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Application of Linear Programming in Multi-Design Selection

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ABSTRACT

The primary aim of the employer, the contractor and project managers engaged in the management of construction and other allied project is to maximize the return on investment and or to minimize the cost of production. The final states of these hitherto capital – intensive projects usually show the outcomes of design and cost decisions that were made at the planning stages of these projects. Noticeably too, conceptual/planning errors noticed in construction projects accounts for a huge amount of schedule slippage and budgetary overrun experienced in the construction industry. This paper therefore, attempts to provide an optimal decision-making framework using linear programming model to meet the challenging dynamic requests of today's clients.

KEYWORDS: *Linear programming, optimal solution, multi-design selection.*

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I. INTRODUCTION

Project resources available to practitioners in the construction industry are not only scarce but are also expensive. These resources, which include material, labor and plant constitutes the highest value of the project cost and are subjected to the prevailing technical, managerial and economic forces of waste, risk, high interest rates, inflation and other variables. These seemingly tasking challenges lead to avoidable but common bottlenecks such as sub-optimal design, inadequate constraint consideration at the inception of the project plan. Project resources can be optimized and these noticed shortfalls can be avoided or minimized with the application of linear programming techniques.Linear programming is a resource optimization tool aimed at allocating limited project limited resources optimally under such assumptions as certainty, linearity and fixed technology. In the real sense, linear programming is an improvement over the classical optimization technique, which is based on calculus (Lucey, 1994). General linear programming problem is the problem of optimal planning which deals with the search for optimum of a given objective function. The objective function is further subject to constraints in the form of linear equations or equalities. It is one of the most developed and widely applied mathematical tools in resource selection and allocation. It is because of this fact that most problems, which are originally not linear programming ones, are converted to linear programming problems with the introduction of slack and or artificial variables.

Historically, programming problem first arose in economics, were optimal allocation of resources has long been of interest. One of the outstanding theoretical models developed then was the *Von Neuman's* linear model of an expanding economy. This was the effort of a number of Austrian and German economists and mathematicians. Other parallel studies by Leotif developed the input-output model. This practical model was concerned with the determination of the output levels of different industries in order to match production with demand. A further generalization of this model was later developed to allocate resources in such a manner to either maximize or minimize the objective function. George B. Dansting, a member of the Air Force group, formulated the general linear programming problem and developed one of the most outstanding methods of solving linear programming problems- the simplex method. Thereafter, there has been a rapid progress in both theoretical development and practical applications of linear programming model globally.

Linear programming

Linear programming is a mathematical technique and an aspect of operations research whose primary function is to allocate limited resources of the firm. It is a method of solving problem in which an objective function must be either maximized or minimize within the extremes of available resources. It is a resource optimization technique used to help project managers to properly utilize project scare resources to achieve their goals of space, cost, time, aesthetics, quality etc. There are five properties a problem must have to permit the application of linear programming. These include the following:

Objective function

The objective function is simply a mathematical statement expressing the relationship between the items the decision maker whishes to optimize and the level of operation of the decision variables in the problem. It is usually preceded by either *max* or *min* depending on whether the item under consideration is to be maximized or minimized.

Alternative course of action

In a linear programming problem, there must be more than one course of action. This will enable the decision maker to make choice between the alternatives. For the case of a project, the decision maker or project manager is opened to making choice among alternative design options, resource scheduling/allocation options and other decisions that would optimize the objective function.

II. CONSTRAINTS

If a problem does not have restrictions, certainly it is no longer a problem. As a condition, linear programming problem must operate within the limits of restrictions placed upon the problem, which the decision maker must always take into consideration. For the project manager to realize his dream designs, he will be regularly faced with several conditions like the client's budget, allowable project time, available manpower, market share and other environmental and socio-economic factors. The constraints section of the linear programming formulation is generally preceded by words "subject to" which imply that the decision makers' choice of action is restricted by the constraints that follow. In each resource constraint, the mathematical expression on the left side of the inequality sign represents the amount of resources consumed by a particular linear programming solution. The quantities on the right side of the constraint equation show how much of this resource is available.

Interrelationship of variables

Another requirement for a linear programming solution is that the variable must be interrelated. It is only then that the decision maker would be able to express their relationship mathematically.

Limited resources

The resources for a linear programming problem must be limited in supply and economically quantifiable. For instance, in a project site, equipment can only be available for limited hours, days, weeks or months as the case may be.

The Simplex Method

Among the various methods of solving a linear programming problem the simplex method is one of the most powerful. The method rests on two basic concepts: feasibility and optimality. Procedurally, the search for the optimal solution starts with a basic feasible solution. The solution is then tested for optimality and if it is optimal, the search is stopped. If the test of optimality shows that the current solution is sub-optimal, a new basic and feasible solution is designed. The feasibility of the new solution is guaranteed by the mechanics of the simplex method. This iterative process is continued until an optimal solution is obtained.

The simplex method believes that the optimal solution to a linear programming problem if it exists can be found in one of the basic feasible solutions. Thus the first step is to obtain a basic solution and tested for optimality by examining its net effect on the linear objective function with the introduction of one non-basic variable. If any improvement potential is noticed, the replacement is made always with only one non-basic variable at a time. The replacement process is such that the new solution is always more feasible.

Case study

The linear programming application in project management practice particularly in multi-design decision-making process within existing constraints will be clearer when illustrated with an example. Consider a case where the project manager is requested to optimize the resources of his client, who intend to construct three different building design types for accommodation type 1, 2 and 3. The property market information available to the project manager shows that design type-1 would attract \$1000 unit profit earning and design type 2 and 3 would attract \$2,000 and \$3,000 unit profit earning respectively. With the available information, the project manager is required to advice his client the most optimal design selection. In order to meet up the projected demand by the different income groups, the employer further requested that:

- maximum number of the units of all design types should be 600units.
- design type-1 for low income earners should not be more than 200 units.
- design type-3 for high income earners should not be less than 100 units.

  The simplex technique would be of serious assistance in this context. It will help to formulate the problem as well as provide the optimal solution. For an easy problem formulation and solution, the following steps would be necessary.

Firstly, the project manager should identify the objective of the problem. In this case it is a maximization problem. Your client needs maximum profit from your decision. Secondly, he would identify the decision variables of the problem and their expected unit returns. In this case the decision variables are the various design types and returns are the unit profits of the various design types. You then attach connation to each of them as follows:

X_1 = no. of units of design type-1
X_2 = no. of units of design type-2
X_3 = no. of units of design type-3
Then the objective function is then formulated as follows:

Maximize $Z = 1000X_1 + 2000X_2 + 3000X_3$

The project manager upon the formulation of the problem should identify all the constraints imposed on the problem. In this case, the project manager is faced with two major constraints: the number of dwelling units and the specific number of dwelling units for low and high-income groups. Since the constraint levels cannot be exceeded, we have the following constraint equations.

$X_1 + X_2 + X_3 = 600$ (maximum number of dwelling units)
$X_1 > 200$ (dwelling units of for low-income earners)
$X_3 < 100$ (dwelling units for high income earners)
$X_1, X_2, X_3 > o$

The final formulation of the problem is stated below:
Maximize $Z = 1000X_1 + 2000X_2 + 4000X_3$
Subject to

$X_1 + X_2 + X_3 = 600$ (maximum number of dwelling units)
$X_1 > 200$ (dwelling units for low-income earners)
$X_3 < 100$ (dwelling units for high income earners)
$X_{1r}\ X_{2r}\ X_3 > o$

After a series of mechanical iterations, the optimal solution of the problems is as follows:
Z = $1, 200,000, X_1 = 200 units, X_2 = 300units and X_3 = 100units.

III. DISCUSSION

The above case study typifies a real life situations most practicing architect/project managers face on a daily basis. But for the solution offered by linear programming, decision-making in the above problem among the seemingly confusing constraints ordinarily would have been extremely difficult. The entire mechanics of the simplex method is not included in the paper for purposes of demonstration of the application. The above output implies that the optimal decision of the architect/project manager that will generate maximum profit is only when he chooses to build 300 units for the low income category, 200units for the middle income earners and 100units for the high income earners, which will give a maximum profit of $1,200,000 for the client.

IV. CONCLUSION

Linear programming application is quite a complex and tedious process. This is perhaps why its application in the construction industry is infinitesimal. But as the entire world and indeed the practice of construction professionals tend to be technology-driven, it is the view of the author that the incorporation of this resource optimization technique in their practice ethics will enhance their performance and indeed the accuracy of their technical advice to clients

REFERENCE

[1] Brownson Richard, *Theory and practice of operation research*, (Singapore, McGraw-hill Book Company, 1983)
[2] Bunday D. Brian, *Basic optimization methods*, (London, Edwards Arnold publishers Limited,, 1984)
[3] T. Lucey, *Quantitative technique: an instructional manual*,(London, DP-Publication, 1994)
[4] R.J. Meredith and S.J. Mantel, *Project management: a managerial approach*, (New York, John Willey and Sons, 1995)
[5] Smith E. David, *Quantitative business analysis*,(New York, John Willy and Sons, 1984)
[6] Thierant C. Rebert, *Decision making through operations research*,(New York, John Willy and Sons, 1980)