Asset-Liability Management 2026 Project (Corrected Version)

Introduction

The project is designed to be solved in groups of 2-3 students. The technical work should result in a report of no more than 10 pages. The report should be in such a form that a non-mathematical person gets an idea of what you have done and why. Please place important results, tables and graphs into your report, to make it accessible to a reader who does not want to dive into programs. Use whatever programming tool comes natural for you.

You may write your report in English or Portuguese.

You may contact me with questions at the address tiagofardilha@iseg.ulisboa.pt.

The deadline for delivery of the report and underlying workings is Monday, 23rd November 2026.

Have fun!

1.Interest rate analysis

Below are the risk-free zero-coupon rates for the fictitious country of Livonia at 31/12/2025, annual compounding, according to EIOPA.

Maturity	rate
1 year	1,933771
2 years	1,994661
3 years	2,076875
4 years	2,171733
5 years	2,272852
6 years	2,375602
7 years	2,437792
8 years	2,525144
9 years	2,601642
10 years	2,668869
11 years	2,728156
12 years	2,780625
13 years	2,827223
14 years	2,868753
15 years	2,905893

1.1 Determine the term structure with continuous compounding.

1.2 Determine forward rates that are consistent with the zero rates.

1.3 Produce a graph showing the zero rates and forward rates.

2. Liability valuation and Exact Portfolio Matching

For a certain insurance portfolio in Livonia, the actuarial department reports the following outstanding claims and predicted payments. He also proposes buying the following bonds to face those payments. You may assume that payments fall due at the end of the year.

Time t	Payments
1	6.527.416
2	4.801.976
3	3.772.174
4	2.841.440
5	2.224.827

Bond maturity	Face value	Coupon rate (annual)
31-12-2026	100	2,00%
31-12-2027	100	2,00%
31-12-2028	100	2,00%
31-12-2029	1.000	2,25%
31-12-2030	1.000	2,50%

2.1 Calculate the discounted value of the liability cash flow, using the Livonia yield curve.

2.2 Price the 5-year maturity bond, using the same yield curve.

2.3 Find the average yield of the same bond using continuous compounding.

2.3 How many of each of the bonds displayed should be bought to follow the suggestion of the actuarial department?

3. Immunisation

Assume that bonds of every maturity are available and that they have a coupon rate of 2% for maturities up to 6 years, 3% for maturities between 7 and 11 years and 4% for maturities of 12 years and above. The face value is 100 EUR for all of them.

3.1 Recommend a portfolio that combines **three bonds** in such a way as to match the present value, duration and convexity of liabilities of 1M yearly, for the following **15** years. Negative holdings are not allowed.

3.2 Create three "buckets" of bonds: Short (maturity 1-5 years), Medium (maturity 6-10 years) and Long (maturity 11-15 years). Each bucket contains one piece of each bond in the specified maturity range. Determine the mix of the three buckets that matches the present value, duration and convexity of the liability cash flow.

4. Mean-Variance analysis

Your investment mandate is restricted to three asset classes: Equity, Bonds and Money market. Use the following set of assumptions for the yearly asset returns:

Asset	Asset class	E(return)	SD(return)	Correlations	1	2	3
1	Equity	0,06	0,08	**1**	1	0,016	0,158
2	Bonds	0,015	0,005	**2**	0,016	1	0,677
3	Money Market	0,005	0,002	**3**	0,158	0,677	1

Assume the risk-free rate is 0.1%.

4.1 Use the mean-variance structure to determine, with a one-year time horizon:

1. $\mathbf{w}_{min}$: The minimum asset variance portfolio,
2. $\mathbf{w}_{ref}$: The reference portfolio of risky assets,
3. $\mathbf{w}_{tan}$: The tangency portfolio when the risk-free return is 0.1%.

4.2 Now assume that liability growth R_L has the following stochastic behaviour:

$E(R_L)$	= 1,5%
$SD(R_L)$	= 0.5%
$Corr(R_L, R_{Equity})$	= 10%
$Corr(R_L, R_{Bonds})$	= 40%
$Corr(R_L, R_{Money\ market})$	= 25%

Also, assume that the funding ratio is F = 110%. Determine $\mathbf{w}_{min}$(F, gamma), the minimum surplus variance portfolio. Remember that you first need to determine the covariances between your asset classes and the liability growth, as well as $\mathbf{w}_{gamma}$, the liability hedge portfolio.

4.3 Can the liability hedge portfolio $\mathbf{w}_{gamma}$ be realized in practice? If not, why?