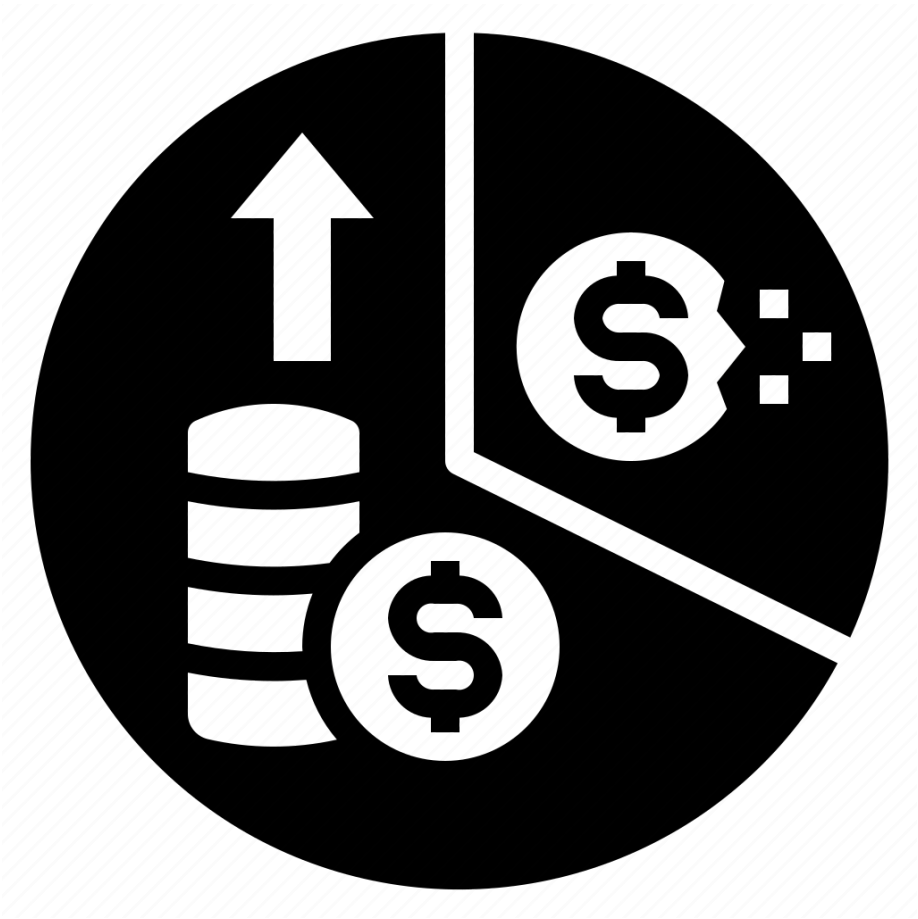
OPERATIONS RESEARCH



ASSET-LIABILITY MANAGEMENT

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PREFACE

This project includes 2 MATLAB code files, a rough-work draft reminiscent of the effort put behind the project and this project report.

Initially started as a mini-project to implement the linprog function in MATLAB, the project escalated thanks to my friends and came to be what it is today.
The project took about 2-3 weeks to complete and the formalisation of the report took another week.

Though the project includes 4 files, this project report is complete in itself and the readers don't need to go through any other files to go through the project. In fact that was the motivation behind making this project report.

The MATLAB code is included in this project report (as indicated in the index) and so are the screenshots of the code (after being executed).

The other document deserves at least a paragraph here. The document on first sight looks messing with very less clarity of thought and no regard is given to the reader. The draft was my white-board of sorts which I was using while brainstorming, whenever I was stuck on a particular issue. The draft should technically not be included in the files but I have kept in there for a very particular and selfish reason. The draft will keep helping me in the near future, whenever I am asked to explain how I created the project from scratch. Even though it is unorganised, I can make perfect sense of it and hence will be able to explain all my thought process as if I was just done with the project. Plus the draft will also help me during the times I don't have any writing material with me but still want to explain my workings, thought process and assumptions.

As a reader, I encourage you to skip the draft altogether and just stick to this project report. As indicated earlier this was the reason the report was made this comprehensive, neat and legible.
Let the messy board of the draft be abstracted by this project report.

Finally I would like to thank all my friends for having discussions with me and helping me organise my thoughts when I felt hazy.

Pranav Chatur

INTRODUCTION

What is Asset/Liability Management?

An asset is anything of value or a resource of value that can be converted into cash. Individuals, companies, and governments own assets. For a company, an asset might generate revenue, or a company might benefit in some way from owning or using the asset.

A liability is something a person or company owes, usually a sum of money. Liabilities are settled over time through the transfer of economic benefits including money, goods, or services.

Asset/liability management is the process of managing the use of assets and cash flows to reduce the firm's risk of loss from not paying a liability on time. Well-managed assets and liabilities increase business profits. The asset/liability management process is typically applied to bank loan portfolios and pension plans. It also involves the economic value of equity. The concept of asset/liability management focuses on the timing of cash flows because company managers must plan for the payment of liabilities. The process must ensure that assets are available to pay debts as they come due and that assets or earnings can be converted into cash.

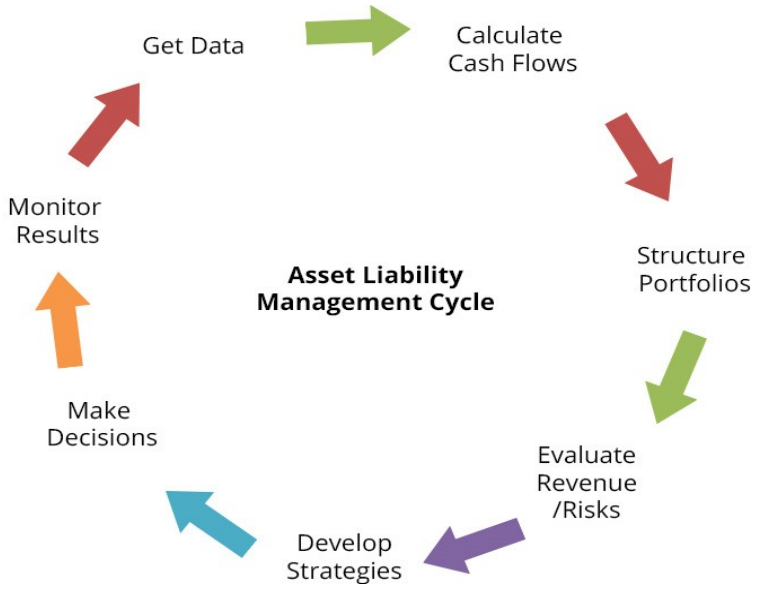
Asset/Liability Management problem

Design a model that can be applied to asset/liability management problem in which funds are allocated to various investments to maximise portfolio return while ensuring that periodic liabilities are fully funded.

In this type of problems, they are generally solved by formulating the problems into a Mathematical Model & then solve it by a suitable Linear/Non-Linear Programming algorithm in order to maximise portfolio return or to maximise overall gain at the level of an individual or organisation.

Steps involved in solving such problems:
Understanding the problem completely, with the objective clear.
Elaborate the problem such that formulation becomes easy.
Make the Mathematical Model for problem with Min/Max Objective function & all the necessary constraints.
Solve the model optimally.

PROBLEM DESCRIPTION



PROBLEM STATEMENT

Description

Investor 'Y' has 'I' Income. He has to, first and foremost fund periodic liabilities (F) and then invest the remaining budget 'B' into assets.

- Asset 'A' has fraction invested 'X_A', return% 'R_A ' and risk% 'K_A ' and loss at risk% 'L_A'
- Periodic Liability 'L' has cost 'C_L' inflation% ' W_L'

Goals

The goal of the project is to maximise the profit of investor Y.

Approach

By designing a system, formulating proper computational model around the system, assigning computable variables for each physical quantity and finally using MatLab to simulate, we can find the distribution of investment to gain maximum profit. #Refer rough work for understanding of formulation process..

Two models

I have presented two models, one of an individual and another of an organisation, both under completely different situations, having different incomes, different assets and different liabilities

MODEL 1 : DESCRIPTION

Decision Variables

Income -> I (= $10,000)

Assets-

1. Shares (X_s, R_s, K_s, L_s)
2. Real Estate (X_r, R_r, K_r, L_r)

Liability-

1. Maintenance (C_m , W_m)
2. Loan Repayment (C_{lr} , W_{lr})
3. Taxes (C_t , W_t)

Objective

Maximise $z = f(Y) = \sum X_i[(K_i)(1-L_i) + (100-K_i)(1+R_i)] - \sum(Cj)(1+W_j)$

where i, j represent i^{th}, j^{th} asset and liability respectively

$$= X_s\{K_s(1 - L_s) + (1 - K_s)(1 + R_s)\} + X_r\{K_r(1 - L_r) + (1 - K_r)(1 + R_r)\} - C_m(1+W_m) - C_{lr}(1+W_{lr}) - C_t(1+W_t)$$

Constraints

1. $X_s + X_r + C_m + C_{lr} + C_t = 10000$
2. $7*C_m + 3*C_{lr} = 3000$
3. $3*X_s + C_t \geq 8000$
4. $C_{lr} \geq 500$
5. $C_t \geq 1000$
6. $W_t = 4$
7. $W_m = 3$
8. $W_{lr} = 8$
9. $K_s = 60$
10. $K_r = 20$
11. $R_s = 30$
12. $R_r = 15$
13. $L_s = 70$
14. $L_r = 10$
15. $R_i , L_i, W_i , K_i < 100$
16. $X_i, R_i, K_i, L_i, C_i, W_i > 0$

MODEL 1: COMPUTATION

Assignation

Let-

1. $X_s = X_1$
2. $X_r = X_2$
3. $C_m = X_3$
4. $C_{lr} = X_4$
5. $C_t = X_5$

Computable Objective

$Z = X_S\{K_S(1 - L_S) + (1 - K_S)(1 + R_S)\} + X_r\{K_r(1 - L_r) + (1 - K_r)(1 + R_r)\} - C_m(1+W_m) - C_{lr}(1+W_{lr}) - C_t(1+W_t)$

$Z = X_1\{0.6(0.3) + 0.4(1.3)\} + X_2\{0.2(0.9) + 0.8(1.15)\} - X_3(1.03) - X_4(1.08) - X_5(1.04)$

$Z = 0.7^* X_1 + 1.1^* X_2 - 1.03^* X_3 - 1.08^* X_4 - 1.04^* X_5$

Computable Constraints

1. $(-7)^* X_1 + 0^* X_2 + 0^* X_3 + 0^* X_4 + (-1)^* X_5 \leq -8000$
2. $0^* X_1 + 0^* X_2 + 0^* X_3 + (-1)^* X_4 + 0^* X_5 \leq -500$
3. $0^* X_1 + 0^* X_2 + 0^* X_3 + 0^* X_4 + (-1)^* X_5 \leq -1000$
4. $1^* X_1 + 1^* X_2 + 1^* X_3 + 1^* X_4 + 1^* X_5 = 10000$
5. $0^* X_1 + 0^* X_2 + 7^* X_3 + 3^* X_4 + 0^* X_5 = 3000$

MODEL 1: MATLAB & SOLUTION

MatLab Code

```
f = [0.7 1.1 -1.03 -1.08 -1.04];
A = [-3 0 0 0 -1
0 0 0 -1 0
0 0 0 0 -1];
b = [-8000 -500 -1000];
Aeq = [1 1 1 1 1
0 0 7 3 0];
beq = [10000 3000];
lb = [0 0 0 0 0];
ub = [10000,10000,10000,10000, 10000];
x = linprog(-f,A,b,Aeq,beq,lb,ub); disp(x);
fval = f*x;
disp("Net Profit after performing Asset-Liability Management modelling is " + fval + "$");
```

Optimal Solution

$Z = 6380.24$

$X_s = 2333.33$

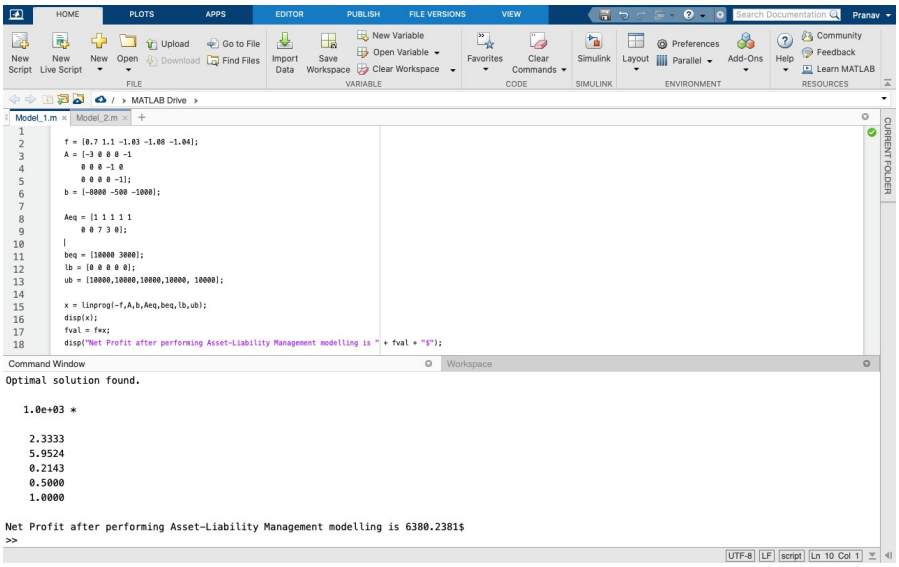
$X_r = 5952.48$

$C_m = 214.28$

$C_{lr} = 500$

$C_t = 1000$

Screenshot



MODEL 2 : DESCRIPTION

Decision Variables

Income -> I (= $10,000,000)

Assets-

1. Stock Trading (X_t, R_t, K_t, L_t)
2. Services Provided (X_S, R_S, K_S, L_S)
3. Loan Collection (X_C, R_C, K_C, L_C)

Liability-

1. Wages (C_w , W_W)
2. Non-performing loans (C_n , W_n)

Objective

Maximise $z = f(Y) = \sum X_i[(K_i)(1-L_i) + (100-K_i)(1+R_i)] - \sum(Cj)(1+W_j)$

where i, j represent i^{th} asset and j^{th} liability respectively

$$= X_t\{K_t(1-L_t) + (1-K_t)(1+R_t)\} + X_S\{K_S(1-L_S) + (1-K_S)(1+R_S)\} + X_C\{K_C(1-L_C) + (1-K_C)(1+R_C) - C_W(1+W_W) - C_n(1+W_n)$$

Constraints

1. $X_t + X_s + X_c + C_w + C_n = 10000000$
2. $X_s - C_w = 2000000$
3. $Xc + 6*C_n \leq 5000000$
4. $X_t + X_s \geq 4000000$
5. $C_n \geq 450000$
6. $C_w \geq 500000$
7. $3*C_n + C_w \geq 2000000$
8. $W_w = 2$
9. $W_n = 5$
10. $K_t = 60$
11. $K_s = 5$
12. $K_c = 15$
13. $R_t = 30$
14. $R_s = 10$
15. $R_c = 15$
16. $L_t = 60$
17. $L_s = 10$
18. $L_c = 30$
19. $R_i , L_i, W_i , K_i < 100$
20. $X_i, R_i, K_i, L_i, C_i, W_i > 0$

MODEL 2: COMPUTATION

Assignation

Let-

1. $X_t = X_1$
2. $X_s = X_2$
3. $X_c = X_3$
4. $C_w = X_4$
5. $C_n = X_5$

Computable Objective

$Z = X_t\{K_t(1-L_t) + (1-K_t)(1+R_t)\} + X_S\{K_S(1-L_S) + (1-K_S)(1+R_S)\} + X_C\{K_C(1-L_C) + (1-K_C)(1+R_C) - C_W(1+W_W) - C_n(1+W_n)$

$Z = X_1\{0.24 + 0.52\} + X_2\{0.045 + 1.045\} + X_3\{0.105 + 0.9775\} - X_4\{1.02\} - X_5\{1.05\}$

$Z = 0.76*X_1 + 1.09*X_2 + 1.08*X_3 - 1.02*X_4 - 1.05*X_5$

Computable Constraints

1. $0* X_1 + 0* X_2 + 1* X_3 + 0* X_4 + 6* X_5 \leq 5000000$
2. $(-1)* X_1 + (-1)* X_2 + 0* X_3 + 0* X_4 + 0* X_5 \leq -4000000$
3. $0* X_1 + 0* X_2 + 0* X_3 + 0* X_4 + (-1)* X_5 \leq -450000$
4. $0* X_1 + 0* X_2 + 0* X_3 + (-1)* X_4 + 0* X_5 \leq -500000$
5. $0* X_1 + 0* X_2 + 0* X_3 + (-1)* X_4 + (-3)* X_5 \leq -2000000$
6. $X_1 + X_2 + X_3 + X_4 + X_5 = 10000000$
7. $0* X_1 + X_2 + 0* X_3 + (-1)* X_4 + 0* X_5 = 2000000$

MODEL 2: MATLAB & SOLUTION

MatLab Code

```
f = [0.76 1.09 1.08 -1.02 -1.05];
A = [0 0 1 0 6
-1 -1 0 0 0
0 0 0 0 -1
0 0 0 -1 0
0 0 0 -1 -3];
b= [5000000 -4000000 -450000 -500000 -2000000];
Aeq =[1 1 1 1 1
0 1 0 -1 0];
beq = [10000000 2000000];
lb = [0 0 0 0 0];
ub = [10000000 10000000 10000000 10000000 10000000];
x = linprog(-f,A,b,Aeq,beq,lb,ub); disp(x);
fval = f*x;
disp("Net Profit after performing Asset-Liability Management modelling is " + fval + "$");
```

Optimal Solution

Z= 7270000

X_t = 4500000

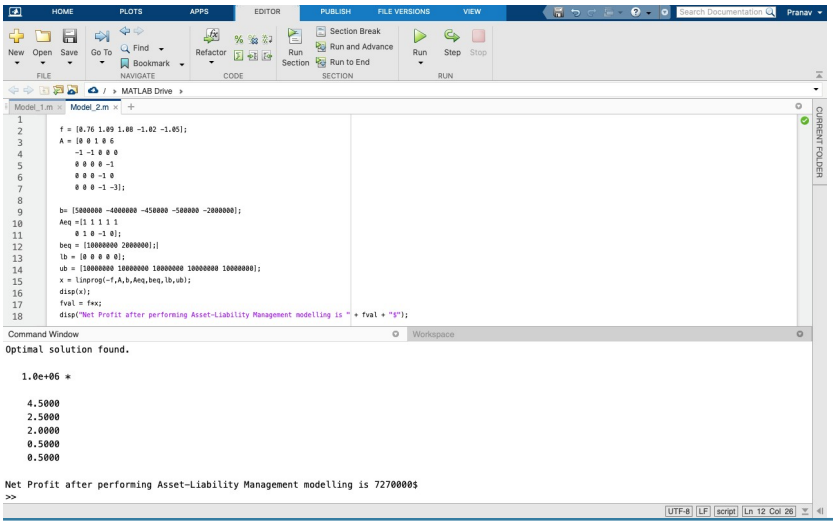
X_s = 2500000

X_c = 2000000

C_w = 500000

C_n = 500000

Screenshot



CONCLUSION

Closing remarks

The purpose of this project was to allocate funds to various investments, so as to maximise portfolio return while ensuring that the periodic liabilities are fully funded.
For the given constraints we have obtained the optimal solution for each model using MATLAB.
We formulated our models such that they were ‘Linear Programming Problems’. Therefore we used the in-built MATLAB function ‘linprog' to obtain the optimal solutions.

The MATLAB files can be found in the same repository as this project report

Bibliography

- Asset/Liability Management Definition (investopedia.com)
- MATLAB Documentation - MathWorks India
- Asset and Liability Management (ALM) - Overview, Pros and Cons (corporatefinanceinstitute.com)