OPTIMIZATION OF BANKS LOAN PORTFOLIO MANAGEMENT USING GOAL PROGRAMMING TECHNIQUE

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ABSTRACT

In this paper we present results of optimization of loan portfolio management of banks. An Operational Research technique, Goal programming, is applied to the management of loan portfolio in banks in order to optimize it. With the result obtained, using a multi objective package, provides an answer on how to handle cases of bad loans or doubtful loans. Bad loan is a major factor militating against optimization of bank goals, and it is one of the major causes of bank failure.

KEYWORDS: Goal Programming, Loan Portfolio, Optimization, Bad Loan, Doubtful Loan

INTRODUCTION

The success of any bank in this very competitive lending environment depends largely on the way and manner the loan portfolio of the banks is being managed. An effective way of evaluating bank's credit policies for loan portfolio is through the Goal programming approach [2,3,6]. Goal programming is an extension of linear programming in which management objectives are treated as goals to be attained as closely as possible within the practical constraints of the problem. Various areas in the lending process where Goal programming is usually applied include; prospect identification and qualification, sales and customer service, loan approval and review, loan booking and servicing, portfolio monitoring, loan scrutinizing, loan workout, and training [4,6,8]. Most of these problems are always with multiple objectives and criteria. These are referred to as multiple criteria optimization problems. Goal programming technique is usually applied to these multiple criteria optimization problems. It provides a pragmatic and flexible way to cater for such problems [1, 2]. It is perhaps the most well-known method of solving multi objective optimization problems [2]. A set of goals that should be obtained for the objective functions is constructed. The goals are assigned weighing factors to rank them in order of importance. A single objective function is written as the minimization of the deviations from the stated goals. The goal programming model can be written as follows: Minimize $Z = d_1^+ + d_1^- + d_2^- + d_3^-$, subject to some constraints, where d_i^- and d_i^+ measure the amount by which the target is under achieved and over achieved respectively [3].

MODEL FORMULATION

Notations

I – denotes the ith class of the loan portfolio (where I=1 implies long term loan,

$I = 2$ is medium term loan and $I = 3$ is short term loan)

J – denotes the jth investment type in each loan portfolio class

M – represents number of loan portfolio classes

Ni – represent number of investments type in the ith loan portfolio Class

Parameters

The input parameters for this study are defined as follows:

CB_t – Cooperate Banking Contribution to loan in year t.

B_t – Branches Contribution to loan in year t.

L_t – Bad debt in year t

D_t – Deposit in year t

NP_t – Non performing loan in year t

Decision Variables

X_{ijt} – denotes the amount (in naira) to be allocated to investment type j within the loan Class i in year t.

Table 1: The Decision Variables

Loan Class (i)	Class Specification	Investment Type(j)	Decision Variable
1	Long term loan	Mortgage finance Lease finance	X_{11t} X_{12t}
2	Medium term loan	Higher purchase SME finance	X_{21t} X_{22t}
3	Short term loan	LPO finance Contract finance Building finance Warehouse warrant finance Import finance Export finance overdraft finance Rediscount finance facility	X_{31t} X_{32t} X_{33t} X_{34t} X_{35t} X_{36t} X_{37t} X_{38t}

Deviational Variables

d^+_{kt} --- denotes the over–achievement of the target set for goal k in year t.

d^-_{kt} --- denotes the under –achievement of the target set for goal k in year t.

Sources of loan and proportion of each source that is used to finance each categories of loan is shown as follows:

Table 2: Sources and Application of Funds

Sources	Long Term Loan	Medium Term Loan	Short Term Loan
Commercial bank	5%	35%	60%
Individual with high worth	30%	30%	40%
Cooperative	10%	50%	40%
Debenture loan	40%	30%	30%
Family & friends	30%	30%	40%

Table 3: Proportion of Loan Contribution

Sources of Fund	Total Deposit	Total Loan	Non-Performing Loan	Year
Commercial Bank	61364.85	15756.80	157.98	1
	68309.30	17344.98	146.37	2
Individual	20004.81	5726.98	5.61	1
	22102.90	6214.85	-16.4	2
Cooperative	30112.06	8235.85	17.62	1
	33642.93	9007.16	-8.44	2
Debenture	---	5260.60	64.55	1
	---	5855.22	66.39	2
Family and Friends	466535.77	2868.42	8.68	1
	467517.20	3168.99	2.91	2

Goals and Priority Level

The goals stated by the bank and their priority levels are as follows:

Table 4: Goal Specification and Priority Level

S/N	Goal Specification	Priority Level
1	To achieve a loan portfolio mix of 50% each for cooperate Banking and Branches respectively.	P_1
2	To achieve a maximum of 1.5% ratio of non-performing loan as a proportion of total loan.	P_2
3	To achieve a loan –deposit ratio of 30:70	P_3
4	To maintain a yield of not less than 35% on all loans	P_4

THE MODEL

Objective Function

$$\text{Minimize } Z = P_1(d^+_{1t} + d^-_{1t} + d^+_{2t} + d^-_{2t}) + P_2(d^+_{3t} + d^+_{3t}) + P_3(d^+_{4t} + d^-_{4t}) + P_4(d^+_{5t} + d^-_{5t}) \tag{1}$$

Subject to:

Goal Constraints

$$\sum\sum X_{ijt} - d^+_{1t} + d^-_{lt} = 0.5 \, CB_t \tag{2}$$

$$\sum\sum X_{ijt} - d^+_{2t} + d^-_{2t} = 0.5 B_t \tag{3}$$

$$1.5\sum\sum X_{ijt} - d^+_{3t} + d^+_{3t} = NP_t \tag{4}$$

$$\sum\sum X_{ijt} - d^+_{4t} + d^-_{4t} = 0.3 D_t \tag{5}$$

$$0.35\sum\sum X_{ijt} - d^+_5t + d^-_5t = 0 \tag{6}$$

Structural Constraints

Loan Standing Structural Constraints: (For Year One)

$$X_{11t} + X_{12t} < 5\% \text{ of } 15756.8 = 787.84 \tag{7}$$

$$X_{21t} + X_{22t} < 35\% \text{ of } 15756.8 = 5514.88 \tag{8}$$

$$X_{31t} + X_{32t} + X_{33t} + X_{34t} + X_{35t} + X_{36t} + X_{37t} + X_{38t} < 60\% \text{ of } 15756.8 = 9454.08 \tag{9}$$

$$X_{11t} + X_{12t} < 30\% \text{ of } 5726.98 = 1718.094 \tag{10}$$

$$X_{21t} + X_{22t} < 30\% \text{ of } 5726.98 = 1718.094 \tag{11}$$

$$X_{31t} + X_{32t} + X_{33t} + X_{34t} + X_{35t} + X_{36t} + X_{37t} + X_{38t} < 40\% \text{ of } 5726.98 \tag{12}$$

$$X_{11t} + X_{12t} < 10\% \text{ of } 8235.85 = 823.585 \tag{13}$$

$$X_{21t} + X_{22t} < 50\% \text{ of } 8235.85 = 4117.925 \tag{14}$$

$$X_{31t} + X_{32t} + X_{33t} + X_{34t} + X_{35t} + X_{36t} + X_{37t} + X_{38t} < 50\% \ 8235.85 = 3294.34 \tag{15}$$

$$X_{11t} + X_{12t} < 30\% \text{ of } 2868.42 = 860.526 \tag{16}$$

$$X_{21t} + X_{22t} < 30\% \text{ of } 2868.42 = 860.526 \tag{17}$$

$$X_{31t} + X_{32t} + X_{33t} + X_{34t} + X_{35t} + X_{36t} + X_{37t} + X_{38t} < 40\% \text{ of } 2868.42 = 1147.368 \tag{18}$$

$$X_{11t} + X_{12t} < 40\% \text{ of } 5260.60 = 2104.24 \tag{19}$$

$$X_{21t} + X_{22t} < 30\% \text{ of } 5260.60 = 1578.18 \tag{20}$$

$$X_{31t} + X_{32t} + X_{33t} + X_{34t} + X_{35t} + X_{36t} + X_{37t} + X_{38t} < 30\% \text{ of } 2868.42 = 860.526 \tag{21}$$

Non – Performing Loan Structural Constraints (For Year One)

$$X_{11t} + X_{12t} < 5\% \text{ of } 157.98 = 7.899 \tag{22}$$

$$X_{21t} + X_{22t} < 35\% \text{ of } 157.98 = 55.293 \tag{23}$$

$$X_{31t} + X_{32t} + X_{33t} + X_{34t} + X_{35t} + X_{36t} + X_{37t} + X_{38t} < 60\% \text{ of } 157.98 = 94.788 \tag{24}$$

$$X_{11t} + X_{12t} < 30\% \text{ of } 5.61 = 1.683 \tag{25}$$

$$X_{21t} + X_{22t} < 30\% \text{ of } 5.61 = 1.683 \tag{26}$$

$$X_{31t} + X_{32t} + X_{33t} + X_{34t} + X_{35t} + X_{36t} + X_{37t} + X_{38t} < 40\% \text{ of } 5.61 = 2.244 \tag{27}$$

$$X_{11t} + X_{12t} < 10\% \text{ of } 17.62 = 1.762 \tag{28}$$

$$X_{21t} + X_{22t} < 50\% \text{ of } 17.62 = 8.81 \tag{29}$$

$$X_{31t} + X_{32t} + X_{33t} + X_{34t} + X_{35t} + X_{36t} + X_{37t} + X_{38t} < 40\% \text{ of } 17.62 = 7.048 \tag{30}$$

$$X_{11t} + X_{12t} < 30\% \text{ of } 8.68 = 2.604 \tag{31}$$

$$X_{21t} + X_{22t} < 30\% \text{ of } 8.68 = 2.604 \tag{32}$$

$$X_{31t} + X_{32t} + X_{33t} + X_{34t} + X_{35t} + X_{36t} + X_{37t} + X_{38t} < 40\% \text{ of } 8.68 = 3.472 \tag{33}$$

$$X_{11t} + X_{12t} < 40\% \text{ of } 64.65 = 25.86 \tag{34}$$

$$X_{21t} + X_{22t} < 30\% \text{ of } 64.65 = 19.395 \tag{35}$$

$$X_{31t} + X_{32t} + X_{33t} + X_{34t} + X_{35t} + X_{36t} + X_{37t} + X_{38t} < 30\% \text{ of } 64.65 = 19.395 \tag{36}$$

Total Deposit Structural Constraints: (For Year One)

$$X_{11t}+X_{12t}<5\% \text{ of } 61364.85 = 3068.24 \tag{37}$$

$$X_{21t}+X_{22t}<35\% \text{ of } 61364.85 = 21477.698 \tag{38}$$

$$X_{31t}+X_{32t}+X_{33t}+X_{34t}+X_{35t}+X_{36t}+X_{37t}+X_{38t}<60\% \text{ of } 61364.85 = 36818.91 \tag{39}$$

$$X_{11t}+X_{12t}<30\% \text{ of } 20004.81 = 6001.443 \tag{40}$$

$$X_{21t}+X_{22t}<30\% \text{ of } 20004.81 = 6001.443 \tag{41}$$

$$X_{31t}+X_{32t}+X_{33t}+X_{34t}+X_{35t}+X_{36t}+X_{37t}+X_{38t}<40\% \text{ of } 20004.81 = 8001.924 \tag{42}$$

$$X_{11t}+X_{12t}<10\% \text{ of } 30112.06 = 3011.206 \tag{43}$$

$$X_{21t}+X_{22t}<50\% \text{ of } 30112.06 = 15056.03 \tag{44}$$

$$X_{31t}+X_{32t}+X_{33t}+X_{34t}+X_{35t}+X_{36t}+X_{37t}+X_{38t}<40\% \text{ of } 30112.06 = 12044.824 \tag{45}$$

$$X_{11t}+X_{12t}<30\% \text{ of } 466535.77 = 139960.731 \tag{46}$$

$$X_{21t}+X_{22t}<50\% \text{ of } 466535.77 = 139960.731 \tag{47}$$

$$X_{31t}+X_{32t}+X_{33t}+X_{34t}+X_{35t}+X_{36t}+X_{37t}+X_{38t}<40\% \text{ of } 466535.77 = 186614.308 \tag{48}$$

$$X_{11t}+X_{12t}<40\% \text{ of } 21628.24 = 8651.296 \tag{49}$$

$$X_{21t}+X_{22t}<50\% \text{ of } 21628.24 = 6488.472 \tag{50}$$

$$X_{31t}+X_{32t}+X_{33t}+X_{34t}+X_{35t}+X_{36t}+X_{37t}+X_{38t}<30\% \text{ of } 21628.24 = 6488.472 \tag{51}$$

Loan Standing Structural Constraints (For Year Two)

$$X_{11t}+X_{12t}<5\% \text{ of } 17344.98 = 867.249 \tag{52}$$

$$X_{21t}+X_{22t}<35\% \text{ of } 17344.98 = 6070.743 \tag{53}$$

$$X_{31t}+X_{32t}+X_{33t}+X_{34t}+X_{35t}+X_{36t}+X_{37t}+X_{38t}<60\% \text{ of } 17344.98 = 10406.988 \tag{54}$$

$$X_{11t}+X_{12t}<30\% \text{ of } 6214.85 = 1864.455 \tag{55}$$

$$X_{21t}+X_{22t}<30\% \text{ of } 6214.85 = 1864.455 \tag{56}$$

$$X_{31t}+X_{32t}+X_{33t}+X_{34t}+X_{35t}+X_{36t}+X_{37t}+X_{38t}<40\% \text{ of } 6214.85 = 2485.94 \tag{57}$$

$$X_{11t}+X_{12t}<10\% \text{ of } 9007.16 = 900.716 \tag{58}$$

$$X_{21t}+X_{22t}<50\% \text{ of } 9007.16 = 4503.58 \tag{59}$$

$$X_{31t}+X_{32t}+X_{33t}+X_{34t}+X_{35t}+X_{36t}+X_{37t}+X_{38t}<40\% \text{ of } 9007.16 = 3602.864 \tag{60}$$

$$X_{11t}+X_{12t}<40\% \text{ of } 5855.22 = 2342.088 \tag{61}$$

$$X_{21t}+X_{22t}<50\% \text{ of } 5855.22 = 1756.566 \tag{62}$$

$$X_{31t}+X_{32t}+X_{33t}+X_{34t}+X_{35t}+X_{36t}+X_{37t}+X_{38t}<30\% \text{ of } 5855.22 = 1756.566 \tag{63}$$

$$X_{11t} + X_{12t} < 30\% \text{ of } 3168.99 = 950.697 \tag{64}$$

$$X_{21t} + X_{22t} < 30\% \text{ of } 3168.99 = 950.697 \tag{65}$$

$$X_{31t} + X_{32t} + X_{33t} + X_{34t} + X_{35t} + X_{36t} + X_{37t} + X_{38t} < 40\% \text{ of } 3168.99 = 1267.596 \tag{66}$$

Non-Performing Loan Structural Constraints (For Year Two)

$$X_{11t} + X_{12t} < 5\% \text{ of } 146.37 = 7.319 \tag{67}$$

$$X_{21t} + X_{22t} < 35\% \text{ of } 146.37 = 51.23 \tag{68}$$

$$X_{31t} + X_{32t} + X_{33t} + X_{34t} + X_{35t} + X_{36t} + X_{37t} + X_{38t} < 60\% \text{ of } 146.37 = 87.822 \tag{69}$$

$$X_{11t} + X_{12t} < 30\% \text{ of } -16.37 = -4.92 \tag{70}$$

$$X_{21t} + X_{22t} < 30\% \text{ of } -16.37 = -4.92 \tag{71}$$

$$X_{31t} + X_{32t} + X_{33t} + X_{34t} + X_{35t} + X_{36t} + X_{37t} + X_{38t} < 40\% \text{ of } -16.4 = -6.56 \tag{72}$$

$$X_{11t} + X_{12t} < 10\% \text{ of } -8.44 = -0.844 \tag{73}$$

$$X_{21t} + X_{22t} < 50\% \text{ of } -8.44 = -4.22 \tag{74}$$

$$X_{31t} + X_{32t} + X_{33t} + X_{34t} + X_{35t} + X_{36t} + X_{37t} + X_{38t} < 40\% \text{ of } -8.44 = -3.376 \tag{75}$$

$$X_{11t} + X_{12t} < 30\% \text{ of } 2.91 = 0.873 \tag{76}$$

$$X_{21t} + X_{22t} < 30\% \text{ of } 2.91 = 0.873 \tag{77}$$

$$X_{31t} + X_{32t} + X_{33t} + X_{34t} + X_{35t} + X_{36t} + X_{37t} + X_{38t} < 40\% \text{ of } 2.91 = 1.164 \tag{78}$$

$$X_{11t} + X_{12t} < 40\% \text{ of } 66.39 = 26.556 \tag{79}$$

$$X_{21t} + X_{22t} < 30\% \text{ of } 66.39 = 19.917 \tag{80}$$

$$X_{31t} + X_{32t} + X_{33t} + X_{34t} + X_{35t} + X_{36t} + X_{37t} + X_{38t} < 30\% \text{ of } 66.39 = 19.917 \tag{81}$$

Total Deposit Structural Constraints (For Year Two)

$$X_{11t} + X_{12t} < 5\% \text{ of } 68309.30 = 3415.465 \tag{82}$$

$$X_{21t} + X_{22t} < 35\% \text{ of } 68309.30 = 23908.255 \tag{83}$$

$$X_{31t} + X_{32t} + X_{33t} + X_{34t} + X_{35t} + X_{36t} + X_{37t} + X_{38t} < 60\% \text{ of } 68309.30 = 40985.58 \tag{84}$$

$$X_{11t} + X_{12t} < 30\% \text{ of } 22102.90 = 6630.87 \tag{85}$$

$$X_{21t} + X_{22t} < 30\% \text{ of } 22102.90 = 6630.87 \tag{86}$$

$$X_{31t} + X_{32t} + X_{33t} + X_{34t} + X_{35t} + X_{36t} + X_{37t} + X_{38t} < 40\% \text{ of } 22102.90 = 880.79 \tag{87}$$

$$X_{11t} + X_{12t} < 10\% \text{ of } 33642.93 = 3364.293 \tag{88}$$

$$X_{21t} + X_{22t} < 50\% \text{ of } 33642.93 = 16821.465 \tag{89}$$

$$X_{31t} + X_{32t} + X_{33t} + X_{34t} + X_{35t} + X_{36t} + X_{37t} + X_{38t} < 40\% \text{ of } 33642.93 = 13457.172 \tag{90}$$

$$X_{11t} + X_{12t} < 30\% \text{ of } 467517.20 = 140255.1 \tag{91}$$

$$X_{21t} + X_{22t} < 30\% \text{ of } 467517.20 = 140255.1 \tag{92}$$

$$X_{31t} + X_{32t} + X_{33t} + X_{34t} + X_{35t} + X_{36t} + X_{37t} + X_{38t} < 40\% \text{ of } 467517.20 = 18700.88 \tag{93}$$

$$X_{11t} + X_{12t} < 40\% \text{ of } 2436.40 = 9744.96 \tag{94}$$

$$X_{21t} + X_{22t} < 30\% \text{ of } 2436.40 = 7308.72 \tag{95}$$

$$X_{31t} + X_{32t} + X_{33t} + X_{34t} + X_{35t} + X_{36t} + X_{37t} + X_{38t} < 30\% \text{ of } 24362.40 = 7308.72 \tag{96}$$

Expansion

Goal Constraint (Expansion)

For t = 1 (i.e. year one):

$$X_{111} + X_{121} + X_{211} + X_{222} + X_{311} + X_{322} + X_{331} + X_{341} + X_{351} + X_{361} + X_{371} + X_{381} - d^+_{11} + d^+_{11} = 0.5CB_1 \tag{97}$$

$$X_{111} + X_{121} + X_{211} + X_{222} + X_{311} + X_{321} + X_{331} + X_{341} + X_{351} + X_{361} + X_{371} + X_{381} - d^+_{11} + d^+_{11} = 0.5B_1 \tag{98}$$

$$1.5 (X_{111} + X_{121} + X_{211} + X_{222} + X_{311} + X_{321} + X_{331} + X_{341} + X_{351} + X_{361} + X_{371} + X_{381}) - d^+_{31} + d^-_{31} = NP_1 \tag{99}$$

$$X_{111} + X_{121} + X_{211} + X_{222} + X_{311} + X_{321} + X_{331} + X_{341} + X_{351} + X_{361} + X_{371} + X_{381} - d^+_{41} + d^+_{41} = 0.3D_1 \tag{100}$$

$$0.35 (X_{111} + X_{121} + X_{211} + X_{222} + X_{311} + X_{321} + X_{331} + X_{341} + X_{351} + X_{36\backslash 1} + X_{371} + X_{381}) - d^+_{51} + d^+_{51} = 0 \tag{101}$$

For t = 2 (i. e year 2)

$$X_{112} + X_{122} + X_{212} + X_{222} + X_{312} + X_{322} + X_{332} + X_{342} + X_{352} + X_{362} + X_{372} + X_{382}d^t_{12} + d^-_{12} = 0.5CB_2 \tag{102}$$

$$X_{112} + X_{122} + X_{212} + X_{222} + X_{312} + X_{322} + X_{332} + X_{342} + X_{352} + X_{362} + X_{372} + X_{382}d^t_{11} + d^-_{11} = 0.5B_2 \tag{103}$$

$$1.5 (X_{112} + X_{122} + X_{212} + X_{222} + X_{312} + X_{322} + X_{332} + X_{342} + X_{352} + X_{362} + X_{372} + X_{382}) - d^t_{32} + d^-_{32} = NP_1 \tag{104}$$

$$X_{112} + X_{122} + X_{212} + X_{222} + X_{312} + X_{322} + X_{332} + X_{342} + X_{352} + X_{362} + X_{372} + X_{382}d^t_{42} + d^t_{42} = 0.3D_2 \tag{105}$$

Objective Function (Expansion)

$$\text{Minimize} Z = P_1(d^+_{1t} + d^-_{1t} + d^+_{2t} + d^-_{2t}) + P_2(d^+_{3t} + d^+_{3t}) + P_3(d^+_{4t} + d^-_{4t}) + P_4(d^+_{5t} + d^-_{5t}) \tag{106}$$

That is

$$\text{Min } Z = P_1 d^+_{11} + P_1 d^-_{11} + P_1 d^+_{21} + P_1 d^-_{21} + P_2 d^+_{31} + P_2 d^-_{31} + P_3 d^+_{41} + P_3 d^-_{41} + P_4 d^+_{51} + P_4 d^-_{51} \text{(for t=1)} \tag{107}$$

$$\text{Min} Z = P_1 d^+_{12} + P_1 d^-_{12} + P_1 d^+_{22} + P_1 d^-_{22} + P_2 d^+_{32} + P_2 d^-_{32} + P_3 d^+_{42} + P_3 d^-_{42} + P_4 d^+_{52} + P_4 d^-_{52} \text{(for t=2)} \tag{108}$$

MODEL SOLUTION AND ANALYSIS OF RESULTS

In this study, twelve decision variables (X_{ijt}) were considered, which denote the amount of different categories of loan that fall under long term, medium term and short term, respectively, to be allocated. Other variables are also considered. In all, twenty – two variables and fifty constraints are involved. A computer package is therefore employed. Due to the peculiar nature of the model constraints, the model (problem) could not be solved using "ADBASE", a goal programming computer package. A multi – objective computer package, "PROTASS" was then adopted, and eventually obtained solutions to the model variables. "PROTASS" uses the simplex algorithm. It starts at some extreme feasible

points and by a sequence of exchange, proceeds systematically to other basic feasible solutions having better values for the objectives while giving the decision maker the privilege of setting the range for which its objectives should fall, in their order of priority. After running the program on computer, the following results were obtained; In Model 1: the decision variables X_{111} = 244.8460 and X_{311} = 860.5300 while other decision variables have zero value. This implies that the amount to be allocated to long term mortgage finance in year one is 244.8460 million naira, while the amount to be allocated to short term LPO finance in year one is 860.53 million naira. In Model 2: the decision variable X_{311} = 2.24, which implies that the amount to be allocated to short term LPO finance, in period 1 is 2.24 million naira in order to obtain an optimal result. In Model 3: the decision variable X_{111} is 67.8773.

That is to say the amount to be allocated to long term mortgage finance during the first period is 67.8773 million naira. In Model 4: the value of the decision variable X_{111} is same as in model 3. In Model 5: the decision variable X_{111} = 1.1600 which implies the amount to be allocated short term LPO finance in period 1 is 1.1600 million naira. In Model 6: the decision variable X_{111} = 67.8773. Which means that the amount to be allocated to long term mortgage finance is 67.8773 million naira. Table 5 shows how much of the right hand side values of contents were actually used in Model 1 through model 6. We can deduce from the table that in model 1 out of the total amount 787.84 million naira available for long term mortgage finance (X_{111}) and lease finance (X_{121}), only 244.846 million naira was used up in order to optimize the objective. Which means that 542.994 million naira was not used. We can also see the unused fund available in the other models. For the objective (goals): Table 6 to Table 11 show the results of objectives (goals) for model 1 to model 6 respectively.

Table 5: Showing How Much of Right Hand Value was actually Used

Sources of Fund		Models					
		1	**2**	**3**	**4**	**5**	**6**
Commercial bank	Given	787.84	7.9	3,068.2	3,068.2	7.32	7.32
	Used	244.846	0	67.9	67.9	0.3	0.3
	Unused	542.994	7.9	3000.3	3000.3	7.03	7.03
Individual	Given	1718.094	1.68	6001.4	6001.4	4.9	4.9
	Used	244.846	0	67.9	67.9	0.3	0.3
	Unused	1473.248	1.68	5933.5	5933.5	4.6	4.6
Family and friends	Given	860.526	2.6	139,960.7	139,960.7	0.9	0.9
	Used	244.846	0	67.9	67.9	0.3	0.3
	Unused	615.68	2.6	139,892.9	139,892.9	0.6	0.6
Cooperative	Given	823.585	1.76	3,011.2	3,011.2	0.8	0.8
	Used	244.846	0	67.9	67.9	0.3	0.3
	Unused	578.739	1.76	2943.3	2943.3	0.5	0.5

SENSITIVITY ANALYSIS OF THE RESULTS OF THE OBJECTIVES

From table 6, it implies that if the value is outside the range, (lower and upper), the objectives will no longer be feasible. So in order to maximize the corporate branches input in the loan portfolio management of the bank, an ideal value of 1, 105.3760 million naira is expected, but between 169.6933 million naira and 2,508.9 million naira is still okay. The same kind of explanation goes for the Branches, Non – Performing, Deposit and Yield on loan

Table 6: Results for Objectives (Goals) in Model 1

	Name	Type	Lower(Million)	Value(Million)	Upper(Million)
1	Corporate Branches	Max	169.6933	1105.3760	2508.9000
2	Branches	Max	169.6933	1105.3760	2508.9000
3	Non-Performing	Max	2545400	16580640	37633500
4	Deposit	Max	1696933	11053760	25089000
5	Yield on Loan	Max	593927	3868816	8781150

Table 7: Results for Objectives (Goals) in Model 2

	Name	Type	Lower	Value	Upper
1	Corporate Branches	Max	0	2.24	5.6
2	Branches	Max	0	2.24	5.6
3	Non-Performing	Max	0	3.36	8.4
4	Deposit	Max	0	2.24	5.6
5	Yield on Loan	Max	0	0.7840	1.96

Table 8: Results for Objectives (Goals) in Model 3

	Name	Type	Lower	Value	Upper
1	Corporate Branches	Max	0	67.8773	169.6933
2	Branches	Max	0	67.8773	169.6933
3	Non-Performing	Max	0	101.8160	254.54
4	Deposit	Max	0	67.8773	169.6933
5	Yield on Loan	Max	0	23.7571	59.3927

Table 9: Results for Objectives (Goals) in Model 4

	Name	Type	Lower	Value	Upper
1	Corporate Branches	Max	0	67.8773	169.6933
2	Branches	Max	0	67.8773	169.6933
3	Non-Performing	Max	0	101.8160	254.54
4	Deposit	Max	0	67.8773	169.6933
5	Yield on Loan	Max	0	23.7571	59.3927

Table 10: Results for Objectives (Goals) in Model 5

	Name	Type	Lower	Value	Upper
1	Corporate Branches	Max	0	1.1600	2.9000
2	Branches	Max	0	1.1600	2.9000
3	Non-Performing	Max	0	1.7400	4.3500
4	Deposit	Max	0	1.1600	2.9000
5	Yield on Loan	Max	0	0.4060	1.0150

Table 11: Results for Objectives (Goals) in Model 6

	Name	Type	Lower	Value	Upper
1	Corporate Branches	Max	0	1.1600	2.9000
2	Branches	Max	0	1.1600	2.9000
3	Non-Performing	Max	0	1.7400	4.3500
4	Deposit	Max	0	1.1600	2.9000
5	Yield on Loan	Max	0	0.4060	1.0150

In model 2; from table 7, it can be deduced that for the objectives (goals) of the bank to be feasible the value for the objectives should fall within the indicated ranges (lower and upper). For instance, for corporative branches, on an objective, in order to maximize that goal, the value should be between 0 and 5.6 million naira. This is the amount to be allocated to short term LPO finance for period 1 which falls within the range 0 and 5.6. For model 3; in order to maximize

the goal of the bank as regards corporate branches, branches, deposit and yield on loan, the value of these goals must fall within 0 and the respective upper value as shown in table 3. Also in order to minimize the non – performing loan, the value must not exceed 254.54 million naira. Similar explanations go for model 4, model 5, and model 6 respectively.

CONCLUSIONS

Loan portfolio management is a very important aspect of Banking. If it is mismanaged, it can cause the Bank a huge loss of income. The problem of decision facing banks, as lenders, in selecting credit policy can be tackled by application of some Operational Research Techniques. To know the best strategies to adopt in order to achieve the goals or objectives of a bank in Nigeria especially as it concerns loan portfolio management, an operational research technique – goal programming is used. Of great interest also is to know how the loan portfolio should be proactively positioned in order to manage threats and maximize opportunities. With the results obtained, using a multi objective package, provide an answer on how to handle, not only the above but also how to make sure that the case of bad loan is minimize. Based on the analysis of the result obtained and discussion that followed the following conclusions are drawn.

Firstly, for the organization (bank) to optimize her objectives (goal), the decision variable X_{111}, that is, the long – term mortgage finance should be closely monitored.

Secondly, the decision variable X_{311}, which is the short term LPO finance, plays a very important role in ensuring that the organization optimizes her goals.

Thirdly, the range of values of the amount allocated to the decision variables have to be put into consideration because any attempt to go out of the range will definitely prevent the organisation from achieving her goals. For instance in model 1; for short term, loan resources were use up which implies more should be allocated to that sector.

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