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Formulation of Investment Problem Using Linear Programming Problem

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Abstract: Operations research (OR) focus on a wide range of problem-solving techniques and methods applied in the pursuit of improved decision-making and efficiency, such as simulation, mathematical optimization, queuing theory and stochastic-process models, neural networks, expert systems, decision analysis, and the analytic hierarchy process. Nearly all of these techniques involve the construction of mathematical models that attempt to describe the system. Because of the computational and statistical nature of most of these fields, OR also has strong ties to computer science and analytics. Operational researchers faced with a new problem must determine which of these techniques are most appropriate given the nature of the system, the goals for improvement, and constraints on time and computing power.[1] In this content we are going to discuss about the formulation of investment problem by using Linear Programming Problem.

Keywords: Investment Problem, Decision – Making, Objective Function, Constraints, Non - negative restriction

I. INTRODUCTION

Operations Research is a science which comprises various quantitative tools for decision – making processes. According to Operational researchers the development of linear programming method is one of the most important scientific advances of the second half of the 20th century. Linear Programming has been used to formulate investment problem at maximum profit and with a set of restrictions. In order to attain optimized solutions for investment problems, we first present the formulation of a investment problem at maximum profit using six restrictions aiming at making investigators in the field of investment problem more familiar with the terms and method reported.

A. Describing A Linear Programming Method

The general Linear Programming Problem calls for optimizing a linear function of variables called the Objective Function subject to a set of linear equations and inequalities called the Constraints or Restrictions.[3]

The main objective of optimization is to find a set of decision-making variables that generates an optimal solution for the objective function, a maximum or minimum value depending on the problem, and complies with a set of conditions imposed by the model. Such conditions are restrictions that limit the decision-making variables and their relations to assume feasible solution. The Linear Programming models are composed of an objective function which is linear, i.e., it is defined as a linear combination of decision-making variables and a set of constants, restricted to a set of linear inequality or equality equations and parameters.

Objective Function:
The objective function evaluates some quantitative criterion of immediate importance such as cost, profit, utility, or yield. The general linear objective function can be written as

$$z = c_1x_1 + c_2x_2 + \ldots + c_nx_n = \sum_{j=1}^{n} c_j x_j$$

Here c_j is the coefficient of the jth decision variable. The criterion selected can be either maximized or minimized.

Constraints:
A constraint is an inequality or equality defining limitations on decisions. Constraints arise from a variety of sources such as limited resources, contractual obligations, or physical laws. In general, an LP is said to have *m* linear constraints that can be stated as

$$\sum_{j=1}^{n} a_{ij}x_j \begin{Bmatrix} \le \\ = \\ \ge \end{Bmatrix} b_i, \quad \text{for } i = 1 \ldots m$$

Restriction : Limitations which cannot be exceeded or rules which cannot be broken. These can be either explicit or implicit.

$$x_j \ge 0, \text{for } j = 1 \ldots n$$

Decision variables describe the quantities that the decision makers would like to determine. They are the unknowns of a mathematical programming model. Typically we will determine their optimum values with an optimization method.

The collection of coefficients (c_j, a_{ij}, b_i, u_i) for all values of the indices *i* and *j* are called the parameters of the model. For the model to be completely determined all parameter values must be known.

Fig - 1: Structure of general LPP

The chart represented in figure shows definitions and interactions among these components. A solution of a problem is called optimal when the decision-making variables assume value of the objective function and complies with all restrictions of the model.
An algebraic representation of a generic formulation of linear programming model could be presented as follows.
To maximize or minimize the objective function:

$P = k_1x_1 + k_2x_2 + \text{---------------} + k_nx_n$ (i)

It is subject to restrictions

$a_{11}x_1 + a_{12}x_2 + \text{---------------} + a_{1n}x_n \le = \ge b_1$ (ii)

$a_{21}x_1 + a_{22}x_2 + \text{---------------} + a_{2nn} \le = \ge b_2$ (iii)

$a_{m1}x_1 + a_{m2}x_2 + \text{--------------} + a_{mn}x_n \le = \ge b_m$ (iv)

$x_j \ge 0$ (j = 1,2,------------------ n) (v)

Where
(i)Represents the mathematical function encoding the objective of the problem and is called objective function.
In linear Programming, this function must be linear.
(ii)To (iv) represents the linear mathematical function encoding the main restrictions identified.
(v)Non-negativity restrictions, i.e., the decision-making variables may assume any positive value or zero.
" X_j " Corresponds to the decision-making variables that
represent the quantities one wants to determine to optimize the result.
" k_i " represents gain or cost coefficients that each variable is able to generate.
" b_j " represents the quantity available in each resource.
" a_{ij} " represents the quantity of resources each decision making variable consumes.

B. The Investment Problem

To illustrate an application of linear programming in investment formulation:
Let us assume that Mr. Kumar, a retired Govt. officer, has recently received his retirement benefits, viz., provident fund, gratuity etc. He is contemplating as to how much funds he should invest in various alternatives open to him so as to maximize return on investment. The investment alternatives are : Government Securities, Fixed Deposits of a public limited company, Equity shares, Term Deposits in banks, National Saving Certificates and Real Estate. He has made a subjective estimate of the risk involved on a five point scale. The data on the return on investment, the number of years for which the funds will be blocked to earn this return on investment and the subjective risk involved are as follows:

Table 1: Investment Details

Investment Alternatives	Return	Number of Years	Risk
Govt. Securities	5%	12	1
Company Deposits	14%	2	2
Equity Shares	21%	4	5
Term Deposits	10%	2	1
NSC	12%	5	1
Real Estate	30%	12	3

He was wondering what percentage of funds he should invest in each alternative so as to maximize the return on investment. He decided that average risk should not be more than 3 and funds should not be locked up for more than 15 years. He would necessarily invest at least 35% in real estate.
Decision making variables:

x_1 unit of Govt. Securities
x_2 unit of Company Deposits
x_3 unit of Equity Shares
x_4 unit of Term Deposits
x_5 unit of NSC
x_6 unit of Real Estat

C. Objective function (p)

The function is to be maximized. The objective function of this problem is defined by the combination of total funds invested in Govt. Securities(x_1), Company Deposits(x_2), Equity Shares(x_3), Term Deposits(x_4), NSC(x_5), Real Estate(x_6) respectively.

Maximize P = Rs 0.05 x_1+ Rs 0.14 x_2 + Rs 0.21 x_3
+ Rs 0.10 x_4+ Rs 0.12 x_5+ Rs 0.30 x_6 (vi)

This Objective function is a linear.

D. Restrictions

The average risk should not be more than 3.
The funds should not be locked up for more than 15 years and invest at least 35% in real estate.
Non negative quantities of investment should be
$x_1 \geq 0,\ x_2 \geq 0,\ x_3 \geq 0,\ x_4 \geq 0,\ x_5 \geq 0,\ x_6 \geq 0$

E. Mathematical model for the Investment Problem

Maximize P = Rs 0.05 x_1+ Rs 0.14 x_2 + Rs 0.21 x_3
+ Rs 0.10 x_4+ Rs 0.12 x_5+ Rs 0.30 x_6
is subject to conditions
$12x_1 + 2x_2 + 4x_3 + 2x_4 + 5x_5 + 12x_6 \leq 15$
(lock up restriction) (vii)
$1x_1 + 2x_2 + 5x_3 + 1x_4 + 1x_5 + 3x_6 \leq 3$
(average risk restriction) (viii)
Non negative restrictions
$x_1 \geq 0,\ x_2 \geq 0,\ x_3 \geq 0,\ x_4 \geq 0,\ x_5 \geq 0,\ x_6 \geq 0.35$
(ix)

II. CONCLUSION

Many researchers have developed different algorithms to solve Linear Programming Problem. This formulation can be solved by using analytical method and iterative method. The analytic solution is not possible because the tools of analysis are not well suited to handle inequalities. In such case iterative methods are well suited techniques.

Using computers also, we can solve the LPP which takes less time when compared to all the other methods. Since this method takes less time, it can be applied to solve optimization problem in industries and other fields too.

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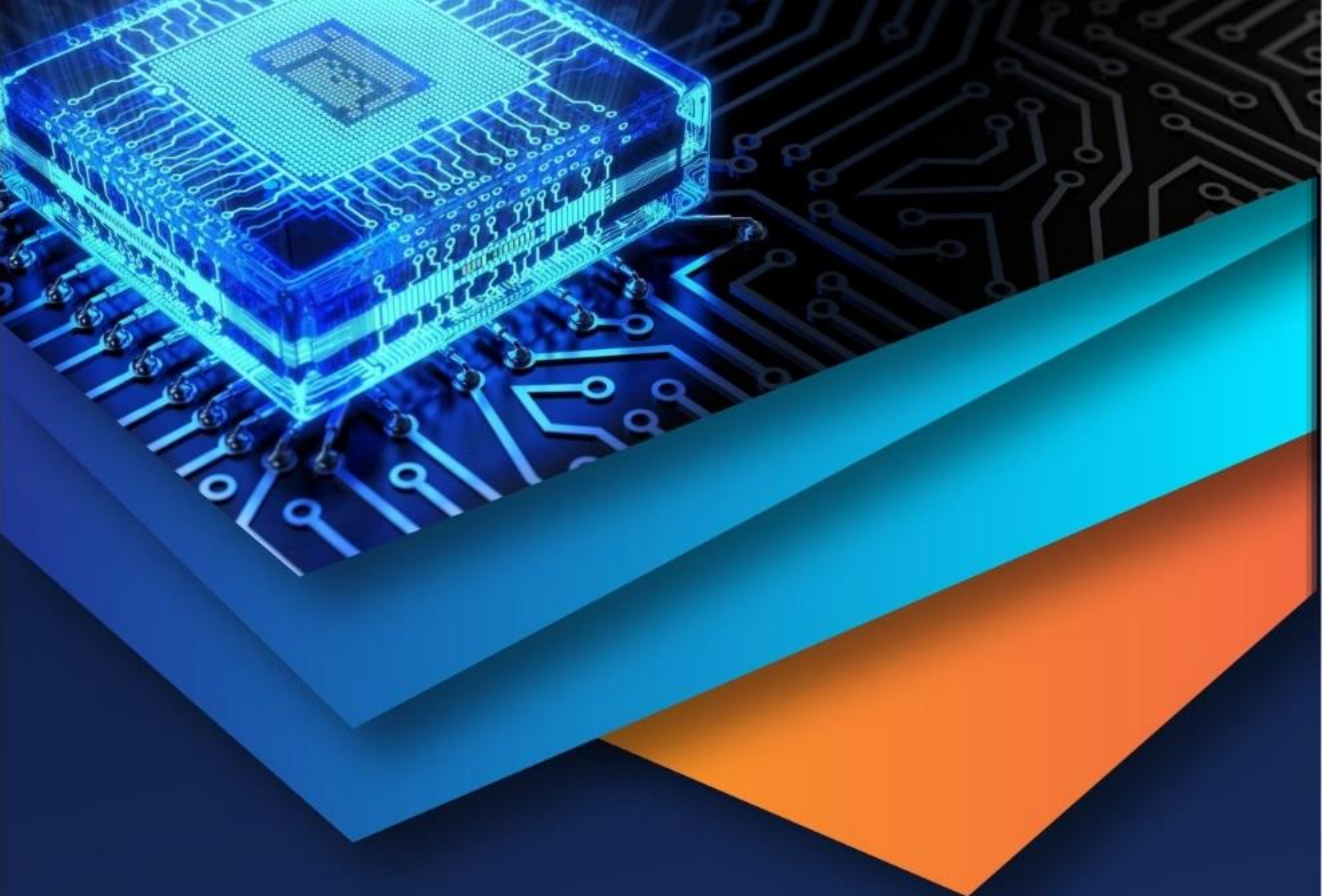

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