



MATHEMATICAL MODELING FOR PROFIT MAXIMIZATION OF THE FUNDS AND THE SHAREHOLDER

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Abstract: The primary goal of this paper is to optimize (maximize) the net return of an Indian bank in the area of interest from loans such as personal loans, car loans, home loans, agricultural loans, commercial loans, and education loans, as well as to maximize the net return of an investor by investing some money in an Indian bank's investment policies such as fixed deposits, savings accounts, public provident funds, and other investment policies. The use of a linear function to optimize profit for the funds and the shareholders is a mathematical modeling technique.

Keywords: Simplex method, Maximization, Marginal cost of funds based Lending Rate(MCLR), Linear Programming Model, Objective function, Constraints, Decision variables, Simplex method

1. INTRODUCTION

“Operational Research is a scientific approach to problem-solving for executive management”. O.R has become increasingly important in the face of fast-moving technology and increasing complexities in business and industry. There are limited resources at your disposal and your problem is to make such a use of these resources so as to yield the maximum production or to minimize profit etc., for example in manufacturing raw materials must pass through various machines for set amounts of time in an assembly line. To maximize profit, a company can use a linear expression of how much raw material to use. Constraints include the time on each machine creating bottlenecks that must be addressed. The number of products made be affected, in order to maximize profit based on the raw material and the time needed. Many Researchers worked for maximum profit using Linear Programming in different fields as:

Chambers and Charnes (1961) developed linear programming models for bank dynamic balance sheet management to determine the sequence of period-by-period balance sheets which will maximize the bank's

maximum, exposure to risk, minimum supply of liquidity, and a host of other relevant considerations. Akhigbe, A. and Mc Nulty, J.E.(2003) used Linear Programming for the profit efficiency of small U.S. Banks. Joly (2012) used linear programming in the oil sector to find optimal production processes towards the maximum profit. Waheed et al (2012) used linear programming for profit maximization in a product-mix company.

The intention of this paper is to find the maximum profit of the Indian Bank of Tamilnadu in the area of interest by investing some amount in different policies of the Bank under some conditions.

The general form of linear programming problem is

$$\text{Optimize } Z = C_1X_1 + C_2X_2 + \dots + C_nX_n \text{ (Objective function)} \quad \dots\dots\dots (2.1)$$

Subject to the constraints

$$\left. \begin{array}{l} a_{11}X_1 + a_{12}X_2 + \dots + a_{1n}X_n (\leq, =, \geq) b_1 \\ a_{21}X_1 + a_{22}X_2 + \dots + a_{2n}X_n (\leq, =, \geq) b_2 \\ \dots \quad \dots \quad \dots \quad \dots \\ \dots \quad \dots \quad \dots \quad \dots \\ a_{m1}X_1 + a_{m2}X_2 + \dots + a_{mn}X_n (\leq, =, \geq) b_m \end{array} \right\} \dots\dots\dots (2.2)$$

and non-negative restrictions

$$X_j \geq 0, \quad j=1,2,\dots,n$$

Where a_{ij} 's, b_j 's, c_j 's are constants and X_j 's are variables. In the conditions given by there may be of the three signs $\leq, =, \geq$.

The standard form of a Linear programming problem for solving by the simplex method is as

- Using slack and surplus variables to express all constraints as equations.
- For each constraints all if any is negative then multiply the corresponding constraint by -1.
- Always, the problem must be of maximization type if not convert it in maximization type by multiplying the objective function by -1.

Using slack and surplus variables the linear programming problem of n variables and m constraints can be written as follows:

$$\text{Optimize } Z = C_1X_1 + C_2X_2 + \dots + 0.S_1 + 0.S_2 + \dots + 0.S_m \quad \dots\dots\dots (2.3)$$

(Objective function)

Subject to the constraints

$$\left. \begin{array}{l} a_{11}X_1 + a_{12}X_2 + \dots + a_{1n}X_n + s_1 = b_1 \\ a_{21}X_1 + a_{22}X_2 + \dots + a_{2n}X_n + s_2 = b_2 \\ \dots \quad \dots \quad \dots \quad \dots \\ \dots \quad \dots \quad \dots \quad \dots \\ a_{m1}X_1 + a_{m2}X_2 + \dots + a_{mn}X_n + s_m = b_m \end{array} \right\} \dots\dots (2.4)$$

and non-negative restrictions

$$X_j \geq 0, s_j \geq 0, j=1,2,\dots,m$$

Where a_{ij} 's, b_j 's, c_j 's are constants and X_j 's & s_j 's are variables.

II. ASSUMPTION FOR PROBLEM

- It is assumed that the total loan amount of the Bank for maximum profit is fixed.
- It is assumed that the sum total for investing for maximum profit is fixed.
- It is assumed that there is a linear relationship among the variables used in the problem.

III. DATA PRESENTATION AND ANALYSIS FOR BANK PROFIT

The data for this paper is collected by the Indian Bank of Tamil Nadu, India.

The total fund is Rs.120Crore for different loan products.

The bank is faced with the following restrictions:

- Amounts appropriate to the different loan products not more than the total fund.
- The sum total for Home loans, Agricultural loans, and Educational loans is not more than 60% of the total fund.
- The sum total for a Personal loan and Car loan is not more than 50% of the total fund.
- The sum total for a Commercial loan (Secured) is not more than 40% of the total fund.
- The sum total for a Commercial loan (Unsecured) is not more than 20% of the total fund.
- The sum total appropriate to a Home loan is at least 5% of the total fund.
- The sum total appropriate to the Agricultural loan is at least 5% of the total fund.
- The sum total appropriate to a Car loan is at least 5% of the total fund.

The interest rate of different loans are given in the following table: (MCLR=7.35%)

Types of loan	Rate of Interest
Home	7.1%
Agricultural	7%
Car	MCLR+0.7%=8.05%
Personal	MCLR+6.6%=13.95%
Educational	MCLR+1.95%=9.3%
Commercial (Secured / Unsecured)	MCLR+3.55%=10.9%

IV. MODEL FORMULATION

Let amount for Home Loan = X_1

Let amount for Agricultural Loan = X_2

Let amount for Car Loan = X_3

Let amount for Personal Loan = X_4

Let amount for Educational Loan = X_5

Let amount for Commercial Loan (secured) = X_6

Let amount for Commercial Loan (Unsecured) = X_7

Let the objective function which is to be maximized be denoted by Z.

The mathematical form of the above problem (data) is

$$\text{Max } Z = 0.071X_1 + 0.07X_2 + 0.08X_3 + 0.139X_4 + 0.093X_5 + 0.109X_6 + 0.109X_7$$

Subject to

$$X_1 + X_2 + X_3 + X_4 + X_5 + X_6 + X_7 \leq 120$$

$$X_1 + X_2 + X_5 \leq 72$$

$$X_3 + X_4 \leq 60$$

$$X_6 \leq 48$$

$$X_7 \leq 24$$

$$X_1 \geq 6$$

$$X_2 \geq 6$$

$$X_3 \geq 6$$

and $X_1, X_2, X_3, X_4, X_5, X_6, X_7 \geq 0$

Using slack and surplus variables, the problem converted to

$$\text{Max}Z = 0.071X_1 + 0.07X_2 + 0.08X_3 + 0.139X_4 + 0.093X_5 + 0.109X_6 + 0.109X_7 + 0.S_1 + 0.S_2 + 0.S_3 + 0.S_4 + 0.S_5 + 0.S_6 + 0.S_7 + 0.S_8 \quad \text{Subject}$$

to

$$X_1 + X_2 + X_3 + X_4 + X_5 + X_6 + X_7 + S_1 = 120$$

$$X_1 + X_2 + X_5 + S_2 = 72$$

$$X_3 + X_4 + S_3 = 60$$

$$X_6 + S_4 = 48$$

$$X_7 + S_5 = 24$$

$$X_1 - S_6 = 6$$

$$X_2 - S_7 = 6$$

$$X_3 - S_8 = 6$$

$$\text{and } X_1, X_2, X_3, X_4, X_5, X_6, X_7, S_1, S_2, S_3, S_4, S_5, S_6, S_7, S_8 \geq 0$$

Using the simplex method the optimal solution of the above problem is

$$X_1 = 0$$

$$X_2 = 0$$

$$X_3 = 0$$

$$X_4 = 60$$

$$X_5 = 0$$

$$X_6 = 48$$

$$X_7 = 12$$

$$\text{and } \text{Max}Z = 89.94 \text{ Crore}$$



V. INTERPRETATION OF RESULT

The best result obtained from the model, based on the data gathered, indicated that the bank's maximum profit is 89.94 crores, with appropriate amounts for Home Loans of 0 crores, Agricultural Loans of 0 crores, Car Loans of 0 crores, Personal Loans of 60 crores, Educational Loans of 60 crores, Commercial Loans Secured of 48 crores, and Commercial Loans Unsecured of 12 crores.

VI. DATA PRESENTATION AND ANALYSIS FOR INVESTOR PROFIT

The total fund is 2 lakhs for different investment policies by senior citizen (S.C) investors. The investor has the following restrictions.

- Total invested amount not more than the total fund.
- Total invested amount in the saving account is at least 20% of the total fund.
- Total invested amount in fixed deposit is at least 25% of the total fund.
- Total invested amount in a public provident fund (PPF) and senior citizen savings scheme (SCSS) is at least 10% of the total fund.
- Total invested amount in a public provident fund (PPF) and senior citizen savings scheme (SCSS) is not more than 20% of the total fund.

The interest rate of different investment policies are given in the following table:

Investment policies	Interest rate
Saving account	2.9
Fixed deposit (S.C)	5.5
PPF	7.4
SCSS	7.4

VII. MODEL FORMULATION

Let amount for saving account = X_1

Let amount for fixed deposit (S.C) = X_2

Let amount for PPF = X_3

Let amount for SCSS = X_4

Let the objective function which is to maximize is denoted by Z .

The mathematical form of the above problem (data) is

$$\text{Max } Z = 0.029 X_1 + 0.055 X_2 + 0.074 X_3 + 0.074 X_4$$

Subject to

$$X_1 + X_2 + X_3 + X_4 \leq 2,00,000$$

$$X_1 \geq 40,000$$

$$X_2 \geq 50,000$$

$$X_3 + X_4 \geq 20,000$$

$$X_3 + X_4 \leq 40,000$$

and $X_1, X_2, X_3, X_4 \geq 0$

Using slack and surplus variables the problem converted to

$$\text{Max } Z = 0.029 X_1 + 0.055 X_2 + 0.074 X_3 + 0.074 X_4 + 0.S_1 + 0.S_2 + 0.S_3 + 0.S_4 + 0.S_5$$

Subject to

$$X_1 + X_2 + X_3 + X_4 + S_1 = 2,00,000$$

$$X_1 - S_2 = 40,000$$

$$X_2 - S_3 = 50,000$$

$$X_3 + X_4 - S_4 = 20,000$$

$$X_3 + X_4 + S_5 = 40,000$$

and $X_1, X_2, X_3, X_4, S_1, S_2, S_3, S_4, S_5 \geq 0$

Using the simplex method the optimal solution of the above problem is

$$X_1 = 0$$

$$X_2 = 1,40,000$$

$$X_3 = 60,000$$

$$X_4 = 0$$

and $MaxZ = 12,140$.

VIII. INTERPRETATION OF RESULT

The best result obtained from the model based on the data collected stated that the investor's maximum profit is \$12,140, and the amount invested in a savings account is 0; the amount invested in a fixed deposit is 1,40,000; the amount invested in a PPF is 60,000, and the amount invested in an SCSS is 0.

IX. CONCLUSION

The maximum net return of the bank is Rs. 89.94 crores by allocating none of the amounts to a home loan, agriculture loan, or car loan, the amount of Rs. 60 crores to a personal loan, none of the amount to educational loan, the amount of Rs. 48 crores to commercial loan (secured), Rs. 12 crores to commercial loan (unsecured), and the maximum profit of the investor is Rs. 12,140 by allocating none of the amounts to the savings account, investment account, or investment account.

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