Stochastic Asset and Liabilities Management Model

Group Members: *Davide Messina, Matteo Lenzi, Fabio Marcaurelio, Umberto Bechis*
Asset and Liabilities Management
Instructor: *Habib Dogguy, Cyril Bénézet*
Date: February 16, 2025

Abstract

This project explores an Asset and Liability Management (ALM) framework for insurance portfolios, focusing on return optimization and risk management. The goal is to develop a model that dynamically manages asset allocation and liability evolution over a 10-year horizon. The study evaluates the effectiveness of ALM strategies in achieving financial stability and mitigating interest rate risk.

Contents

1 Introduction

Asset and Liability Management (ALM) is a fundamental framework for insurance companies to anticipate balance sheet dynamics, ensuring solvency and optimizing asset allocation. The complexity of life insurance portfolios, which include embedded options, surrender behavior, and uncertain future cash flows, makes it necessary to adopt a stochastic approach rather than traditional deterministic methods.

In this project, we develop a stochastic ALM model for a life insurance company, simulating both asset and liability dynamics over time. On the asset side, the portfolio is composed of one bond, equities, and cash. On the liability side, we model a portfolio of with-profit life insurance policies, where policyholders' savings accounts earn a return based on a guaranteed minimum rate. Additionally, the model integrates biometric risks, policyholder surrender behavior, and new policy subscriptions to more accurately represent liability dynamics.

A life insurance company's balance sheet includes Capital Invested in Assets (bonds, equities, and cash) on the asset side, and the Present Value of Life Insurance Policies on the liability side. The difference between the two represents Equity Capital, ensuring solvency and risk absorption.

Assets	Liabilities and shareholder's equity
Capital invested in assets	Present value of life insurance policies
	Equity capital

Figure 1: Simplified life insurance company's balance sheet.

By integrating asset-liability dynamics and market risks, this ALM framework provides a tool for insurers to optimize their investment strategy while maintaining financial stability.

2 Model

The model simulates a simplified balance sheet, with equity capital defined as the difference between assets and the present value of life insurance policies. The company adopts a conservative investment strategy, prioritizing fixed-income assets over equities to minimize risk, in line with regulatory requirements and shareholder interests. It consists of a diversified asset portfolio, including bonds, equities, and cash, which evolves stochastically over time. The liability side is characterized by life insurance policies, with factors such as mortality rates, policy abandonment, and interest rate models influencing the company's obligations. To maintain financial stability, the portfolio undergoes annual rebalancing, adjusting the asset mix to achieve the composition target.

2.1 Asset

The asset portfolio consists of bonds, equities, and cash. Each asset class is simulated over time to capture price dynamics while maintaining a conservative risk profile.

Bonds: The bond portfolio consists of a single zero-coupon bond with a maturity of 10 years. It provides stability and reduces risk, making it the core component of the asset portfolio.
Equities make up a smaller portion of the portfolio. Stocks are also modeled stochastically, with their prices evolving based on market volatility and other financial factors. Although equities offer higher return potential, they entail greater risk, leading to a conservative allocation aligned with regulatory requirements to mitigate insurer exposure.
Cash provides liquidity and ensures that the insurer has the necessary funds available to meet immediate liabilities.
Overall, the asset portfolio is carefully balanced between bonds, equities, and cash to manage risk while aiming for the target return, all within the constraints of regulatory requirements and the company's risk appetite.

2.2 Liability

Liabilities encompass life insurance policies with diverse characteristics.
Model points are a common actuarial technique used to simplify the analysis of large insurance portfolios. Instead of evaluating each policy individually, similar contracts are grouped together based on key characteristics, allowing for efficient calculations while maintaining representativeness. In our case, a model point is constructed to represent a group of policyholders with homogeneous attributes. All individuals share the same life insurance contract, with variations only in the guaranteed return rate. Policyholders are categorized into age bands, each associated with an appropriate **mortality rate**. A uniform gender assumption is adopted to ensure model consistency.
Another crucial factor is the possibility of policy **abandonment**, which historically depends on the external interest rate that a benchmark offers. If external rate offer better returns, policyholders may abandon their policies, increasing the risk for the insurer.
The model also considers the probability of **new policies**, which can affect the liability portfolio. The sale of new policies depends on market conditions, marketing strategies, and the competitiveness of the insurance product.
Finally, the **interest rate model** is used to discount future liabilities to their present value. Since liabilities are long-term obligations, changes in interest rates can significantly affect their present value, making interest rate risk a key consideration in managing the portfolio.
In short, the liability portfolio is modeled with dynamic factors such as mortality, abandonment, new policies, and interest rates, all interconnected to ensure the insurer can adequately plan for future obligations.

2.3 Portfolio Rebalancing

The portfolio rebalancing strategy is crucial for maintaining the balance between assets and liabilities over time. It is carried out annually and aims to ensure that the proportion of bonds and stocks within the portfolio remains aligned with the target allocation. This strategy is particularly important because, over time, market fluctuations can cause the value of different assets to change, leading to an imbalance in the portfolio.

By rebalancing annually, we ensure that the portfolio's risk and return characteristics stay in line with the original investment goals. The process involves adjusting the proportions of stocks and bonds by buying or selling assets based on their market value.

3 Stochastic Market Dynamics

In this section, we aim to simulate the evolution of both stock prices and zero-coupon bonds (ZCB) under stochastic models. The code provided illustrates two key financial simulations: the evolution of a stock price using the Black-Scholes (B&S) model, and the simulation of interest rates using the Vasicek model. Finally, we calculate the price of a ZCB based on the simulated interest rates. Below is a detailed explanation of the code for points 2 and 3.

3.1 Stock Price Simulation Using the Black-Scholes Model

The Black-Scholes model is widely used in financial theory to describe the price evolution of a stock over time under the assumption of continuous trading. This model is grounded in stochastic differential equations, specifically:

$$dS_t = \mu S_t \, dt + \sigma S_t \, dW_t$$

where:

- S_t is the price of the stock at time t,
- μ is the expected return (drift) of the stock,
- σ is the volatility of the stock,
- dW_t is the increment of a Wiener process (standard Brownian motion).

In the code, the stock price simulation is carried out by discretizing the equation over M time steps (monthly intervals). The process is simulated using the Euler-Maruyama method, which is an approximation technique for stochastic differential equations. The stock price at each time step is calculated as:

$$S_{t+1} = S_t \exp\left(\left(\mu - 0.5\sigma^2\right) \, dt + \sigma\sqrt{dt} \, Z_t\right)$$

where Z_t is a random normal variable with zero mean and unit variance, representing the stochastic part of the process. The dW variable in the code corresponds to this term, and the stock price is updated iteratively.

The parameters used in the simulation are:

- Initial stock price $S_0 = 100$,
- Expected return $\mu = 0.07$,
- Volatility $\sigma = 0.2$.

This setup allows us to observe the evolution of the stock price over time, considering both the deterministic trend (expected return) and the randomness (volatility) inherent in stock prices.

3.2 Simulation of Interest Rates Using the Vasicek Model

The Vasicek model is used to describe the evolution of interest rates, especially in the context of mean-reverting processes. The model is given by the following stochastic differential equation:

$$dr_t = \kappa(\theta - r_t)\,dt + \sigma_r\,dW_t$$

where:

- r_t is the short-term interest rate at time t,
- κ is the speed of mean reversion,
- θ is the long-term mean (the equilibrium level the rate tends toward),
- σ_r is the volatility of the interest rate,
- dW_t is the increment of a Wiener process.

The Vasicek model captures the tendency of interest rates to revert to a long-term mean over time. In the code, the interest rate simulation is discretized similarly to the Black-Scholes model. The interest rate at each time step is updated as:

$$r_{t+1} = r_t + \kappa(\theta - r_t)\,dt + \sigma_r\sqrt{dt}\,Z_t$$

where Z_t is again a random normal variable. The parameters chosen for the simulation are:

- Initial interest rate $r_0 = 0.02$,
- Mean reversion speed $\kappa = 0.1$,
- Long-term mean $\theta = 0.03$,
- Volatility $\sigma_r = 0.01$.

By using this model, we simulate the path of interest rates over time and observe their mean-reverting nature. This is crucial for pricing interest rate derivatives or modeling the behavior of bonds.

3.3 Evolution of Zero-Coupon Bond (ZCB) Price

Once the interest rates are simulated, we can use them to price a zero-coupon bond (ZCB). A ZCB pays a fixed amount at maturity, and its price is the present value of this payout discounted by the interest rates over time. The price of a ZCB at time t with maturity T is given by:

$$ZCB_t = \exp\left(-r_t \cdot (T - t)\right)$$

In the code, the ZCB price is calculated iteratively for each time step based on the simulated interest rates. The bond price decreases as the interest rate increases because higher interest rates reduce the present value of future payments. The ZCB price is plotted over time to visualize this evolution, taking into account the stochastic nature of the interest rates.

The results of the simulated evolution of stock prices, interest rates, and zero-coupon bond (ZCB) prices are illustrated in Figure 2, which consists of three subplots corresponding to each financial process under consideration.

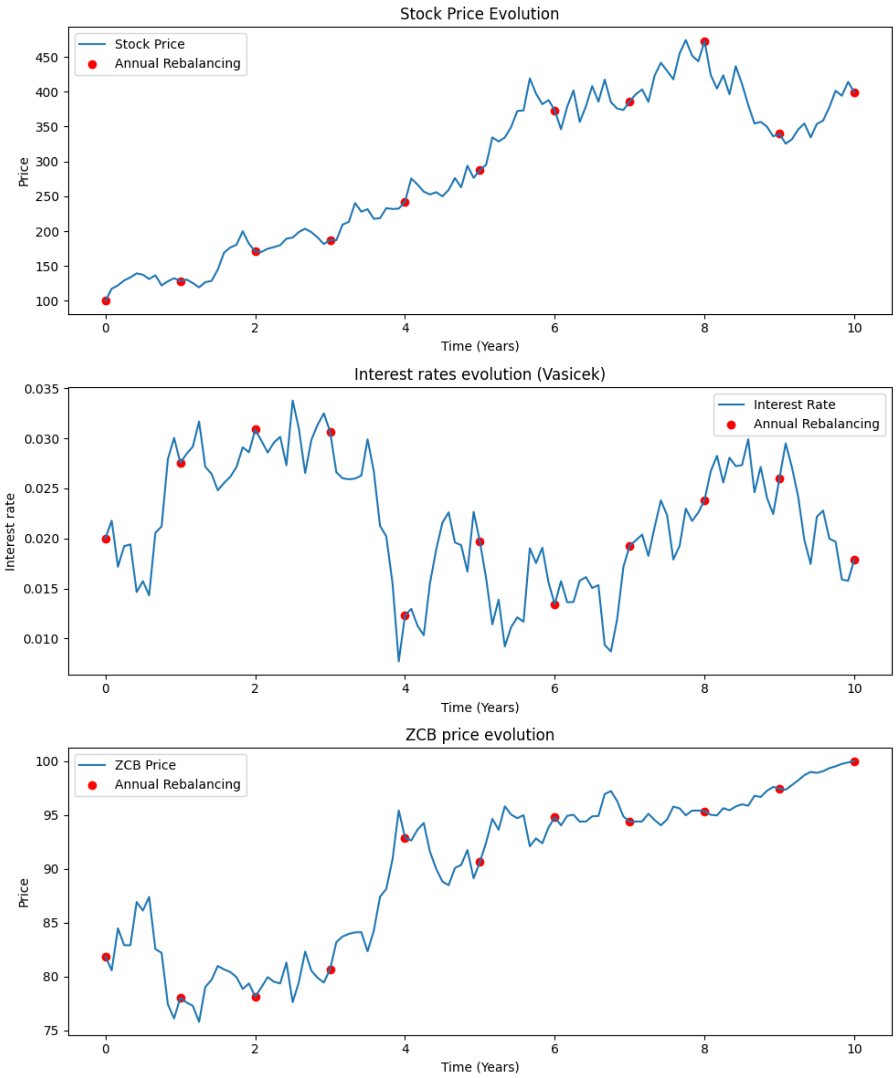

Figure 2: Simulated evolution of stock prices, interest rates, and zero-coupon bond prices.

The red markers represent annual rebalancing points, which are particularly relevant for portfolio management strategies that involve periodic adjustments. These points allow for an evaluation of stock performance at discrete intervals, confirming that despite local fluctuations, the overall trend remains positive.

4 Model Points and Policy Evolution Dynamics

The insurance sector is characterized by significant complexity, driven by the dynamics that govern the evolution of insurance policies over time. Life insurance, in particular, is subject to various factors that influence the number of active policies, the generation of new contracts, and the management of liquidity required to meet surrender, mortality, and claims obligations. This section focuses on the analysis of "model points," a fundamental concept used to simulate the evolution of insurance policies over time, divided by age and returns. Additionally, we will explore the dynamics of lapses (policy surrender) and their impact, as well as the introduction of new contracts and their effects on policy growth and liquidity requirements.

4.1 Model Points

Model points refer to the essential elements used in actuarial modeling to represent individual insurance contracts. Each policy is represented by one or more points, each corresponding to a contract with specific attributes such as the policyholder's age and the contract's value. These model points are categorized by age to reflect different mortality rates and by return to account for the investment performance linked to the policy. The analysis of these points allows for a more precise simulation of the policy evolution, incorporating factors such as lapse rates, mortality rates, and the subscription of new policies.

4.2 Policy Evolution

The management of insurance policies is influenced by three key factors: lapses, mortality, and new business. These elements dictate the evolution of policies over time and the liquidity required to handle claims associated with surrender, death, and new subscriptions.

4.2.1 Lapse (Policy Surrender)

The term *lapse* refers to the discontinuation of an insurance policy before its scheduled expiration date. This event typically occurs when the policyholder decides to terminate the contract, often as a result of various factors, such as unsatisfactory investment returns, changing financial circumstances, or a reassessment of personal needs. A lapse can significantly affect the financial stability of an insurance company, as it leads to a reduction in the active policy base, potentially influencing cash flows and the overall risk profile.

In the context of the model, the lapse rate is not treated as a fixed probability but as a dynamic variable that evolves over time, depending on the financial performance of the policy. Specifically, the lapse rate is determined by the difference between the benchmark return and the internal return that the contract offers. In this case, the benchmark is represented by the trend of interest rates, as historically, higher interest rates have led to the emergence of more attractive risk-free products. On the other hand, the internal return is based on the policy's guaranteed rate.

When the difference between the benchmark return and the internal return widens, the likelihood of policyholders choosing to surrender their policies increases. This is because policyholders are more likely to find alternative investments with better returns if the internal return offered by their contract is not competitive enough. Consequently, a higher disparity in returns signals a greater risk of lapses, as policyholders seek to optimize their financial outcomes.
The lapse rate in the model is updated using the following formula:

$$\text{Lapse Rate} = \text{Base Lapse Rate} \times e^{5\times\Delta R_s}$$

where ΔR_s represents the difference between the benchmark return and the guaranteed rates. This formula incorporates an exponential function to capture the non-linear relationship between return discrepancies and the propensity to lapse.
By dynamically adjusting the lapse rate based on return differentials, the model provides a more realistic representation of policyholder behavior. This approach reflects the sensitivity of policyholders to changes in financial performance, making the lapse rate more responsive to external market conditions and internal policy dynamics.

4.2.2 Mortality

The mortality rate reflects the probability of death for an insured individual within a given year, and is derived from actuarial mortality tables, which provide age-specific death probabilities based on historical data. In general, the probability of death increases with age, meaning that older policyholders face a higher likelihood of mortality. Within the model, these age-adjusted mortality rates are used to simulate the reduction in the number of active policies due to the death of the insured. The mortality rates are applied progressively, with higher rates corresponding to older age groups, thus accurately reflecting the impact of aging on policyholder longevity and the subsequent reduction in the active policy count.

4.2.3 New Contracts

The subscription of new contracts plays a crucial role in the growth and composition of the policy portfolio. Each year, new policies are introduced, and the number of new contracts is determined by a probability that depends on the guaranteed interest rate and a base growth rate, which reflects the expected growth. If the guaranteed rate is higher, there is a greater likelihood of new contracts being subscribed, while lower guaranteed rates reduce this probability.

New policies are distributed across age groups based on weighted probabilities, with younger policyholders generally more inclined to take out new contracts due to their longer investment horizon. The allocation is designed to reflect the demographic profile of the target population.

To simulate the subscription of new contracts, the following formula is used:

$$\text{New Contracts} = \text{Binomial}(1000, \text{average subscription rate})$$

This approach captures the random nature of new business acquisition and adapts to factors such as the guaranteed rate and demographic trends. By incorporating age-specific probabilities, the model ensures that the evolution of the policy portfolio aligns with real-world patterns, improving the accuracy of growth forecasts and risk assessments.

4.3 Results

The results obtained from the analysis of the evolution of insurance policies over time and the related liquidity needs are illustrated in the tables below. The first table shows the evolution of the number of active policies, considering both surrenders (policy lapses) and new subscriptions, over a 10-year period. The second table illustrates the annual liquidity requirements needed to cover payments for lapses and mortality-related claims.

4.3.1 Evolution of Active Policies

Table 1 shows the evolution of the number of active policies across six different age groups over a 10-year period. The results indicate that, in general, the number of policies increases for most of the age groups during the first years, particularly for the younger age groups (0.00% - 30 years, 1.00% - 40 years, and 1.20% - 50 years). This increase in the number of active policies for the younger age groups suggests that new subscriptions have outweighed the effects of lapses and mortality during the initial years. Over the 10-year period, the younger age groups show a consistent increase in the number of policies, while the older groups show a steady decrease. This behavior can be attributed to a combination of mortality and lapse rates, which have a larger impact on the older age groups, leading to a decline in the number of policies as the time progresses. In contrast, the younger age groups, with lower mortality and lapse rates, see a steady growth in the number of active policies, likely due to the continuous addition of new policies.

Table 1: Policy evolution over time

Anno	0.00% - 30 anni	1.00% - 40 anni	1.20% - 50 anni	1.50% - 60 anni	1.70% - 70 anni	2.00% - 80 anni
0	100	80	60	40	20	10
1	100	85	62	40	19	7
2	101	88	62	42	19	8
3	96	89	60	42	19	7
4	101	85	63	38	17	6
5	109	84	68	40	14	7
6	115	87	67	41	16	8
7	122	87	65	38	19	10
8	122	90	63	40	19	8
9	122	92	61	39	19	11
10	121	95	62	40	19	9

Interestingly, the older age groups demonstrate a certain degree of resilience despite the higher mortality rates. This can be attributed to the higher guaranteed returns offered to these groups, which help offset the negative effects of mortality and lapses to some extent. While mortality rates in these groups are naturally higher, the attractive guaranteed returns may encourage policyholders to maintain their policies, resulting in a slower decline compared to what might otherwise be expected. Thus, while the number of policies in the older age groups still declines over time, the presence of higher guaranteed returns allows these groups to retain a relatively higher number of active policies than would be the case if they had lower guarantees. This dynamic illustrates how the combination of product design (in terms of guaranteed returns) and the inherent demographic risks of aging can influence policy retention, even in the face of higher mortality.

4.3.2 Annual Liquidity Requirements

Tabel 2 provides an overview of the annual liquidity required to cover payments for lapses and mortality claims. The liquidity requirements exhibit significant fluctuations over the 10-year period, with peaks occurring in certain years. These peaks correspond to years with higher-than-usual claims due to an increase in lapses and mortality rates. On the other hand, in years with lower claims, the liquidity needs decrease.

The liquidity requirement for each year is calculated based on the total expected claims for lapses and mortality within that specific year. As the number of active policies decreases over time, the overall liquidity required to meet obligations also decreases, though this reduction is not linear due to the variability in lapse and mortality rates.

Overall, the analysis of liquidity requirements highlights the financial challenges faced by insurers in managing the costs associated with policy lapses and mortality over time. These costs must be carefully projected and managed to ensure that the insurer maintains sufficient liquidity to meet its obligations while sustaining profitable growth.

Year	Annual Cashflow
1	15000
2	13000
3	17000
4	17000
5	10000
6	10000
7	12000
8	17000
9	17000
10	16000

Table 2: Annual Cashflow

5 Rebalancing

Rebalancing a portfolio is the process of adjusting its composition to maintain a predefined asset allocation or risk profile. Over time, due to market fluctuations, asset performance, or external cash flows, the portfolio's structure may deviate from its original allocation. Such drifts can expose the portfolio to unintended risks or alter its expected return characteristics. To ensure consistency with the investment strategy, periodic rebalancing is necessary to realign asset weights with their target proportions.

5.1 Market Value of the Portfolio

To formalize this process, let us introduce the market value of the portfolio at time step K:

$$VM_K^P = VM_K^B + VM_K^S + C_K$$

where:

- VM_K^B represents the market value of bonds held in the portfolio,
- VM_K^S denotes the market value of stocks,
- C_K is the amount of cash available.

The total portfolio value VM_K^P is therefore the sum of these three components.

5.2 Rebalancing Conditions

At each time step K, the allocation of assets must be checked against predefined limits. If any asset class deviates significantly from its target proportion, rebalancing actions—such as buying or selling securities—must be undertaken to restore the intended allocation.

The portfolio begins with a total value of 10 million. The initial allocation is structured as follows:

- **Stocks**: Limited to a maximum of 20% of the total portfolio value.
- **Bonds**: Constituting up to 70% of the portfolio.
- **Cash**: The remaining 10% of the portfolio, held as liquid assets.

By maintaining these allocation constraints, the portfolio can balance risk and return while ensuring liquidity. The rebalancing mechanism ensures that market fluctuations do not lead to excessive exposure in any single asset class, preserving the portfolio's intended financial objectives.

5.3 Main Scenarios

Let x_S, x_B, and x_C represent the target proportions of stocks, bonds, and cash, respectively, in the portfolio. The portfolio must be regularly adjusted to maintain these allocations. Over time, due to market movements, the actual values of these asset classes may drift away from their target proportions, requiring corrective actions.

In our code, we account for deviations from the target allocation and adjust the portfolio's quantities based on specific inequalities. The rebalancing conditions ensure that the portfolio remains within its predefined limits by adjusting the quantities of stocks, bonds, and cash accordingly.

5.3.1 Rebalancing Stocks

If the market value of stocks exceeds the target allocation, stocks are overweight in the portfolio, and some must be sold. This occurs when:

$$VM_K^S \geq x_S VM_K^P$$

To rebalance, we determine the excess value of stocks:

$$\Delta^S = VM_K^S - x_S VM_K^P$$

The Plus-Minus Value of stocks is given by:

$$PMV_K^S = \Delta^S - VC_K^S \frac{\Delta^S}{VM_K^S}$$

where VC_K^S represents the account value associated with stocks and it is defined as:

$$VC_K^S = VC_{K-1}^S \left(1 - \frac{\Delta^S}{VM_K^S}\right)$$

Finally, the new market value of stocks after rebalancing is set to the target allocation:

$$VM_K^S = x_S VM_K^P$$

Conversely, if the market value of stocks falls below the target allocation, the portfolio is underweight in stocks, and additional stocks must be purchased:

$$VM_K^S \leq x_S VM_K^P$$

In this case, we have:

$$\Delta^S = x_S VM_K^P - VM_K^S$$

The new values after purchase become:

$$VC_K^S = VC_{K-1}^S + \Delta^S$$

$$VM_K^S = x_S VM_K^P$$

5.3.2 Rebalancing Bonds

A similar process is followed for bonds. If the bond holdings exceed the target allocation, meaning bonds are overweight in the portfolio, we must sell some bonds:

$$VM_K^B \geq x_B VM_K^P$$

The difference is:

$$\Delta^B = VM_K^B - x_B VM_K^P$$

The Plus-Minus Value of bonds is given by:

$$PMV_K^B = \Delta^B - VC_K^B \frac{\Delta^B}{VM_K^B}$$

In the case of bonds, the excess amount is sold and set aside in the Capitalization Reserve.

$$CR_K = max(0, CR_{K-1} + PMV_K^B)$$

The updated values after rebalancing are:

$$VC_K^B = VC_{K-1}^B \left(1 - \frac{\Delta^B}{VM^B}\right)$$

$$VM_K^B = x_B VM_K^P$$

Conversely, if the bond holdings are below the target, more bonds must be purchased:

$$VM_K^B \leq x_B VM_K^P$$

and the required bond purchase is:

$$\Delta^B = x_B VM_K^P - VM_K^B$$

The updated values after rebalancing are:

$$VC_K^B = VC_{K-1}^B + \Delta^B$$

$$VM_K^B = x_B VM_K^P$$

5.3.3 Financial Income Calculation

The financial income is computed as the sum of the plus-minus value of stocks and the capitalization reserve adjustment, which considers the previous reserve level and the plus-minus value of bonds. Specifically, the capitalization reserve adjustment is only included when the total reserve is non-positive, ensuring a conservative estimation of financial income:

$$\mathrm{RF}_K = \mathrm{PMV}_K^S + (\mathrm{CR}_{K-1} + \mathrm{PMV}_K^B) \cdot \mathbb{1}_{\mathrm{CR}_{K-1} + \mathrm{PMV}_K^B \leq 0}$$

To obtain the **adjusted financial income**, we subtract the annual cash flows from the financial income. These cash flows, detailed in Table 2, represent the total amount required each year to cover policyholder benefits, including lapse and death payments:

$$\text{Adjusted } \mathrm{RF}_K = \mathrm{RF}_K - \mathrm{L}_K - \mathrm{D}_K$$

This adjustment reflects the actual available financial resources after accounting for contractual liabilities.

As we can see in Figure 4, which we will analyze in detail in the next paragraph, the Adjusted Financial Income can take negative values in certain periods. This means that, during those times, the financial flows generated by the assets alone are not sufficient to cover policy lapses and death-related claims. As a result, we would need to cover these shortfalls by using additional liquidity, ensuring that all obligations are met despite the temporary deficit.

5.4 Results and conclusions

Tables 3, 4, and 5 offer a comprehensive numerical representation of the portfolio's financial evolution, detailing stock and bond transactions, account values, and financial income adjustments. Table 3 focuses on stock-related data, outlining yearly market values, target allocations, and buy/sell operations, which illustrate the impact of rebalancing decisions on equity investments. Table 4 mirrors this analysis for bonds, showing the portfolio's bond transactions and their effect on the account value over time. Finally, Table 5 consolidates key financial metrics such as PMV, capitalization reserves, and adjusted financial income, offering insights into the financial performance of the strategy.

The graphical analysis presented in Figures 3 and 4 highlights the dynamic evolution of the portfolio throughout the 10-year simulation. Figure 3 illustrates the portfolio's overall market value trajectory, reflecting the impact of periodic rebalancing decisions on asset allocation. The portfolio undergoes fluctuations due to market conditions, with stocks and bonds being actively adjusted to maintain target proportions. Figure 4 provides a detailed breakdown of key financial indicators, including the Plus-Minus Value (PMV) of stocks and bonds, the Capitalization Reserve, and Adjusted Financial Income. The observed trends confirm that rebalancing actions help stabilize financial income while mitigating excessive market volatility. Despite short-term fluctuations, the adjusted financial income remains in alignment with the broader asset-liability management strategy.

Overall, the results demonstrate the effectiveness of the stochastic asset and liability management framework in optimizing financial stability while ensuring long-term solvency. The implemented rebalancing strategy successfully maintains risk control and enhances portfolio resilience in response to evolving market conditions.

Year	Market Value Stocks	Target Value Stocks	Delta Stocks	Operation Stocks	Account Value Stocks
0	2000000.00				
1	2047448.31	2047448.31	300622.11	Sell Stocks	1743941.14
2	2128816.51	2128816.51	3110.39	Sell Stocks	1741396.81
3	2113141.68	2113141.68	139614.65	Sell Stocks	1633473.68
4	2116127.47	2116127.47	68468.39	Sell Stocks	1582278.26
5	2194152.89	2194152.89	12212.92	Sell Stocks	1573519.86
6	2154522.64	2154522.64	8543.82	Sell Stocks	1567304.66
7	2142473.86	2142473.86	82337.64	Buy Stocks	1649642.31
8	2062120.36	2062120.36	165899.56	Sell Stocks	1526809.05
9	2005901.17	2005901.17	162923.76	Buy Stocks	1689732.81
10	1943006.66	1943006.66	159207.31	Sell Stocks	1561764.01

Table 3: Stock-Related Financial Data

Year	Market Value Bonds	Target Value Bonds	Delta Bonds	Operation Bonds	Account Value Bonds
0	7000000.00				
1	7166069.09	7166069.09	276897.96	Buy Bonds	7276897.96
2	7450857.77	7450857.77	61297.86	Sell Bonds	7217519.76
3	7395995.89	7395995.89	83043.80	Buy Bonds	7300563.56
4	7406446.13	7406446.13	10404.66	Buy Bonds	7310968.22
5	7679535.10	7679535.10	84863.52	Sell Bonds	7231060.61
6	7540829.25	7540829.25	68717.50	Sell Bonds	7165761.01
7	7498658.51	7498658.51	153574.57	Sell Bonds	7021949.56
8	7217421.25	7217421.25	134839.39	Buy Bonds	7156788.95
9	7020654.11	7020654.11	165874.35	Sell Bonds	6991601.03
10	6800523.30	6800523.30	187703.98	Buy Bonds	7179305.00

Table 4: Bond-Related Financial Data

Year	Plus-Minus Value Stocks	Plus-Minus Value Bonds	Capitalization Reserve	Financial Income	Adjusted Financial Income
0					
1	44563.26	0	0	44563.26	29563.26
2	566.06	1919.66	1919.66	566.06	-12433.94
3	31691.52	0	1919.66	31691.52	14691.52
4	17272.97	0	1919.66	17272.97	272.97
5	3454.52	4955.92	6875.58	3454.52	-6545.48
6	2328.63	3417.89	10293.47	2328.63	-7671.37
7	0	9763.13	20056.60	0.00	-12000.00
8	43066.31	0	20056.60	43066.31	26066.31
9	0	686.43	20743.03	0.00	-17000.00
10	31238.50	0	20743.03	31238.50	15238.50

Table 5: Additional Financial Data

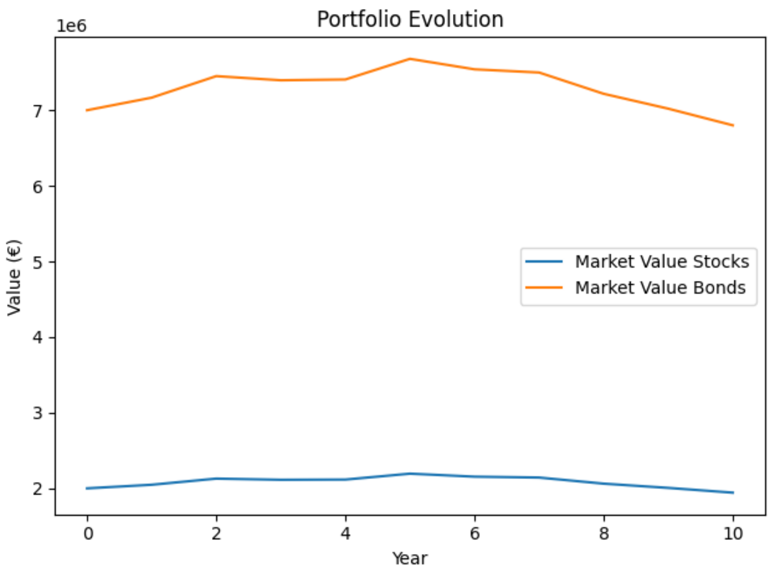

Figure 3: Portfolio Evolution

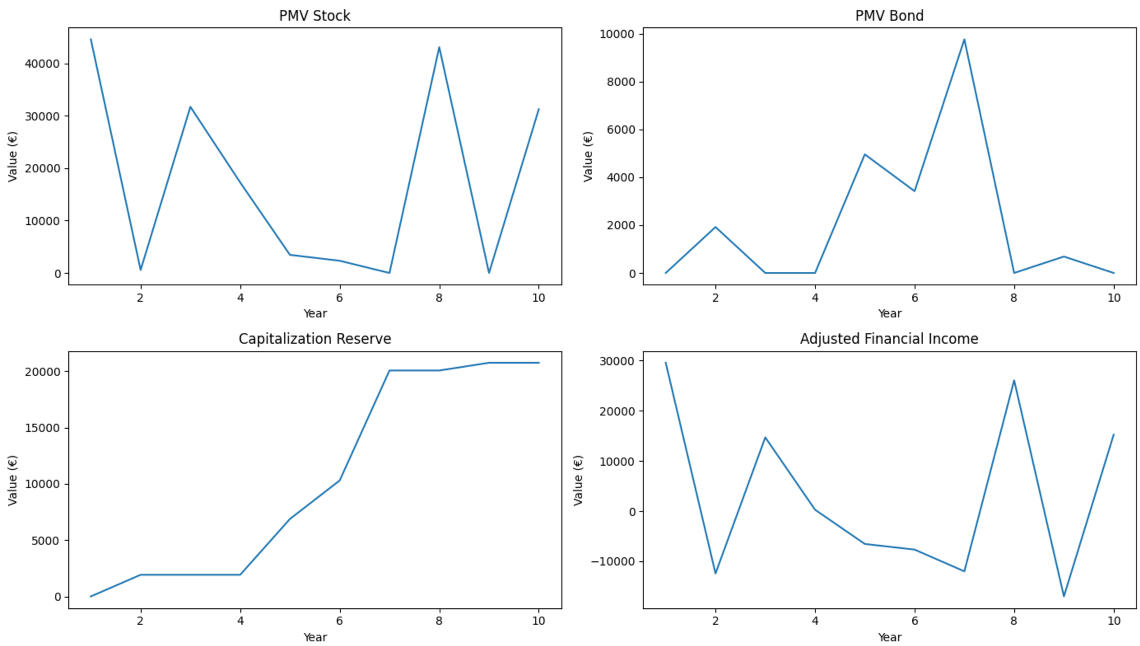

Figure 4: Evolution of PMV Stock, PMV Bond, Capitalization Reserve, Adjusted Financial Income