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MATHEMATICAL MODELING OF ASSET LIABILITY MANAGEMENT IN BANKS USING GOAL PROGRAMMING AND AHP

Jyoti Tanwar
Research Scholar
Department of Economics and Finance
BITS-Pilani, Pilani Campus
Jhunjunu, Rajasthan- 333031, India
E-mail: jyotanwar@gmail.com

Arun Kumar Vaish
Assistant Professor
Department of Economics and Finance
BITS- Pilani, Pilani Campus
Jhunjunu, Rajasthan- 333031, India

N V M Rao
Professor
Department of Economics and Finance
BITS-Pilani, Pilani Campus
Jhunjunu, Rajasthan- 333031, India

ABSTRACT

Asset Liability Management has gained popularity in the banking sector. Earlier banks focused on asset allocation, but now the management of assets and liabilities is equally essential. Asset liability management targets the optimum distribution of funds in assets and managing liabilities so that banks can earn higher profits and minimize risk. In this paper, the optimization of assets and liabilities of Indian banks has been concentrated using mathematical models. Combining the Analytical Hierarchy Process (AHP) and Goal Programming (GP) model has been used to solve the optimization problem. AHP is a multi-criteria decision-making approach for deriving priority weights. Goal Programming is a linear programming model to solve complex issues having multiple objectives. In this paper, the primary data gathered from Bank senior managers have been analyzed using the AHP approach to derive weights for criteria. These weights are assigned to goals in goal programming to prioritize the goals. Secondary data on OBC bank is used in goal programming from 2010-2019 collected from OBC bank's annual reports and RBI websites. The findings show that OBC bank has the scope of improving its assets and liabilities position to increase its profit and minimize the risk. The model generates an optimum balance sheet that achieves the set goals and satisfies all the statutory and planning constraints. The same model can be useful for scheduled commercial banks in India with modifications concerning banks' targets and controls. The model developed in this paper is helpful for bank managers in planning and forecasting. AHP and GP's combined approach is unique in this *paper, which uses experts' knowledge and applies it in the model. The model is created on the bank's realistic goals and constraints after carefully considering the issues faced by bank officials. The paper is limited to the Indian Banking system as other countries have different balance sheet structures and constraints.*

Keywords: Asset-Liability Management, Goal Programming, Analytical Hierarchy Process, Indian Banking.

INTRODUCTION

The history of banking in India is as old as Vedic civilization, where usury has been commonly referred to money lenders. Banking in India originated in the 18th century and has evolved over the years to the present shape (Tanwar, Seth, Vaish, and Rao, 2020). Some of RBI's significant reform events led to greater competition and strengthening of the Indian banking sector. In 1969, 14 major Indian Scheduled Commercial banks were nationalized to serve the development of the economy. In 1970, RBI prescribed a minimum interest rate to be charged by banks on advances. In response to inflation, RBI took strong measures to increase bank rates and raised the Statutory Liquidity Ratio (SLR) from 25% to 28%. In 1992, RBI introduced income recognition and asset classification norms, putting most of the banks under severe Non-Performing Assets (NPAs) stress. The capital adequacy standards were specified to be fulfilled by Indian banks by 1996. In 1993, RBI released new guidelines that aimed at increasing competition by establishing private sector banks. In 2003, the risk-based supervision of banks was introduced (*Chronology of events*, n.d.).

The banking sector has undergone many structural changes, from well defined, directed norms to prudence-based compliance to move towards greater consistency. Deregulation and intense competition have led Indian banks to compete on the asset side and the liability side of the balance sheet, forcing them to assume greater and newer risk in their quest for higher returns. The composition and risk profile of banks' assets and liabilities have a direct effect on their performance and profitability. The process of managing assets and liabilities of a bank while achieving the bank's objectives and satisfying the constraints is known as Asset Liability Management (ALM). ALM is a process where risks and benefits go hand in hand. On one side, the risk is minimized, and on the other side, financial goals are maximized by optimally allocating the fund in assets and managing liabilities (Samuel, 2011). As banking regulations and management's plans change from time to time; therefore, ALM needs continuous formulation, implementation, and control. Based on the results, strategies need to be revised to improve performance and reduce risk (Romanyuk, 2010).

ALM policy framework targets achieving higher profitability and minimizing risks after considering the statutory and regulatory constraints such as liquidity, credit quality, capital adequacy, etc. Therefore ALM aims to improve the quality of assets and balance the number of assets and liabilities in addition to focusing on the riskiness in the future (Naderi, Minouei, & Gashti, 2013).

In this research paper, an attempt has been made to optimize the assets and liabilities of Indian banks using the example of the Oriental Bank of Commerce (OBC). A combination of the Analytical Hierarchy Process (AHP) with weighted goal programming is used to optimize the assets and liabilities while simultaneously fulfilling the statutory and regulatory compliance. The model developed here tries to satisfy multiple goals that are desired by all banks.

LITERATURE REVIEW

ALM is an essential tool for banks and other financial institutions to establish sound financial management that can target higher profits and lower bank risk. A bank faces market risk, operational risk, liquidity risk, interest rate risk, counterparty risk, financial risk, etc. ALM was introduced in the Indian Banking industry with effect from 1st April 1999[1]. Even in the absence of a formal asset-liability management program, understanding these concepts is of value to an institution as it provides a more authentic picture of the risk/reward trade-off in which the institution is engaged (Fabozzi & Konishi, 1991). The study of ALM develops a clearer picture of risk and return trade-off for banks. Risk and reward are complementary to each other. If banks desire to increase profits, then it has to take a calculated risk. Banks and other institutions have to create a balance between risk and reward. Therefore, ALM deals with narrowing the unfavorable effects of risk in parallel to managing the assets-liabilities.

As discussed, the bank's managers face the problem of improving profitability with their limited resources. In past decades, many techniques have been developed to assist bank officials. Various studies considered an optimization problem of selecting an optimal portfolio that can yield adequate returns while minimizing risk. A suggested by Kosmidou and Zopounidis (2002) ALM techniques can be deterministic or Stochastic. Chambers and Charnes (1961) applied deterministic linear programming in the model bank to resolve banks' functional problems. The study focuses on implementing the requirements Federal Reserve System while developing the best profitable portfolio plan. This model focuses on actual problems and optimizing the fund allocation within the defined limits of bank examiners. Fielitz and Loeffler (1979), Cohen and Hammer (1967), and many others have implemented Chambers and Charner’s model with modifications. However, they all had a single objective function, i.e., maximizing profitability within defined constraints. A Linear Programming model concentrates on maximization or minimization of objective function within a set of relevant constraints. Fielitz and Loeffler (1979) describe a mathematical model that deals with the liquidity management of commercial banks. Liquidity supports the operation of the bank, but if appropriately governed, it can also generate profits. The study aims to maximize the profits that resulted from managing liquidity variables subject to external and internal constraints. Cohen and Hammer (1967) explain an analytical model using linear programming to improve profitability subject to policy constraints. The model endeavor to create a balance between the assets and liability compositions of the bank. Eatman and Sealey (1979) developed a multi-objective linear programming model to improve commercial banks' profitability and solvency. The bank managers have solvency and risk minimization as other goals which are employed in the paper. Liquidity and risk are measured by capital adequacy ratio and risk-weighted assets to capital, respectively. Dash and Pathak (2011) proposed a linear programming model for Indian banks to optimize the assets and liability mix. The objective of the study is to maximize the profitability subject to liquidity and statutory constraints.

Apart from deterministic models, various stochastic models were also proposed after the 1970s. Markowitz (1959)introduced the Portfolio selection theory, which led to the origination of the stochastic model, also known as the static mean-variance method. Ziemba and Mulvey (1998) determined a multi-period stochastic linear program that defines the target over the

[1]Reserve Bank of India, Bombay, Asset-Liability Management (ALM) System, DBOD Circular BP.BC.8/21.04.098/99 dtd. Feb. 10, 1999

planning period. Russell-Yasuda at the Frank Russell Company used stochastic programming to develop a model that can maximize wealth and income.

Many scholars have used the goal Programming technique for generating an optimized solution for multiple goals. In the real world, a problem deals with numerous goals. Every business, bank, a household has not just one but many goals to achieve. Goal Programming (GP) is one such model that deals with multiple objectives decisions. In this model, many objectives can be achieved while seeking an optimal and feasible solution. In this model, goal constraints are set equal to target values that need not be achieved.

D. Giokas and Vassiloglou (1991) developed multi-objective programming for bank assets and liabilities management. They argued that banks have multiple goals. Bank management not only strives to maximize revenue but also put effort to reduce risk. Apart from revenue/profit, banks try to gain market share of deposits and credits. As linear programming can only handle a single objective function, goal programming is the right approach for multiple goals. Kruger (2011) used a single-period approach and multi-period approach to finds that it is possible to optimize the balance sheet using advanced software. Viswanathan and Balasubramanian (2007)applied the preemptive GP model and studied optimal deployment of funds across different asset classes of varying risk and return characteristics to attain the profit goals. The regulatory and other constraints are also satisfied while pursuing objectives. Sedzro, Marouane, and Assogbavi (2012) use goal programming models for asset allocation. The authors incorporated the investor's risk profile and future economic scenarios while optimizing asset allocation. Jain, Dalela, and Tiwari (2010) presented the ALM model for pensioners. The study discussed the fuzzy programming approach to control the risk of volatility on investment returns and liabilities.

Viswanathan, Ranganatham and Balasubramanian (2014) used the goal programming model in ALM. Goal programming optimally allocated the assets to achieve the target goals, namely Other Income, Deposits, Investments, and Advances. Halim et al. (2015)applied the GP model to attain six goals: asset accumulation, liability reduction, equity wealth, earning, profitability, and optimum management of a bank in Malaysia. The proposed model is capable of supporting financial decision making while dealing with diverse economic scenarios. Rezaei, Ameleh, Ghalmegh, and Ramezanzadeh (2013), studied assets and liabilities management by comparing the model value with actual values using Fuzzy AHP and goal programming.

Goal Programming assists in structured decision-making; however, it has no method of evaluating the priority in goals or assigning weights to goals. All goals do not have the same importance. Some goals are more important than others and have to be fulfilled. Analytical Hierarchy Process (AHP) allows pair-wise comparison and shows the domination of one element concerning others. AHP reckon the judgment of experts to obtain priority scales. The AHP is first introduced by Saaty (2008)as the most common multi-criteria decision-making method.

The use of AHP in the banking industry for ranking and assigning weights is extensive. Hunjak & Jakovčević (2001) evaluated bank performance by integrating quantitative and qualitative data. The AHP assisted in the activity of comparing and deriving bank ratings. AHP was used to assess the best applicant for irrigation and equipment loans. The purpose is to allocate the loan to rank one applicant and distribute the remaining fund to the best candidate. AHP assisted in ranking based on service, loan history, and insurance (Srdevic, Blagojevic, and Srdevic, 2011). Kamil, Ismail, and Shahimi (2013) tried to establish that Islamic banking operates to realize society's socio-economic objectives. AHP method is used to derive the priorities for financial resource allocation (ALM) while considering economic and social objectives.

Similarly, the bank decision-maker can use AHP to increase customer base and customer satisfaction by understanding their preferences (Javalgi, Armacost, & Hosseini, 1989). Tummala, Smith, and Uppuluri (1983) evaluated companies' credit risk belonging to the construction industry, which applied for loans. The ranking of the criteria was estimated with AHP. The requirements were character, capitalization, collateral, capacity, and conditions. Combing AHP with GP will provide a systematic approach to rank/prioritize or weight the goals.AHP can establish relative importance among goals, which can be readily used in the GP model to solve the problems (Naderi et al., 2013; Sedzro et al., 2012; Wang & Chin, 2008). The combination of (AHP) with GP to gain an ideal solution is the best approach.

OBJECTIVE

There are very few studies in the Indian banking industry that has applied AHP and GP together. Most of the studies have either used AHP to derive the ranking/weights or used GP to solve a multi-decision-making problem. In the Indian banking industry, the combined used of AHP and GP to optimize Asset-Liability Management is not yet focused. Therefore, in this paper, the weights for the goals or objectives are attained using AHP. Those weights are assigned to goals while optimizing the bank's assets and liabilities in the study. The paper aims to determine the optimal structure of assets and liabilities for Indian commercial banks. The targets for goals have to be achieved while simultaneously satisfying the constraints. Secondly, to analyze whether the model can provide banking management with policy inputs.

METHODOLOGY

The main objective of this paper is to design a mathematical model that can optimize the assets and liabilities of the Oriental Bank of Commerce (OBC Bank) using Goal Programming. The relative importance of the goals of Indian scheduled commercial banks is determined with AHP.

Analytical Hierarchy Process

Interviews were conducted with banks' management in risk profile and balance sheet management to identify the goals or criteria for the banks. The interviews were conducted with OBC bank, Allahabad Bank, Punjab & Sind Bank, ICICI Bank, Axis Bank, and Bank of Baroda. The seven main goals were then arranged in a questionnaire for further processing to obtain the priority and weights for the goals from banks' management.AHP used pairwise comparison and relies on the experts' judgments to obtain priority scales (Saaty, 2008). The comparison depicts the relative importance of one element over another. The process of AHP follows:

1. Define the problem
2. Determine the decision hierarchy from top to intermediate level and to the lowest level (if any).
3. Construct pair wise comparison matrices.
4. There is n (n-1)/2 judgments required, and reciprocals are assigned automatically.
5. Obtain the experts' judgment and calculate the priority scale.
6. Check for inconsistency. CR is determined using the Consistency index. To determine Consistency Ratio: **Lambda-max =** Σ (weighted sum value/ criteria weight)**/ n.** Consistency Index (CI) = (Lambda-max – n) / (n – 1). Consistency Ratio = CI/RI

Table 1. Random Index table

Size of Matrix	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

The data collected from the questionnaires are analyzed using MS Excel. After that, the consistency ratio (CR) and the relative weights vector of goals are calculated. The CR must be less than 0.1 for each pairwise comparison; otherwise, the questionnaire has to be sent again to be filled by experts (Vaidya & Kumar, 2004). Each expert's judgment is combined using geometric means to derive outcomes, as suggested by Saaty (2008). Table 2 below shows the pairwise comparison scale for AHP preferences:

Table 2. Pairwise Comparison Scale

Judgment of Preferences	**Numerical Value**
Equally important	1
Moderately important	3
Strongly important	5
Very strongly important	7
Extremely important	9
Intermediate values	
Equally to moderately preferred	2
Moderately to strongly preferred	4
Strongly to very strongly preferred	6
Very strongly to extremely preferred	8

The goals for the banks, as suggested by experts, are liquidity risk, Capital Adequacy, Market share of the deposit, Market share of Credit, Return on Asset, Return on Equity, and reducing Non-Performing Assets.

Table 3. Goals for Banks

Goals	Definition
Liquidity	Liquidity risk is the inability of a bank to meet its obligation when it arises. Banks manage their liquidity risk through ALM.
Capital Adequacy	Capital Adequacy ratio determines the extent of capital a bank requires against its risk-weighted credit exposure to protect it against losses before the risk of insolvency.
Market share of the deposit	It shows the bank's share of customer deposits in an aggregate deposit of scheduled commercial banks in India.
Market Share of credit	It shows the credit available to banks from the aggregate credit facility available to all scheduled commercial banks in India.
Return on Asset	It shows the profit-generating capacity of a bank from its total asset available. The higher the ratio better it is for the bank.
Return on Equity	It measures the return on investment invested by shareholders. The higher the ratio the better it is for the company.

Non-Performing Asset (NPA)	The banks want to reduce their nonperforming asset. It is calculated by dividing Gross NPA with Gross Advances. The lower the ratio, the better it is for the bank.

The results of the AHP are given below in table 4:

Table 4. Weights of Goal as per AHP

Goals	Weights (using AHP)
Market share of credit	0.0504
Market share of deposits	0.0446
Return on assets	0.138
Return on equity	0.133
Capital adequacy ratio	0.229
Liquidity risk	0.208
Non-Performing Asset	0.107

Goal Programming

The priority scale obtained from AHP is used to weight goals and optimize the assets and liabilities. The GP data is obtained from annual reports of OBC banks over the last ten years, i.e., from 2010 to 2019 from its website. Secondary data has also been collected from the Reserve Bank of India website for analysis. Goal Programming is used for solving the asset-liability management problem with the help of LINGO version 17 software.

Ignizio (1981)developed the following steps to formulate the GP model:

1. Define the decision variables
2. Define the structural constraints and goal constraints
3. Determine the relative weight
4. Define the objective function
5. State the non-negative requirement

The structural constraints are the statutory constraints and management constraints in the bank for the assets and liabilities. Goal constraints are the target to be achieved with positive and negative deviations. The objective function in the GP model is to minimize the variations. In this paper, weighted goal programming is used where the objective is to minimize the weighted sum of goal deviations.

The weighted Goal Programming as given by Charnes & Cooper (1977)is given below:

Minimize

$$z = \sum_{i=1}^{m} (w_i^- d_i^- + w_i^+ d_i^+) \tag{1}$$

Subject to linear constraints-

Goal Constraints:

$$\sum_{j=1}^{n} a_{ij} x_j + d_i^- - d_i^+ = b_i \quad , \quad i = 1,2,\ldots,m \tag{2}$$

Structural constraints:

$$\sum_{j=1}^{n} a_{ij}x_j \begin{bmatrix} \leq \\ = \\ \geq \end{bmatrix} b_i \quad , \quad i = m+1, \dots, m+p \tag{3}$$

With

$$x_j, d_i^-, d_i^+ \geq 0 \quad , \quad i = 1,2, \dots, m \quad , \quad j = 1,2, \dots, n$$

Where m, p, and n represent goals, structural constraints, and decision variables, respectively.
W_i negative represents weight assigned to negative deviation and W_i positive represent weight assigned to positive deviations.
D_i negative represents the negative deviational variable of the i^{th} goal (underachievement of goal).
D_i positive represents the positive deviational variable of the i^{th} constraints (overachievement of goal).
B_i represents the aspiration level or the target value.
Z= objective function
A_{ij}= The coefficient associated with variable j in the i^{th} goal
X_j= the j^{th} decision variables

Decision Variables
Identification of the decision variables:
The Indian bank balance sheet has assets and liabilities. These assets and liabilities are the decision variables.

Assets
Cash and Bank Balance
YA_1 = Cash in hand
YA_2 = Balance with RBI
YA_3 = Balance with Banks & Money at call & short notice in India
YA_4 = Balance with Banks & Money at call & short notice outside India

Investments
YA_5 = Investment in government securities
YA_6 = Investment in approved securities
YA_7 = Shares
YA_8 = Debentures
YA_9 = Investment in Subsidiaries/Joint Ventures
YA_{10} = Others (Commercial papers, Mutual funds, etc.)

Advances
YA_{11} = Bills Purchased & discounted
YA_{12} = Cash Credit, Overdrafts, Loans repayable on demand
YA_{13} = Term Loans
YA_{14} = Advances in Priority Sector
YA_{15} = Advances in Banks in India

FA = Fixed Assets and Intangible assets
OA = Other Assets

Liabilities
Shareholders fund
XL_1 = Capital
XL_2 = Reserves & Surplus

Deposits
XL_3 = Demand Deposit
XL_4 = Saving Deposits
XL_5 = Term Deposits

Borrowings
Borrowings from India
XL_6 = Borrowings from RBI
XL_7 = Borrowings from Banks and other institutions & Agencies
Borrowings outside India
XL_8 = Borrowings outside India

XL_9 = Other Liabilities
XL_{10} = Others (including provisions)

Decision Constraints

1. Total Assets = Total Liabilities

   $$\Sigma_{i=1}^{13} YA_i + FA + OA = \Sigma_{j=1}^{10} XL_j$$

   Total Asset (TA) = 2719095661

2. Cash Reserve Ratio = 4%

   $YA_2 \geq 0.04$(Net demand and Time Liability)

   $YA_2 \geq 0.04\ (XL_3 + XL_4 + XL_5 + XL_6 + XL_7 + XL_9 - YA_3 - YA_{15})$

3. Statutory Liquidity Ratio = 19.5%

   Liquid Asset = excess cash and balance with RBI over CRR + investment in govt. securities + Investment in approved securities

   Liquid Assets (LA) = $YA_1 + (YA_2) - 0.04\ (XL_3 + XL_4 + XL_5 + XL_6 + XL_7 + XL_9 - YA_3 - YA_{15}) + (YA_3 + YA_5 + YA_6$

   NTDL = $XL_3 + XL_4 + XL_5 + XL_6 + XL_7 + XL_9 - YA_3 - YA_{15}$

   $YA_1 + (YA_2) - 0.04\ (XL_3 + XL_4 + XL_5 + XL_6 + XL_7 + XL_9 - YA_3 - YA_{15}) + (YA_3 + YA_5 + YA_6 \geq 19.5\%\ (XL_3 + XL_4 + XL_5 + XL_6 + XL_7 + XL_9 - YA_3 - YA_{15})$

4. Priority Sector Lending = 40% of the Adjusted Net Banking Credit

$YA_{14} \geq 0.40\ (YA_{11} + YA_{12} + YA_{13})$

5. Investments

$\%(\Sigma_{i=1}^{13} YA_i + FA + OA) \leq (YA_5 + YA_6 + YA_7 + YA_8 + YA_9 + YA_{10}) \leq \%(\Sigma_{i=1}^{13} YA_i + FA + OA)$

$0.26\ (\Sigma_{i=1}^{13} YA_i + FA + OA) \leq (YA_5 + YA_6 + YA_7 + YA_8 + YA_9 + YA_{10}) \leq 0.30\ (\Sigma_{i=1}^{13} YA_i + FA + OA)$

6. Investments in Government Securities & approved securities

$\%\ (YA_5 + YA_6 + YA_7 + YA_8 + YA_9 + YA_{10}) \leq (YA_5 + YA_6) \leq \%\ (YA_5 + YA_6 + YA_7 + YA_8 + YA_9 + YA_{10})$

$0.75\ (YA_5 + YA_6 + YA_7 + YA_8 + YA_9 + YA_{10}) \leq (YA_5 + YA_6) \leq 0.85\ (YA_5 + YA_6 + YA_7 + YA_8 + YA_9 + YA_{10})$

7. Investments in Non-SLR securities

$\%\ (YA_5 + YA_6 + YA_7 + YA_8 + YA_9 + YA_{10}) \leq (YA_7 + YA_8 + YA_9 + YA_{10}) \leq \%(YA_5 + YA_6 + YA_7 + YA_8 + YA_9 + YA_{10})$

$0.15\ (YA_5 + YA_6 + YA_7 + YA_8 + YA_9 + YA_{10}) \leq (YA_7 + YA_8 + YA_9 + YA_{10}) \leq 0.25\ (YA_5 + YA_6 + YA_7 + YA_8 + YA_9 + YA_{10})$

8. Cash & Balance with RBI

$\%(\Sigma_{i=1}^{13} YA_i + FA + OA) \leq (YA_1 + YA_2) \leq \%(\Sigma_{i=1}^{13} YA_i + FA + OA)$

$0.045(\Sigma_{i=1}^{13} YA_i + FA + OA) \leq (YA_1 + YA_2) \leq 0.06(\Sigma_{i=1}^{13} YA_i + FA + OA)$

9. Balance with Banks & Money at call & short notice in India

$\%(\Sigma_{i=1}^{13} YA_i + FA + OA) \leq (YA_3) \leq \%(\Sigma_{i=1}^{13} YA_i + FA + OA)$

$0.001(\Sigma_{i=1}^{13} YA_i + FA + OA) \leq (YA_3) \leq 0.05(\Sigma_{i=1}^{13} YA_i + FA + OA)$

10. Balance with Banks & Money at call & short notice outside India

$\%(\Sigma_{i=1}^{13} YA_i + FA + OA) \leq (YA_4) \leq \%(\Sigma_{i=1}^{13} YA_i + FA + OA)$

$0(\Sigma_{i=1}^{13} YA_i + FA + OA) \leq (YA_4) \leq 0.01(\Sigma_{i=1}^{13} YA_i + FA + OA)$

11. Advances

$\%(\Sigma_{i=1}^{13} YA_i + FA + OA) \leq (YA_{11} + YA_{12} + YA_{13}) \leq \%(\Sigma_{i=1}^{13} YA_i + FA + OA)$

13 13

$$0.58\ (\Sigma_{i=1} YA_i + FA + OA) \leq (YA_{11} + YA_{12} + YA_{13}) \leq 0.65(\Sigma_{i=1} YA_i + FA + OA)$$

12. Bills Purchased & discounted

$\%\ (YA_{11} + YA_{12} + YA_{13}) \leq (YA_{11}) \leq \%(YA_{11} + YA_{12} + YA_{13})$

$0.006\ (YA_{11} + YA_{12} + YA_{13}) \leq (YA_{11}) \leq 0.035\ (YA_{11} + YA_{12} + YA_{13})$

13. Cash Credit, Overdrafts, Loans repayable on demand

$\%(YA_{11} + YA_{12} + YA_{13}) \leq (YA_{12}) \leq \%(YA_{11} + YA_{12} + YA_{13})$

$0.35(YA_{11} + YA_{12} + YA_{13}) \leq (YA_{12}) \leq 0.50\ (YA_{11} + YA_{12} + YA_{13})$

14. Term Loans

$\%(YA_{11} + YA_{12} + YA_{13}) \leq (YA_{13}) \leq \%\ (YA_{11} + YA_{12} + YA_{13})$

$0.48\ (YA_{11} + YA_{12} + YA_{13}) \leq (YA_{13}) \leq 0.62\ (YA_{11} + YA_{12} + YA_{13})$

15. Fixed Assets

$$FA = 0.01(\Sigma_{i=1}^{13} YA_i + FA + OA)$$

16. Other Assets

$$\%(\Sigma_{i=1}^{13} YA_i + FA + OA) \leq (OA) \leq \%(\Sigma_{i=1}^{13} YA_i + FA + OA)$$

$$0.035(\Sigma_{i=1}^{13} YA_i + FA + OA) \leq (OA) \leq 0.065\ (\Sigma_{i=1}^{13} YA_i + FA + OA)$$

17. Deposits

$$\%(\Sigma_{i=1}^{13} YA_i + FA + OA) \leq (XL_3 + XL_4 + XL_5) \leq \%(\Sigma_{i=1}^{13} YA_i + FA + OA)$$

$$0.85(\Sigma_{i=1}^{13} YA_i + FA + OA) \leq (XL_3 + XL_4 + XL_5) \leq 0.90(\Sigma_{i=1}^{13} YA_i + FA + OA)$$

18. Demand Deposit

$\%(XL_3 + XL_4 + XL_5) \leq (XL_3) \leq \%(XL_3 + XL_4 + XL_5)$

$0.06\ (XL_3 + XL_4 + XL_5) \leq (XL_3) \leq 0.09\ (XL_3 + XL_4 + XL_5)$

19. Saving Deposit

$\%(XL_3 + XL_4 + XL_5) \leq (XL_4) \leq \%(XL_3 + XL_4 + XL_5)$

$0.17(XL_3 + XL_4 + XL_5) \leq (XL_4) \leq 0.25(XL_3 + XL_4 + XL_5)$

20. Term Deposit

$\%(XL_3 + XL_4 + XL_5) \leq (XL_5) \leq \%(XL_3 + XL_4 + XL_5)$

$0.68(XL_3 + XL_4 + XL_5) \leq (XL_5) \leq 0.78(XL_3 + XL_4 + XL_5)$

21. Borrowing Limits

$$\%(\Sigma_{i=1}^{13} YA_i + FA + OA) \leq (XL_6 + XL_7 + XL_8) \leq \%(\Sigma_{i=1}^{13} YA_i + FA + OA)$$

$0.025(\sum_{i=1}^{13} YA_i + FA + OA) \leq (XL_6 + XL_7 + XL_8) \leq 0.06(\sum_{i=1}^{13} YA_i + FA + OA)$

22. Borrowings from RBI
 $\%(XL_6 + XL_7 + XL_8) \leq (XL_6) \leq \%(XL_6 + XL_7 + XL_8)$
 $0 (XL_6 + XL_7 + XL_8) \leq (XL_6) \leq 0.3(XL_6 + XL_7 + XL_8)$

23. Borrowings from Banks And other institutions & Agencies
 $\%(XL_6 + XL_7 + XL_8) \leq (XL_7) \leq \%(XL_6 + XL_7 + XL_8)$
 $0.64 (XL_6 + XL_7 + XL_8) \leq (XL_7) \leq 0.98(XL_6 + XL_7 + XL_8)$

24. Borrowings outside India
 $\%(XL_6 + XL_7 + XL_8) \leq (XL_8) \leq \%(XL_6 + XL_7 + XL_8)$
 $0 (XL_6 + XL_7 + XL_8) \leq (XL_8) \leq 0.27 (XL_6 + XL_7 + XL_8)$

25. Other liabilities
 $\%(\sum_{i=1}^{13} YA_i + FA + OA) \leq (XL_9) \leq \%(\sum_{i=1}^{13} YA_i + FA + OA)$
 $0.0034(\sum_{i=1}^{13} YA_i + FA + OA) \leq (XL_9) \leq 0.0084(\sum_{i=1}^{13} YA_i + FA + OA)$

26. Provisions
 $\%(\sum_{i=1}^{13} YA_i + FA + OA) \leq (XL_{10}) \leq \%(\sum_{i=1}^{13} YA_i + FA + OA)$
 $0.014(\sum_{i=1}^{13} YA_i + FA + OA) \leq (XL_{10}) \leq 0.026(\sum_{i=1}^{13} YA_i + FA + OA)$

Goal Constraints

1. **Market Share of Credit**
 Total Credit of Bank = $YA_{15} + YA_{16} + YA_{17}$
 Aggregate Credit (AGCREDIT)= 97674300000
 $YA_{11}+ YA_{12}+ YA_{13}+ d_1^- - d_1^+$ = Share in aggregate Credit of Scheduled commercial bank
 $YA_{11}+ YA_{12}+ YA_{13}+ d_1^- - d_1^+ = 0.018(97674300000)$
 $YA_{11}+ YA_{12}+ YA_{13}+ d_1^- - d_1^+ = 1758137400$

2. **Market Share of Deposit**
 Total deposit of bank = $XL_3 + XL_4 + XL_5$
 Aggregate Deposit (AGDEPOSIT)= 125725860000
 $XL_3 + XL_4 + XL_5 + d_2^- - d_2^+$ = Aggregate deposit of Scheduled commercial bank
 $XL_3 + XL_4 + XL_5 + d_2^- - d_2^+ = 0.0185(125725860000)$
 $XL_3 + XL_4 + XL_5 + d_2^- - d_2^+ =2325928410$

3. **Return on equity**
 $0.0046(XL_1 + XL_2) + d_3^- - d_3^+$ = Net Profit

4. **Return on Asset**

   $0.0004\ (\sum_{i=1}^{13} YA_i + FA + OA) + d_4^- - d_4^+ = \text{Net Profit}$

5. **Capital adequacy ratio**
   Capital + reserves = 11.5 % (risk weighted assets)

   $XL_1 + XL_2 >= 0.115*(0*(YA_1 + YA_2 + YA_3 + YA_4) + 0.5*(YA_5 + YA_6) + 1.25*(YA_7 + YA_8 + YA_9 + YA_{10}) + 1*(YA_{11} + YA_{12}) + 1.25*YA_{13})$

   $XL_1 + XL_2 + d_5^- - d_5^+ = 0.115*(0*(YA_1 + YA_2 + YA_3 + YA_4) + 0.5*(YA_5 + YA_6) + 1.25*(YA_7 + YA_8 + YA_9 + YA_{10}) + 1*(YA_{11} + YA_{12}) + 1.25*YA_{13})$

6. **Liquidity risk- (liquidity coverage ratio)**
   HQLA= Cash+ excess balance with RBI over CRR + Excess govt. securities over SLR + 15% of NTDL
   Cashflow in 30 days = 374319700

   LCR = HQLA/ Cashflow in 30 days
   LCR>=100%
   $HQLA + d_6^- - d_6^+ = 374319700$
   $HQLA= YA_1 + EXCASH + YA_5 - 0.195*NTDL + 0.15*NTDL$
   $EXCASH= YA_2 - 0.04*NTDL$

7. **Gross NPA** NPA<= 10% of Gross Advances (YA_{11} YA_{12} + YA_{13})

   $NPA + d_7^- - d_7^+ = 10\% (YA_{11}\ YA_{12} + YA_{13})$

   The % is the multiplier symbol here and it is estimated on the basis of the past 10-year data of OBC bank.

Objective function
MIN = Z
Where,
Z= 0.0504*D1MINUS+ 0.0446*D2MINUS+ 0.138*D3MINUS + 0.133*D4MINUS + 0.229*D5MINUS + 0.208*D6MINUS + 0.107*D7PLUS

RESULTS AND ANALYSIS

The model developed can be applied to any bank by modifying the multiplier that appears in front of each expression as per their balance sheet structure. The multiplier can be derived after examining the past balance sheet items. In the case of OBC bank, the data for the past 10-years has been studied from 2010-2019. All the figures are presented in ‘000. In this paper, the real balance sheet of 2019 has been compared with the model value for 2019. Any deviation in real value and model value is recorded. Optimized assets and liabilities of OBC banks have been calculated, which shows that the bank can reallocate its assets and liabilities and achieve more than its current position. The model has statutory constraints such as Cash Reserve Ratio (CRR), Statutory Liquidity Ratio (SLR), Priority Sector Lending (PSL), and Capital Adequacy Ratio (CAR). In 2019, CRR was 4%, SLR was 19.5%, PSL was 40% and CAR was 11.5%. It also shows at what level the bank can be optimized. Table 5 presents the results of the model developed in the methodology section.

Table 5. Real value Vs. Model Value

Oriental Bank of Commerce 2019				
				figures in '000
		Real	**Model**	**Deviation**
Assets				
Cash and bank	YA1 & YA2	111938820	122359300	-10420480
Money at call	YA3 & YA4	52822048	2719096	50102952
SLR investment	YA5 & YA6	583275898	600920200	-17644302
Non SLR investment	YA7, YA8, YA9, YA10	209402321	106044700	103357621
Advances	YA11, YA12, YA13	1592848135	1758137410	-165289275
Fixed asset	FA	25892722	33746640	-7853918
Other assets	OA	142915717	95168350	47747367
Total Asset		2719095661	2719095696	-35
Liabilities				
Capital & reserves	XL1 & XL2	189012435	277877600	-88865165
Demand deposit	XL3	142610850	209333600	-66722750
Saving deposit	XL4	541258880	534963500	6295380
Term deposit	XL5	1642584046	1581631000	60953046
Borrowing in India	XL6, XL7	141193671	67977388	73216283
Borrowing outside India	XL8	0	0	0
Other liabilities	XL9	16850484	9245268	7605216
Provisions	XL10	45585295	38067340	7517955
Total liabilities		2719095661	2719095696	-35
Bills Purchased and Discounted	YA11	31570620	61534810	-29964190
Cash Credits, Overdrafts, and Loans repayable on demand	YA12	756933270	795908500	-38975230
Term loans	YA13	804344245	900694100	-96349855
Priority lending	YA14	591650822	703255000	-111604178
Net profit		549938	1087638	-537700

Table 6. Computation of major goals and constraints

Modal Values of Goal Constraints and Statutory constraints	
Constraints	**Model Values**
CRR %	5.13
SLR %	26.47
NTDL	2382850000
HQLA	374319700
Cash Flow For 30 Days	374319700
Return on Asset %	0.04
Return on Equity %	0.39
Liquid Asset	630684500
Market Share of Credit	1.80
Market Share of Deposit	1.85
Capital Adequacy Ratio	11.50
Risk-Weighted Asset	2416327000
Liquidity Coverage Ratio %	100
Priority Sector Lending	40

The above table 6 shows that the model has satisfied all the statutory constraints and decision constraints. The CRR achieved here is 5.13%, and SLR is 26.47%. The credit in priority sector lending is 40%. The total asset is also equal to the total liability. In the model, the total asset's value was kept the same as real total assets in 2019. The model has successfully achieved all seven goals. The objective is to minimize the deviations that negatively affect the bank's performance. There is no underachievement of goals. The actual market share of the credit of OBC bank is 1.63%, whereas we have achieved 1.80% in the model. It shows that the bank can increase its market share of credit, i.e., to reach the optimization level. The real and model market share of the deposit is 1.85% for the bank. It shows that the bank has no scope to increase the market share of the deposit without affecting its performance.

Likewise, the bank generates a 0.04% return on an asset, which is better than the actual value, i.e., 0.02%. Here the bank can earn a higher profit if using its assets and liabilities judiciously. The bank targets to achieve a 0.46% return on equity. However, it has acquired 0.39% (0.4% approximately). This figure is still better than the real return on equity of 0.3%. If the bank could generate 190598.7 more profit, it could achieve the target of 0.46%. However, their model return on equity is higher than the actual value. In the model, the bank has a capital adequacy ratio of 11.50%, as targeted. The liquidity coverage ratio is 100%, which shows that the bank has no risk of liquidity. The Gross NPA is kept 10% and achieved by the model. In real bank has 12.66% of GNPA ratio to gross advances.

Table 7 presented below shows that the objective value is 0, which depicts that deviation is minimized to value 0. Therefore, it can be said that banks can increase their credit share in the market and generate more interest income and satisfy all the statutory constraints.

Table 7. Achievement of goals

	GOALS	**OBJECTIVE VALUE**
D1 MINUS	Market share of credit	0
D2 MINUS	Market share of the deposit	0
D3 MINUS	Return on equity	0
D4 MINUS	Return on Asset	0
D5 MINUS	Capital Adequacy	0
D6 MINUS	Liquidity risk	0
D7 PLUS	NPA	0

The ability to test the sensitivity of the model is the best advantage of goal programming. The variables can be changed to test the effect on the optimal solution. The model has tested sensitivity to arrive at the optimal solution where the deviation is minimized to 0. Any change in the constraint may lead to a solution where deviations from the target may arise. It is an integral part of the solution to test the effect of parameters for sensitivity. There are high chances of frequent change in goals, priorities, and available resources in the real world. Any change will result in the alteration of the optimum solution (Lee, 1981).

FINDINGS

The Goal Programming model is an effective and straightforward method to set targets and constraints to generate an optimum solution. In goal programming, the goal constraints are set equal to the target, which may or may not achieved. However, the model will generate an optimum solution with deviations that shows all goals are not attainable, yet the best available solution is derived. In this paper, the model has developed the asset and liability mix that fulfill all the goals and constraints. The bank can deploy its resources to generate more returns. If a bank can increase its market share of deposits from 1.63% to 1.8%, it can create more revenue and achieve higher profitability. The bank can restructure its assets and liabilities. A decline in money at call with other banks, and an increase in investment will accelerate the income-earning capacity of the bank. The bank should decrease its fund in non-income generating assets and reinvest those funds in income-generating assets. The optimum utilization of fixed and current assets can also increase the efficiency of the bank (Tanwar et al., 2020).This model reveals areas that need focus to attain an optimal level. No institution can run at an optimal level until it knows the particular domain where it can improve. This model helps in pointing out such items in the balance sheet, which need more attention.

This model can be used by banks' management to set its target and management constraints to generate an optimal mix of assets and liabilities. This model is helpful in planning, forecasting, and budgeting for banks and other institutions. Even a bank can prioritize its goals using the Preemptive Goal Programming method, where the most important goals are optimized before lower-level goals are considered. The bank's management can analyze how to achieve the targets and how it affects the bank's performance and regulations.

LIMITATIONS

The model has used past data to arrive at risk weights of assets. The risk weight is difficult to derive for all assets' components. The model can be used more precisely by bank officials as they know the risk weights and other regulations. The effect of interest rate on profitability has not been considered. In future work, I will use weighted lexicographic goal programming and derive the impact of interest rate on the bank's profitability. It can also avoid upper bound on decision variables and determine how it will impact the asset and liability mix.

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