data arising from real-life problems might not be precise due to measurement errors or inadequate estimates. Consequently, one might be interested in obtaining optimal solutions under different scenarios resulting from small perturbations of the data.

Even if the data is precise, one might be concerned with the behavior of the optimal solution with respect to specific perturbations. This might arise, for instance, in the context of capacity expansion. A company might want to determine the most critical resource whose per-unit increase would yield the most significant increase in production or profit.

In a linear programming model it is assumed that the input data (also known as parameters) such as: (i.) cj, profit(or cost) contribution per unit of decision variables, (ii.) bi, availability of resources, and (iii.) aij, consumption of resources per unit of decision variables, are constant and known with certainty. However, data used may be subject to error, cost (or profits) and resource availability can change with time. Uncertainty about any of these parameters may therefore cast doubt on the availability of the optimal solution of an LP problem. Thus an approach is needed to assess the change in the optimal solution due to changes in the original parameter values. Changes in the parameters of the solution of the LP problem have two categories-

1. Discrete change: Such changes are studied through an approach known as sensitivity analysis.
2. Continuous changes: These changes are studied through an approach called parametric programming.

It is concerned with the study of 'sensitivity' of the optimal solution of an LP problem with discrete variations (changes) in parameters.

3.4.1 Dual-simplex method

Dual-simplex method algorithm [1] has five steps.

Step1 : Determine an initial solution

Convert the given LP problem into the standard form by adding slack, surplus and artificial variables and obtain an initial basic feasible solution. Display this solution in the initial dual-simplex table.

Step2 : Test optimality

If all solution values are positive (i.e. x_{Bi}>=0, for all i) then there is no need of applying a dual-simplex method because improved solution can be obtained by simplex method itself.

Step3 : Test inconsistency

If there exists a row, say r, for which solution value is negative (i.e. $x_{Bi}<0$) and all elements in row r and column j are positive (i.e y_{Bi}>=0 for all j), then current solution is infeasible.

Step4 : Obtain improved solution

1.Select a basic variable associated with the raw (called key row) having the largest negative solution value, i.e. $x_{Br}=\mathrm{Min}\{x_{Bi};\ x_{Bi} <0\}$

2. Determine the minimum ratios only for those columns having a negative element in row r. Then select a non-basic variable for entering into the basis associated with the column for which

$$\frac{c_k - z_k}{y_{rk}} = \min_{j} \left\{ \frac{c_j - z_j}{y_{rj}} ;\ y_{rj} < 0 \right\}$$

The element (i.e.y_{rk}) laying at the intersection of key row and key column is called key element. The improved solution can then be obtained by making y_{rk} as I and all other element of the key column zero. Here, it may be noted that key element is always positive.

Step5 : Revise the solution

Repeat steps 2 to 4 until either an optimal solution is reached or there exists no feasible solution.

4. System Implementation

Firstly, resources, labour's cost, and raw material's costs will be entered by the user for input of simplex method as shown in Figure 1.

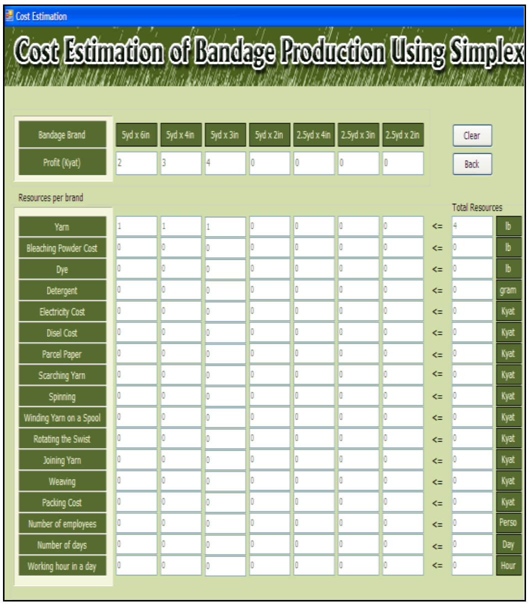

Figure 1. Input of simplex method form

These inputs are substituted in respective constraints and calculated by using simplex method. The maximum profit, quantity of each brand and cost is displayed in the Figure 2.

Figure 2. Result of cost estimation of bandage production

If user wants to change values of input parameters, the system will keep on calculation by sensitivity analysis. In applying, sensitivity analysis; the new parameters will be inserted again by the user. And then system automatically analyses the new parameters by using sensitivity analysis.

If the optimal solution has to change, the system operates to get post-optimal solution by using dual simplex method. The user can compare the original values by simplex method and the new values by sensitivity analysis and dual simplex method as shown in Figure 3.

Figure 3. Result of addition of a new variable (column) form

5. Conclusion and Further Extension

Linear programming is a widely used and extremely useful tool for evaluating a wide variety of business problems. Objective functions and structural constraints can be easily formulated to address very specific types of business decisions and applications. Simplex method is used to solve the problem areas faced in bandage production factory. The system calculates the maximum profits and minimum costs. The system analyses the changing values of sources, profit per type, and the variables. Finally the system provides the optimal solution for the bandage production. The graphical method can be further developed for this system.

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