Report

Bank Asset Liability Management

Vo Tan Phat - 10956
Nguyen Tien Hung - 9972
Tran Huy Hoang - 10396
Hoang Thai Duong - 11052

Studium Generale - Dr. Dinh Hai Dung

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1 Introduction

Bank asset liability management can be defined as the mechanism to manage assets and liabilities to minimize the risks, achieve the goals of bank, ensure liquidity, ad adhere to central bank norms [1].

In this paper, we consider the model in which a bank wants to maximize the profit with a given liability while ensuring liquidity and adhering to central bank norms [3]. There will be eight time periods (or buckets) for assets and liabilities as follows:

- Bucket 1: 1 to 14 days
- Bucket 2: 15 to 30 days
- Bucket 3: one to three months
- Bucket 4: three to six months
- Bucket 5: six months to one years
- Bucket 6: one to three years
- Bucket 7: three to five years
- Bucket 8: more than five years

The following four liabilities are considered in the model for each bucket i, along with associated costs are represented as a table:

Cost	**CLDD Demand**	**CLSD Saving**	**CLTD Term**	**CLB Borrowings**
Bucket 1	0%	3.5%	3.5%	3.5%
Bucket 2	0%	3.5%	4.25%	3.5%
Bucket 3	0%	3.5%	5.75%	5.5%
Bucket 4	0%	3.5%	6.25%	5.5%
Bucket 5	0%	3.5%	8.5%	5.5%
Bucket 6	0%	3.5%	8.75%	8.5%
Bucket 7	0%	3.5%	9%	9%
Bucket 8	0%	3.5%	10%	9.5%

Table 1: Cost table

The following five assets are considered in the model for each bucket i, along with associated returns are represented in Table 2.

Return	RABCB Central bank	RABOB Other banks	RAGS Government Securities	RADB Debentures & Bonds	RAA Advances
Bucket 1	3.5%	3.5%	3.5%	3.5%	5%
Bucket 2	3.5%	4.25%	3.5%	3.5%	5%
Bucket 3	5.5%	5.75%	5.5%	5.5%	6.5%
Bucket 4	5.5%	6.25%	5.5%	5.5%	6.5%
Bucket 5	5.5%	8.5%	5.5%	5.5%	8%
Bucket 6	6%	8.75%	8.5%	8.5%	9%
Bucket 7	6.5%	9.5%	9%	9%	9.5%
Bucket 8	7%	10%	9.5%	9.5%	10%

Table 2: Return table

The profit is given by total revenue from the assets less the total cost of funds. Hence the objective function of the model is given by the following expression:

$$Maximize = \sum_{i=1}^{8}(R_i) - (C_i) \tag{1}$$

Where

- $R_i = ABCB_iRABCB_i + ABOB_iRABOB_i + AGS_iRAGS_i + ADB_iRADB_i + AA_iRAA_i$ is the revenue earned in bucket i.
- $C_i = LDD_iCLDD_i + LSD_iCLSD_i + LTD_iCLTD_i + LB_iCLB_i$ is the cost incurred in bucket i.

The total revenues must equal the total costs for bucket i and up to bucket j to maintain liquidity of funds. This is modelled by the following constraint:

1. $\sum_{i=1}^{j}(ABCB_i + ABOB_i + AGS_i + ADB_i + AA_i - LDD_i - LSD_i - LTD_i - LB_i) = 0$, j = 1, 2, .., 8

Banks also have certain restrictions on assets and liabilities, which have evolved through experience of the markets. These restrictions are:

2. Advances in each bucket should exceed 5% of total term advances in all eight buckets. Hence $AA_j \geq 0.05 * \sum_{i=1}^{8} AA_i, j = 1, 2, ..., 8$
3. Balance with central bank in each bucket should exceed 5% of total assets in all eight buckets. Hence $ABCB_j \geq 0.05 * \sum_{i=1}^{8}(ABCB_i + ABOB_i + AGS_i + ADB_i + AA_i), j = 1, 2, ..., 8$
4. Balance with central bank in bucket 8 should exceed 5% of total balances with central bank in all eight buckets. Hence $ABCB_8 \geq 0.05 * \sum_{i=1}^{8} ABCB_i$
5. Investment in government securities in bucket 8 should exceed 5% of total investment in government securities in all eight buckets. Hence $AGS_8 \geq 0.05 * \sum_{i=1}^{8} AGS_i$
6. Investment in debentures and bonds in bucket 8 should exceed 5% of total investment in debentures and bonds in all eight buckets. Hence $ADB_8 \geq 0.05 \sum_{i=1}^{8} ADB_i$

7. The total investment in government securities in all buckets should exceed 24% of the total demand deposits, savings deposits, and term deposits in all buckets. Hence $\sum_{j=1}^{8} AGS_j \geq 0.24 * \sum_{i=1}^{8}(LDD_i + LSD_i + LTD_i)$

8. The total investment in assets in each bucket should be less than the total demand deposits, savings deposits, and term deposits in all buckets. Hence $ABCB_j + ABOB_j + AGS_j + ADB_j + AA_j \leq \sum_{i=1}^{8}(LDD_i + LSD_i + LTD_i), j = 1, 2, ..., 8$

9. Borrowings in bucket 1 should exceed 80% of total borrowings in all buckets. Hence $LB_1 \geq \sum_{i=1}^{8} LB_i$

10. Borrowings in each of the buckets 6, 7, and 8 should exceed 5% of total borrowings in all buckets. Hence $LB_j \geq 0.05 * \sum_{i=1}^{8} LB_i, j = 6, 7, 8$

2 Genetic Algorithms (GAs)

In this project, we keep the presented model and apply the genetic algorithm. The implemented algorithm is based on the DEAP framework, an evolutionary computation framework for rapid prototyping and testing of ideas. The result will be compared with the Simplex method in the Excel Solver.

Genetic Algorithms (GAs) are search algorithms based on the mechanics of natural selection and natural genetics [2]. It was developed and introduced in 1960 by John Holland and extended by Goldberg in 1989. Genetic algorithms are commonly used to generate high-quality solutions to optimization and search problems by relying on bio-inspired operators such as mutation, crossover and selection.

The process begins with a population, which is a set of individuals. Each individual is a candidate solution to the problem you want to solve. An individual is characterized by a set of parameters (variables) known as Genes. Genes are joined into a string to form a Chromosome (solution). Traditionally, solutions are represented in binary as strings of 0s and 1s, but other type of encoding e.g. floating point are also possible.

3 Methodology

There are five phases are considered in our implemented genetic algorithm as illustrated in the Figure 1.

3.1 Population Initialization

There are 48 variables representing the solution. We represent them as a chromosome (individual) of 48 genes, each is floating point type. For our model, the limits of the variables are unknown. In our implemented algorithm, we set the bounds of the variables (genes) based on the known solution of the Excel Solver. The Figure 2 below shows an example of an individual. By default, we initialize our population with 100 individuals.

3.2 Fitness function

This step will determine the ability of an individual to compare with other individuals. The function is calculated by the objective function mentioned in the Introduction section.

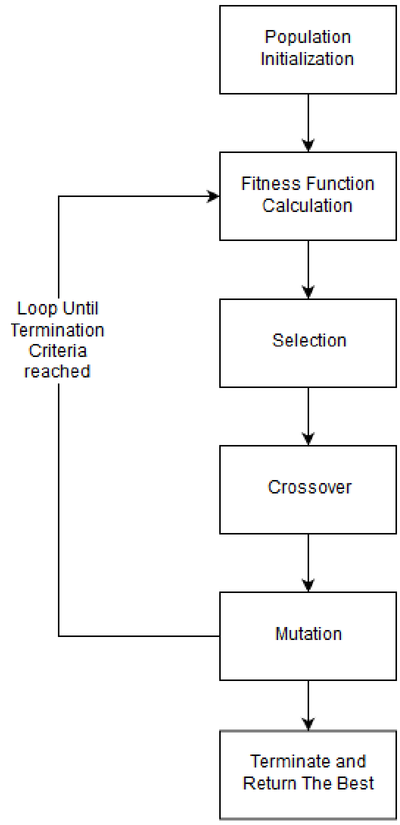

Figure 1: Methodology

Bucket	Borrowings LB	Balance with Central Bank ABCB	Balance with other banks ABOB	Invest. in government and sec. AGS	Investment in debentures and bonds ADB	Advances AA
1	27.264387396856687	26.4228702940551	0.022634045689176402	4.731715619620582	0.010660505391220099	33.54145713034457
2	23.968337457684203	4.9276219842855	0.00035441985361396...	6.428379809830931	0.042605874028540124	69.0326784666915
3	81.86866820269229	26.734995366975696	0.5511085100690131	7.378657108120407	0.03940246247034876	44.08774418122544
4	48.170559389532784	5.10787740372759	0.048365116396000156	2.5561406846050327	0.8099369110899898	92.58676107614801
5	23.242939388926253	2.4476148088030487	0.9216740287078895	14.35319601756798	0.025917490715014785	40.64498783640791
6	90.68660361707641	5.444520848986576	0.03352758475990333	1.163103179778432	0.028727127384435364	69.34940393041475
7	90.34408148915826	25.94840159754692	0.01915905817770643	2.13366722268756	0.5132939853493002	38.03503728137214
8	126.18533739791437	25.882178382802103	0.03655127855068123	29.364363163091404	0.7120210259215765	95.89547572797412

Figure 2: Example of an individual

3.3 Selection

The idea is to select the fittest individuals and let them pass their genes to the next generation. We simply sort the population based on the number of satisfied constraints in descending order.

3.4 Crossover

For each pair of parents to be mated, a crossover point is chosen randomly. Offspring are created by exchanging the genes of parents among themselves. The genes to the right of that point are swapped between the the parent chromosomes.

3.5 Mutation

In certain new offspring formed, some of their genes can be subjected to a mutation with a low random probability. For every gene of an an individual, it will be selected randomly and replaced by a random value which is bound from 0 up to an upper value. Since the bounds of gens (variable) are unknown, the upper bound is based on the known solution of the Excel Solver. Mutation occurs to maintain diversity within the population and prevent premature convergence.

3.6 Termination

The algorithm terminates when it runs through all the generations. By default, the number of generations is 50.

3.7 Hall of fame

The hall of fame is simply a list of the 20 best individuals that ever lived in the population during the evolution. The best ones must contain positive objective function's return value and has the number of satisfy all the eight constraints.

After the program is finished, the best of among those 20 elite individuals will be displayed as the solution for the problem.

4 Result

The implemented genetic Algorithm does not solve well the asset liability management problem. When compare the our implementation to the simplex method, the result shows that the running time is longer than the simplex method implemented in the Microsoft Excel Solver. Also, the objective value is not optimal and not always all the constrains are satisfied.

To make the implemented algorithm comparable with the simplex Solver, we remove the unsatisfied constraints. To find out which constraints are hardly met, we run the implemented algorithm many times and count the number of satisfied constraints. We found that the above constraint 3 and 9 are hardly met. The result of program is not the same as the result of the Excel Solver, however it is indicating that the genetic algorithm is promising to provide alternative solution to the ALM problem.

In the considered model, the bounds of variables are unknown. In the implemented algorithm, they are set based on the known solution of the Excel Solver. The bounds of genes heavily impact the quality of the initialized population and the final result. Therefore, to make the genetic algorithm applicable in real world, further research and test need to be conducted.

References

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