

Original Article

# A Linear Goal Programming Application in Indian Commercial Banks for Loan Management

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Received: 11 November 2024

Revised: 25 December 2024

Accepted: 12 January 2025

Published: 30 January 2025

**Abstract** - This research focuses on applying Linear Goal Programming to optimize loan management in Indian commercial banks by considering the multi-criteria nature inherent in this critical banking function. Efficient loan management involves meeting conflicting goals, such as maximizing profitability and minimizing the risk of Non-Performing Assets - NPAs - amidst regulatory norms. Conventional methods often lag in satisfying these goals simultaneously. This paper, therefore, proposes an LGP model that integrates some major KPIs related to loan portfolios: loan growth targets, acceptable NPA ratios, targeted recovery rates, and desired profitability margins. Minimizing the deviations from pre-set goals gives a much more balanced, hence optimized lending strategy. This research will validate the efficiency and effectiveness of the proposed LGP model with real-world data from Indian commercial banks or simulated data based on industry trends. The model is solved using QSB+ software. By comparing the results generated by the LGP model with current banking practices, this research highlights the potential benefits of this quantitative optimization approach. The paper offers a useful framework for loan management in the Indian banking sector and is, therefore, of value to bank management and policymakers seeking to optimize lending operations and increase financial stability.

**Keywords** - Banking, Goal programming, Multi criteria decision making, Optimization, QSB.

## 1. Introduction

The banking sector is the backbone of the economic development and stability of any economy. Commercial banks in India thus play a very important intermediary role in transferring funds from ultimate savers to ultimate borrowers in their efforts to facilitate investment and economic activity. However, loan portfolio management is a complex task, as a bank must satisfy a lot of conflicting objectives. These range from the disbursement of loans to stimulate economic growth and revenue generation, with a minimum accumulation of NPAs to maintain financial stability and follow regulatory guidelines prescribed through the RBI so desired profitability margins are achieved. In this regard, the conventional practices in loan management depend on subjective judgment or mainly heuristic approaches, which may not effectively handle the inherent multi-criteria nature of the problem. This can result in suboptimal outcomes such as unwarranted risk-taking, poor loan recoveries, or missed opportunities to grow. This includes loan allocation, which is one of the most important business tasks most commercial banks are concerned about. Normally, a bank's loan portfolio is a big asset and, most frequently, the major source of revenue. Thus, loan granting represents one of the biggest risks to a bank's safety and soundness. Traditionally, loan portfolio problems have been the leading cause of bank losses and failures, either because of lax credit standards, poor portfolio risk management, or economic downturns. A bank is safe and sound when management of the loan portfolio and credit work are adequate. In 1969, the banking sector was nationalized to better position commercial banking systems so that they would meet the country's economic requirements. It also contributes more to the country's growth and development. For the upliftment of the weaker section of the population, in 1970, a perception of Priority Sector Lending (PSL) was conceived. Several studies were subsequently published relating to the impact of PSL loans on economic growth and people's livelihood. Commercial banks participating in the priority sector do not deal with mere financing. Special dispensation must be provided for the flow of credit to the needy and priority sectors, considering the progressive role that RBI is playing in strengthening and extending the financial system and the inadequacy and inflexibility that characterize the credit market. A loan waiver scheme would add to the problem of loan recovery and put a heavy burden on the government. The financial performance of all banks that operated in the Republic of Serbia from 2012 until 2017 was assessed using an integrated model combining the CRITIC method and the TOPSIS method [15]. In fact, priority sector guidelines were



laid down in India more than 40 years ago when the corporate and financial sectors of the economy were passing through very different circumstances. Since most of the pieces were handled, they had little effect on the world economy. However, over these years, PSL in India increased lending to exporters of micro, small, and agricultural enterprises, and the cost for the banks has been high compared to the returns on such lending. With the global economy in turmoil, there is a greater need for the nation's currency to be competitive. It is already too much for the financial sector and the country's economy to force the banks to bear the extra burden of priority sector lending, irrespective of their different business plans. Instead, such sectors, especially agriculture, should be made less risky and more credit-worthy to attract investment.

Technology innovation has made its way into practically every industry, supporting those fields in improving and enhancing their products and services. Banking is an example of a technology-driven company. Banking made use of this ever-changing technology to provide far better service to its customers. Traditional banking is defined as "accepting deposits of money from the public for the purpose of investing, repayable on demand or otherwise, and withdrawal by the cheque, draft, order, or other means" [16]. Modern banking has come a long way beyond the traditional business of merely accepting deposits and granting loans. Banking from a client's room, office or anyplace has advanced into a banking system with the advent of Internet Technology. The difference between banks' cost of funding is because of interest paid to depositors and the interest gained by banks on credit extended. To spread, banks participate in hazardous acquiring and loaning exercises over the financial markets. In a nutshell, banks contribute by being willing to accept hazardous loans from borrowers while providing low-risk assets to their depositors. Doubtless, the global financial environment is riskier today due to increased interest rates, commodity prices, and foreign exchange rates. The difference between the cost of funding for banks due to interest paid to depositors and the interest gained by banks on credit extended. As a matter of fact, to spread, banks engage in hazardous acquiring and loaning exercises over the financial markets. In other words, banks contribute by being willing to accept hazardous loans from borrowers while providing low-risk assets to their depositors. Undoubtedly, the global financial environment is riskier today due to increased interest rates, commodity prices and foreign exchange rates. Lending makes up between 65 and 70 percent of a commercial bank's revenue. A bank greatly relies on its lending to make sure it is successful. The interest derived from lending pays for the interest in deposits and all other bank infrastructure. The residual funds must be lent very carefully to make a respectable return. Commercial banks, through their credit granting activities, have further opened more employment opportunities and accelerated the pace of mass production, distribution and mass consumption. Through consumption loans, banks raise consumption propensity. Banks provide consumption loans to create continued demand for consumer goods like houses, furniture, appliances, fixtures, etc. The bank advances and loans could be used to raise the level of employment and output. Consequently, they will have improved incomes that raise their level of living. Banking lending is a high-risk and high-reward service performed by commercial banks that has a great impact on the net profits and gross earnings of commercial banks. In India, the eight categories of Priority Sector would include agriculture, education, micro-, small-and medium-sized businesses, housing, export credit, renewable energy, and social infrastructure, among others. Some of the goals for bank management to accomplish would be related to debt and loan expansion, risk reduction, and return maximization, amongst others. Innovation in the global financial market has resulted in an explosion in the varieties and uses of derivative instruments for risk management. The problems are so complex that the GP model used in this work is necessarily required by challenges involving such multiple objectives [7], [10], and [1]. The GP approach was first presented by Charnes and Cooper [2] in 1961 and then extended by Lee [12] and many others in 1972. This approach was developed to handle multi-criteria situations within the general framework of linear programming. GP has also been applied to academic resource planning [8], agricultural planning [5], and bank resource allocation problems [19], [11], [13], and [17]. It discussed how having different types of money is relevant when making business decisions [1]. Demand deposit growth increases the bank's default risk and decreases its interest margin [8]. Bank credit portfolio impacts tighter capital requirements on financial institutions' risk-taking [14]. Jain, S [18] conducted a primary survey to find out the attitude of bankers towards various aspects of PSL. Statistical research was also conducted to find out the impact of PSL on the economy as a whole and banking.

The latest financial stability report of the RBI tries to remain optimistic. The report says credit expanded in 2019–20 despite weak growth. On the other hand, the gross NPA ratio of banks surged from 11.6% in March 2019 to 12.2% in March 2020. In Rs bn, GNPA of banks continued to rise from Rs 8.82 trillion at the end of December to Rs 10.09 trillion at the end of March, according to a Credit Suisse study. A gap in the literature [3],[4] is that many comprehensive studies have yet to be carried out on the long-term impacts of PSL on economic growth, the usage of technology in enhancing various processes of PSL, and the effectiveness of the current policies regarding PSL. Besides, there is also a lack of adequate research on issues concerning banks' meeting the targets set under PSL and sustainable lending practices within PSL. Such gaps may provide useful insights into the scope for improvement in loan management practices and achieving the intended objectives of PSL. The objective of this research was to use priority-based LGP in modeling one that can be used by bank management to assign loans to people and entities by commercial banks. As part of their social obligation, commercial banks serve the people besides serving the business and industrial sectors. Banks in India, though working on commercial principles for earning profits, must carry out their social

obligations and extend credit facilities to priority sectors as directed by the government of India. The country requires this for its various developmental as well as infrastructural programs and needs. The Reserve Bank of India regulates the financial aspects of the banking industry, and the banks follow, almost in a "tick-to-tack" manner, the rules, regulations, and guidelines that the RBI issues. The RBI regularly carries out on-site inspections of all banks and other financial institutions. The reports are totally confidential. Commercial banks work within the limitations imposed by the RBI in matters relating to interest rates on deposits, advances, statutory credit requirements and specific advances to priority groups, among others. The Data used for the analysis in the study was collected from an arbitrary bank (ABC Bank of India).

## 2. Goal Programming Model Formation

While Charnes et al. (1955) [2] laid the foundations of Goal Programming, Ignizio (1976) [9] made the key contribution to its development by formalizing the generic priority-based Linear Goal Programming paradigm. It is an especially valuable technique when considering objectives that are difficult to trade off against one another.

In this regard, instead of giving different weights to various objectives, priority-based LGP assigns a pre-emptive priority factor P1, P2, P3, etc., showing the relative importance of each goal. Then, in seeking a solution, it aims at the minimum deviation among goals in lexicographic order; that is, the attainment of a higher-order goal is considered infinitely more important than the attainment of any combination of lower-order goals.

According to Ignizio (1976) [9], the generic priority-based LGP model is as follows:

Find  $\bar{x}(x_1, x_2, x_3, \dots, x_n)$  to

$$\text{Minimize: } P_1(w_{p1}p_1 + w_{n1}n_1)$$

$$\text{Minimize: } P_2(w_{p2}p_2 + w_{n2}n_2)$$

.....

.....

$$\text{Minimize: } P_i(w_{pi}p_i + w_{ni}n_i)$$

.....

.....

$$\text{Minimize: } P_m(w_{pm}p_m + w_{nm}n_m)$$

Subject :

$$f_i(\bar{x}) + n_i - p_i = b_i$$

where,  $i = 1,2,3, \dots, m$  and  $x_j, n_i, p_i \geq 0, \forall i, j$

where m is the number of goal restrictions, bi denotes the goal's target level,  $w_{pi}$  and  $w_{ni}$  ( $\geq 0$ ) are used to represent the numerical weights that are associated with the under - and over-deviational variables.  $p_i$  and  $n_i$  ( $\geq 0$ ) respectively.

### 2.1. Decision Variables and Constants

The model restricts the variables and parameters that are studied to those that are necessary to depict ABC Bank of India accurately.

$x_i$	:	Amount of money to lend in loan category $i$
$NC_r$	:	Net credit of the bank
$L_i$	:	Target of $i$ th loan
$r_i$	:	Interest rate in loan category $i$
$R$	:	Target of annual return
$e_i$	:	Processing expenses in loan category $i$
$E$	:	Target of expense for the $i^{th}$ loan
$d_i$	:	Default rate (projected as per the trend of past years) for $i$ th loan
$D$	:	Target limit of default to avoid lending loan
ANBC	:	Adjusted Net Bank Credit

where  $1 \leq i, o, a, s, h \leq L$

## 2.2. Deviation Variables

$n_i$  = constraint in  $i^{\text{th}}$  equation is under achievement  
 $p_i$  = constraint in  $i^{\text{th}}$  equation is over achievement

## 2.3. Description of Goal Constraints

The goal constraints listed below help create the generic model for the loan management problem provided.

*Maximize the Priority Sector's Loans:* The objective of management is to maximize the priority sector's loans as much as possible within the limit of  $C_1$  % of the bank's net credit.

$$\sum_{i=1}^L x_i + n_1 - p_1 = c_1 \% \text{ of } NCr \quad (1)$$

*Maximize the Annual Return:* The objective of management is to maximize the annual return from investment in Loan to PSL.

$$\sum_{i=1}^L r_i \% \text{ of } x_i + n_2 - p_2 = R \quad (2)$$

*Minimize the Expenses:* To maintain the processing expenses on loans is also an important feature in loan management. So, it should also be below the prescribed expense limit.

$$\sum_{i=1}^L (e_i \% \text{ of } x_i) + n_3 - p_3 = E \quad (3)$$

*Minimize the NPA/Defaulters:* Due to social obligation and RBI guidelines, the Bank must advance all the sectors considering the track of defaulters/NPAs. So, while planning the deployment of the loan amount, the overall default value (NPA) should be within the projected default limit. Following is the supporting goal equation:

$$\sum_{i=1}^L (d_i \% \text{ of } x_i) + n_4 - p_4 = D \quad (4)$$

*Agriculture and Allied Sectors Loan:* At least  $C_a$ % of ANBC should be assigned to agriculture and allied sectors.

$$x_1 + n_5 - p_5 = c_a \% \text{ of ANBC} \quad (5)$$

*MSME Loan:* At least  $C_m$ % of ANBC should be assigned to MSME

$$x_2 + n_6 - p_6 = c_m \% \text{ of ANBC} \quad (6)$$

*Maximize other Export Loans:* At least  $C_e$  % of ANBC should be assigned to export loans.

$$x_3 + n_7 - p_7 = c_e \% \text{ of ANBC} \quad (7)$$

*Maximize other Education Loans:* At least  $C_{ed}$  % of ANBC is assigned for an export loan.

$$x_4 + n_8 - p_8 = c_{ed} \% \text{ of ANBC} \quad (8)$$

*Housing Loan:* At least a portion  $C_h$  % of ANBC should be assigned to house loans.

$$x_5 + n_9 - p_9 = c_h \% \text{ of ANBC} \quad (9)$$

*Social Infrastructure Loan:* At least  $C_s$  % of ANBC should be assigned to social infrastructure loans.

$$x_6 + n_{10} - p_{10} = c_s \% \text{ of ANBC} \quad (10)$$

*Renewable Energy Loan:* At least  $C_r$  % of ANBC should be assigned to the Energy sector

$$x_7 + n_{11} - p_{11} = c_r \% \text{ of ANBC} \quad (11)$$

Weaker Section Loan: At least  $C_0$  % of ANBC should be assigned for other weaker section

$$x_8 + n_{12} - p_{12} = c_0\% \text{ of ANBC} \tag{12}$$

The model restricts the variables and parameters that are studied to those that are necessary to depict ABC Bank of India accurately.

### 3. Case Example

ABC Bank (arbitrary name) is one of the largest commercial banks in India. This large network of branches around the country enables the bank to raise money at a lower cost. Whereas foreign banks have an objective of lending to the priority sector of 32% of the bank's credit, banks in the public and private sectors within India are expected to give at least 40 percent of their net credit to the priority sectors. All commercial banks also have to maintain a 5% CRR. Of this, banks must lend 10% to weaker groups, 18% to agriculture and allied industries and 16% to small-scale industries (SSI). For priority sector loans, the RBI has laid down minimum rates of interest. Rates of interest can be determined by banks only for loans exceeding Rs. 2 lakhs. The seven sectors falling under the study were selected based upon the unique rate of interest structure applicable to each. However, the rates of interest on loans granted to non-priority industries are higher. The regulation rates of interest remain one of the major concerns for the banks' profitable operation when they perform their social obligations towards priority sectors. Table 1 presents the loans given by ABC Bank to every sector in 2023. Some data has been calculated and assumed due to its non-availability.

**Table 1. Loan and advances sectors of ABC bank**

Sector	Agriculture and allied sector	MSME	Export Credit	Education	Housing	Social Infrastructure	Renewable Energy	Other weaker section
Lending % of ANBC $x_i$	18	7.5	2	0.05	2	0.02	0.03	10
Interest Rates (r) %	11.5	9	10.5	12.5	9.75	10.5	11.5	14
Expenses $E_i$ (%)	0.9	0.7	0.75	0.6	1	0.8	0.6	0.5
Default rate (%)	8	3.5	0.22	5	1	0.5	0.75	1

Source – Half-yearly return of advances to Priority Sectors RBI 2023

Above mentioned, sectors have their rate of interest structure and loan period-dependent rate of interest in each sector. Calculating the weighted average rate of interest for each sector is done using the historical data of loans as given below. This model deals with finding loans to the priority sectors within a given set of RBI-imposed goals and constraints for the current dilemma faced while managing the loans.

This is done by minimizing the weighted sum of deviations from the ideal goal to the lowest possible value. A model application using ABC Bank of India has been performed. Modelling is done to showcase how loans can be controlled in a commercial bank.

Mathematically, the priority-based GP model developed here is as follows:

**Table 2. Priority structure**

Priority level	Evaluation Criteria	Goal Description
$P_1$	Maximize Sector Investment	Channel the highest possible investments into the Priority Sector for optimal impact
$P_2$	Maximize Annual Financial Return	Focus on achieving the highest return on investment within a given year
$P_3$	Minimize Operational Costs	Strive to minimize expenses while maintaining sector stability and growth
$P_4$	Minimize Default Risk	Reduce the likelihood of defaults and non-performance within the sectors
$P_5$	Maximize Lending Across All Priority Sectors	Ensure balanced lending and support across each Priority Sector

**Table 3. Decision variables description**

Decision Variable	Priority Sector
$x_1$	Agriculture and allied
$x_2$	Micro-Small and Medium Enterprises
$x_3$	Credit for Exports
$x_4$	Education
$x_5$	Housing
$x_6$	Social Infrastructure
$x_7$	Renewable Energy
$x_8$	Other weaker section

**Deviational Variables**

$n_i$  = constraint in the  $i^{th}$  equation is under achievement

$p_i$  = constraint in the  $i^{th}$  equation is over achievement

**Objective Function**

- Minimize  $n_1$
- Minimize  $n_2$
- Minimize  $p_3$
- Minimize  $p_4$
- Minimize  $(2n_5 + n_6 + 2n_7 + n_8 + n_8 + n_9 + n_{10} + 3n_{11} + 3n_{12})$

**4. Results and Discussion**

This study showed how LGP addresses management issues in commercial banks, specifically in relation to loan management. Eight choice variables, twenty-four deviational variables, twelve constraints, and five priorities make up the study's LGP problem. The GP problem, QSB+, can be solved using the GP package. The solution was discovered after 21 repetitive attempts on an i7 computer system. The following is the most appropriate way to express the solutions to the problem.

**Table 4. Decision variables analysis**

Decision Variable	Priority Sector	Current Lending	Lending using the GP Model
$x_1$	Agriculture and allied	48727.425	52363.8
$x_2$	Micro-Small and Medium Enterprises	17454.6	21818.25
$x_3$	Credit for Exports	4363.65	5818.2
$x_4$	Education	58.183	145.455
$x_5$	Housing	4945.47	5818.2
$x_6$	Social Infrastructure	29.091	58.182
$x_7$	Renewable Energy	58.182	87.273
$x_8$	Other weaker section	23272.8	29091

**Table 5. Analysis of the objective function**

Priority	Criteria	Achievement
P <sub>1</sub>	Maximize the total investment in PSL with within the limit of 40% of ANBC	Achieved
P <sub>2</sub>	Maximize the Annual Return	Achieved
P <sub>3</sub>	Minimize the Expenses	Achieved
P <sub>4</sub>	Minimize the NPA/Default	Not Achieved
P <sub>5</sub>	Maximize lending in all individual Priority sectors	Achieved

The significance of the current study is to demonstrate the use of priority based LGP in multiple conflicting goals in banking operations. The results (Table 4) show a marginal improvement in lending the advances in considered priority sector categories. Most of the priorities were indeed achieved: P1, P2, P3, and P5. The only priority that was not achieved was P4-minimizing NPA/Default. This would insinuate some level of loan defaults or non-performing assets during the period under analysis. Though the table generally presents a very successful performance in terms of investment in priority sectors, returns, expenses, and overall lending, the inability to minimize NPA/Default should be a cause for alarm. That might signify potential problems in credit risk management or economic factors affecting borrowers' ability to repay loans. Further investigation into the high reasons for NPA/Default would, therefore, be called for. There are also some other risk factors and regulatory requirements that may affect the management decision on loans, and bringing them into account can make this paper better.

## 5. Conclusion

A priority-based GP model is introduced in this paper that efficiently solves the problem of loan management with its multi-objective nature. It allows for a structured approach to incorporate both operational constraints and the often-conflicting goals associated with loan portfolio management. The flexibility of the model is its major strength. Although the priority and weight structure introduced in this paper is specific to the defined problem context, it is worth noting that the priorities of different banks will be different depending on their specific strategies, risk appetite, and regulatory environment. This model is thus designed to be very flexible, and the decision-makers are allowed to define their structure of priorities and weights in the process of problem formulation. This customization ensures that the model is applicable in as many loan management scenarios as possible.

## Authors Contribution

Dr Avinash Gaur- Problem identification, conceptualization

Dr Manisha Gupta-Literature review

Dr Prakash Chandra Mittal-Data preparation, Problem-solving

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