Lisbon School of Economics & Management
Universidade de Lisboa

MASTER OF SCIENCE IN
FINANCE

MASTERS FINAL WORK
PROJECT

INVESTMENT POLICY STATEMENT FOR INSTITUTIONAL INVESTORS:

LUSITANIA, COMPANHIA DE SEGUROS, S.A.

PORTFOLIO OF PENSIONS WITH COMPENSATIONS

DIOGO RODRIGUES CORDEIRO

JUNE 2023

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SUPERVISORS:

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Abstract

This Investment Policy Statement (IPS) has been designed to fit the liabilities profile of a portfolio of pensions with compensations at Lusitania Companhia de Seguros, S.A. The client wants to ensure security, quality, returns, and liquidity, incorporating environmental, social and governance principles in the investment portfolio.

To compute the optimisation portfolio's expected returns and volatility, we use three main strategies, the Mean-Variance Theory to optimise our investment and Duration Matching for immunisation. The Cash-Flow Matching should also be applied to construct the immunisation portfolio reinforcing the immunisation of the portfolio.

The optimisation portfolio has an expected return of 4 percent and an expected volatility of 3,32 percent. The expected return and volatility were based on JP Morgan's long term capital market assumption for the different asset classes to which the portfolio is exposed. The major constraints include a minimum return of 2,5 percent, a maximum of 7,5 percent volatility, as well as a minimum of 10 and a maximum of 14 for Duration. Short sell is not allowed. Other constraints include minimum and maximum weights for different asset classes, countries, or credit quality exposures.

We have also performed a robustness analysis to better understand our exposures to the different credit qualities, geographies, and asset classes as well as deepest analysis of our returns, volatilities, and Return-at-Risk and Conditional Expected Shortfall at a certain confidence interval.

JEL classification:C6; G11

Keywords: Asset Management; Portfolio Theory; IPS; Institutional Investors

Resumo

Esta Política de Investimentos (IPS) foi desenhado para alinhar o perfil das responsabilidades de uma carteira de pensões com compensações associadas à Lusitania Companhia de Seguros, S.A. O cliente deseja garantir segurança, qualidade e retornos assim como liquidez, incorporando neste portfólio preocupações em matérias ambientais, sociais e de governação

Para calcular a expetativa de retorno e volatilidade do portfólio de otimização, vamos utilizar três estratégias fundamentais, a MVT para otimizar o investimento e o ajuste de *Duration* para imunizar o portfólio. Após esta avaliação deve ser aplicado um ajustamento dos Fluxos de Caixa para reforçar a imunização do portfólio de imunização.

O portfólio otimizado proposto tem uma expetativa de retorno de 4 porcento e uma expetativa de volatilidade de 3,32 porcento. A expetativa de retorno e volatilidade foram baseados nos pressupostos de mercado de capitais de longo prazo da JP Morgan para as diferentes classes de ativos a que o portfólio está exposto. As maiores restrições incluem o retorno mínimo de 2,5 porcento, um máximo de volatilidade de 7,5 porcento, um mínimo de 10 e um máximo de 14 para *Duration*. A venda a descoberto não é permitida. Outras restrições incluem um máximo e mínimo de pesos para as diferentes exposições a classes de ativos, países ou qualidade de crédito.

Foi também executada análises de robustez, para um maior entendimento das nossas exposições às diferentes qualidades de crédito, geografias e classes de ativos, mas também uma análise mais profunda aos retornos, volatilidades, assim como o *Return-at-Risk* e o *Conditional Expected Shortfall* a um determinado intervalo de confiança.

Classificação JEL: C6; G11

Palavras-Chave: Gestão de Activos; Teoria da Carteira; IPS; Investidores Institucionais

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1 Executive Summary

This IPS provides a formal and detailed description for Lusitania Companhia de Seguros, S.A.'s investment objectives, constraints, and risk tolerance. The IPS intend to ensure that Lusitania's investment decisions are in line with its mission following the prudent person principle.

For the portfolio we use three major strategies, the Modern Portfolio Theory, created by Markowitz in 1952 for optimisation purposes and Duration and Cash Flow Matching as immunisation strategies.

Subject to the constraints previously established, the portfolio has an expected return of 4 percent and an expected volatility of 3,32 percent

The IPS applies solely to assets held in Lusitania's general account that is dedicated to fund pension liabilities. Lusitania seeks to achieve its investment objectives by following a conservative investment approach that aims to generate a stable and sustainable return on investment that is consistent with the long-term pension liabilities and obligations to its clients.

2 Investment Policy Statement

2.1 Scope and Purpose

2.1.1 Investor

Lusitania is a Portuguese insurance company that was founded in 1986. Lusitania's mission is to “offer innovative products that fulfil the needs of its clients and partners”. Lusitania is part of Montepio Geral - Associação Mutualista and shares the same principles of adding value to its associates and policyholders.

2.1.2 Structure

The Board of Directors bears the responsibility of overseeing and providing strategic direction for the investment activities of Lusitania. The major responsibility is to ensure that the company's investment portfolio is managed in a manner that serves the best interests of the company’s clients and its stakeholders.
The Investment Committee should support the Board of Directors in developing and executing investment policies and strategies. The committee will be composed of a specified number of members, including individuals with relevant roles or qualifications in finance, investments, and risk management. Their expertise will ensure comprehensive decision-making.
The Chief Investment Officer (CIO) assumes the responsibility of implementing the Investment Policy Statement (IPS) and managing the day-to-day investment operations of Lusitania. The CIO holds the authority to lead the investment team, oversee investment managers, and provide regular reports on portfolio performance, market conditions, and investment strategy to both the Investment Committee and the Board of Directors.

The investment team should be composed of experts with a diverse range of knowledge in asset classes and investment strategies. Under the guidance of the Chief Investment Officer (CIO), this team will be responsible for conducting thorough research, performing due diligence, constructing portfolios, and continuously monitoring investment managers and strategies. Lusitania may require external investment managers to oversee specific portions of the investment portfolio. This

external investment managers shall be aligned with the capabilities required by Lusitania.

The Investment Committee, working in collaboration with the Risk Management Committee, should track investment-related risks and ensure compliance with the risk management framework outlined in the Investment Policy Statement (IPS). The CIO will provide regular risk reports to the Investment Committee and the Board of Directors, presenting key risk indicators and outlining mitigation measures.

To address risk management, Lusitania's Risk Management Department is responsible for identifying, assessing, and managing investment-related risks. This department will include members with expertise in risk management, compliance, and investment operations. They will collaborate closely with the Investment Committee and the CIO to establish risk management policies, monitor portfolio risk exposures, and implement risk mitigation strategies.

The Chief Financial Officer is responsible for establishing a mandate for asset management for every firm hired to offer investment services. Additionally, each firm must confirm in writing that they have received the document and accepted its content.

2.2 Governance

The investment should be made considering adequate levels of diversification and risk, which is why the risks arising from the assets should be measurable and monitored. Both intrinsic and market risks should be considered. The risk level should be adequate for the company's responsibility profile.

In a company, several departments are responsible for different parts of the process. This process includes the treatment, analysis, and collection of data as well as the strategic decisions for the IPS.

The IPS and the investment strategy should both receive approval from the Board of Directors. Additionally, it should manage the company's investments while always keeping in mind the risk tolerance and limitations that the company is ready to accept. They are also in charge of making decisions on deviations from risk tolerance standards and approving the responses to those deviations.

The Investment Committee is responsible for overseeing the investment policy, strategy, and execution. It monitors investment performance relative to benchmarks

and asset allocation while considering established constraints and risk tolerance. The committee analyses investment returns and suggests actions to mitigate potential deviations from established tolerance levels. The Chief Investment Officer shall be entrusted with selecting, monitoring, and terminating any investment management firms employed to handle selected assets.

The Investments Department is responsible for developing and articulating procedures to suggest revisions to the IPS by reviewing and monitoring it. It executes the investment strategy, optimizes the investment profile, and defines fund and asset allocation based on established tolerance limits. The department manages investment risk and suggests new methods and procedures to measure risk and return. It reports to the Investment Committee and Board of Directors on the performance and expectations of financial markets, investment allocation, and return. Finally, it ensures the investment has sufficient liquidity and suggests methods to minimize management costs.

The Risk Management Department oversees the development and articulation of all the procedures to evaluate investment risks. The department should suggest methods and procedures for risk measurement and capital requirements, monitor them, and report them to the board. Finally, it should collaborate on analysing and identifying mitigation measures of possible corrections regarding the tolerance level.

The Financial Department is responsible for accurately valuing financial assets and ensuring proper accounting of financial asset operations. It also oversees the preparation of external reports related to the investment.

2.3 Investment, Return and Risk Objectives

2.3.1 Investment Objective

This IPS is developed in line with Article 132º Solvency II Directive relative to the Prudent person principle. We are building two different portfolios, the optimisation portfolio, and the immunisation portfolio.

The optimisation portfolio aims to fund liabilities arising from Annuities stemming from non-life insurance contracts, such as non-redeemable annuities; workers' accident fund; lifetime assistance; Incurred But Not Reported (IBNR) serious accidents (similar to the life technique) not necessarily redeemable; Mandatory redeemable; Incurred

But Not Reported (IBNR) serious accidents (similar to the life technique) mandatory redeemable. The Cash flow and Duration matching are important to define the behaviour and potential costs.

After this analysis, the major goal is to define a “return-seeking” portfolio, for a predetermined level of risk. For that, we use the returns and volatility from JPMorgan market assumptions to have a central asset allocation. This is important to build, separately, the process in which we define the proper allocation of the assets. Thus, it is crucial to find an equilibrium between the mismatch of assets and liabilities, the duration and originating a return above the risk-free, always according to the level of risk predefined.

Given the substantial costs associated with Cash-flow matching, it becomes crucial to construct an optimised portfolio that can financially support the development of this immunisation portfolio. Consequently, this Investment Policy Statement (IPS) aims to establish the optimised portfolio, enabling a separate process to build the portfolio aligning assets with liabilities.

2.3.2 Return and risk requirements

We are targeting a minimum return of 2.5 percent, while ensuring the volatility does not exceed 7.5 percent. This approach allows us to achieve a portfolio with favourable returns while managing risk.

2.3.3 Risk tolerance

The IPS acknowledges that the portfolio may encounter various risks, including liquidity, legal, political, regulatory, longevity, mortality, business, and health risks. It recognizes that investment returns can fluctuate both positively and negatively over time. By establishing an acceptable level of risk, with a target volatility of 7.5 percent, the IPS aligns with investors' risk tolerance and investment objectives, highlighting a more conservative approach to minimize potential losses.

The IPS considers the client’s time horizon, in this case, extends over 81 years, which could suggest a willingness to accept greater volatility and potentially pursue higher returns, given the objective of the portfolio is to match liabilities. However, we conclude that the client has a relatively low-risk tolerance. Diversification becomes crucial in

managing the associated risks. By investing across different asset classes and sectors, the IPS aims to minimize risks and enhance risk-adjusted returns.

As an insurance company, Lusitania possesses expertise in economics and finance, demonstrating an adequate understanding of the uncertainty surrounding future investment returns. Considering these factors, along with the lower volatility target and the objective of matching liabilities, it can be classified as risk averse.

By incorporating these risk considerations, aligning with the client's time horizon, and emphasizing the importance of diversification, the IPS aims to prudently manage risk while pursuing the investment objectives of the insurance company. Information regarding the IPS is summarised in Table A3.

Cash flow immunisation aims to ensure that the cash flows produced by the investment portfolio correspond to the timing and size of future liabilities. This is accomplished by choosing the proper assets and modifying the portfolio's duration and cash flow characteristics of the portfolio.

The cost of immunisation financing depends on several variables, including the magnitude of the liabilities, the market returns on investments, and the desired level of certainty or risk tolerance. A bigger amount of the portfolio may need to be allocated to low-risk assets if the investor wants to have more assurance that the liabilities will be met, even if this could potentially mean lower returns.

2.3.4 Relevant constraints

Some constraints are considered when the optimised portfolio is created, as we can observe in Table 1. Firstly, by considering liabilities' average duration is approximately 12, we have defined a duration range of 10 to 14.

Having in mind that the investor needs to have a portfolio that cannot be exposed to a high degree of risk, we decided to have a larger allocation in fixed income, since it gives more stable returns and, at the same time, is considered a low risk investment. We have also established a minimum of 45 percent of our investment in that asset class. For all investments, shortsell was not allowed.

For equities, the maximum weight that should be considered is 20 percent and for real estate, we have defined a maximum of 7,5 percent of our investment.

Asset Class	Minimum Weight	Maximum Weight
Fixed Income	45,00%	100,00%
Equity	0,00%	20,00%
Real Estate	0,00%	7,50%
Cash & Equivalents	0,00%	10,00%

Table 1 – Exposure Constraints *Source: Made by Original Author*

We have also established a minimum allocation of 80 percent of the fixed-income part to government bonds, as well as a maximum allocation of 20 percent for emerging markets. While this allocation has the potential for higher returns, we aim to avoid unnecessary risks.

Our investments are limited to assets within the eurozone, or investments hedged to the euro. For investments in countries outside the European Union, we have defined a maximum allocation of 30 percent. By having all indices from Eurozone or hedged to euro, we do not incur any currency risk.

2.3.5 Other considerations relevant to investment strategy

The Asset Liability Management (ALM) process, which includes Cash Flow Matching, is distinct from the IPS and serves the purpose of aligning assets with liabilities.

The liabilities are illustrated in Figure 1, where we can observe a gradual reduction in claims over 81 years. The highest claim value occurs in year 1, amounting to 17,625.082 €, while the lowest value is merely 7€ in year 81. The Net Present Value of the Future Claims totals 176,740,627.46 €.

By analysing our ALM, we can gain insights into managing investments more effectively. This includes identifying risks arising from interest rates and potential mismatches in duration and cash flows.

Additionally, it helps to assess liquidity concerns related to the responsibilities we have undertaken. The ALM analysis serves as a valuable tool for defining our investment management approach and ensuring alignment between assets and liabilities, ultimately supporting prudent decision-making and risk mitigation actions.

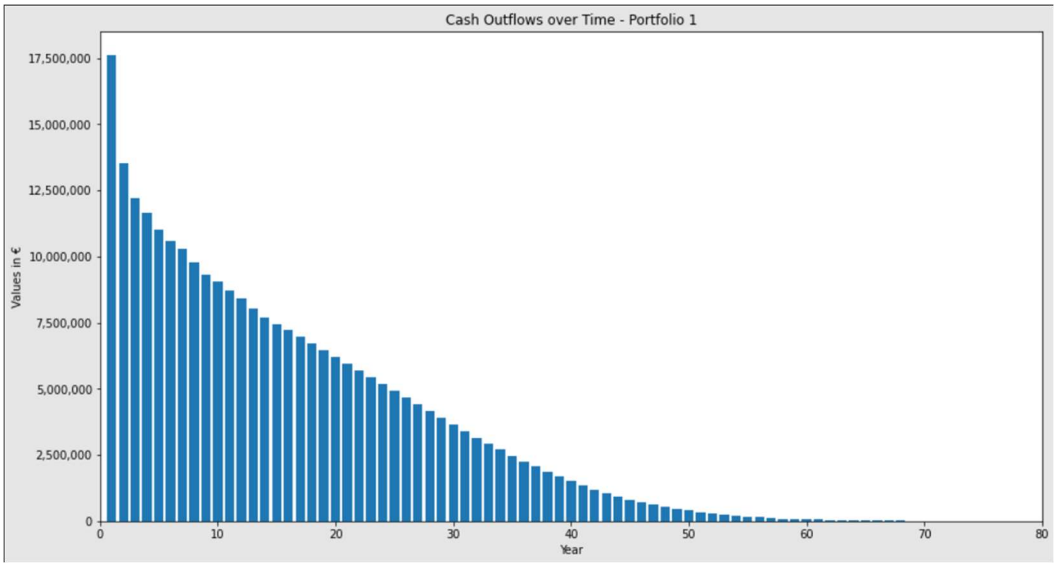


Figure 1 – Claims Cash Flow *Source: Made by Original Author*

2.4 Risk Management

To compute Returns we use the Internal Rate of Return. According to Hawanini Gabriel and Viallet (2010) "All that is needed to calculate the IRR of an investment is the sequence of cash flows the investment is expected to generate. In effect, an investment's IRR summarizes its expected cash-flow stream with a single rate of return. The rate is called internal because it considers only the expected cash flows related to the investment and does not depend on rates that can be earned on alternative investments".

The return should also be monitored through the time-weighted rate of returns. According to Maginn et al (2007), time-weighted rate of returns reflects the compound rate of increase of one unit of money that was initially invested in the account during a specified evaluation period. Every time an external cash flow occurs, the account must be valued as part of the calculation. If there are no such flows, then the TWR is easily calculated by applying Equation (1), which expresses the change in the account's value compared to its starting value. If there are external cash flows, then computing a series of subperiod returns is required under the TWR.

$$R_t = \frac{MV_1 - MV_0}{MV_0} \quad (1)$$

Equation (1) where R_t is the rate of return in period t, MV_1 is the Market Value at the end of the period and MV_0 the Market Value at the beginning of the period.

Performance should also be measured. We measure performance by comparing our performance against benchmarks for each asset class, which can be found in Table 2.

Asset Class	Benchmark
Fixed Income	Bloomberg Barclays EuroAgg Total Return Index Value Unhedged EUR
Equities	MSCI World EUR
Real Estate	APFIN Index
Cash	Annual Average Euribor 6M

Table 2- Benchmarks *Source: Made by Original Author*

In terms of measuring risk, the most common measure used is the standard deviation. In general, it is a useful measure of risk, but it is not the only one.

To better assess the risk to which we are exposed, we computed the Return-at-Risk and Conditional Return-At-Risk (also called Expected Shortfall). According to Joshi et al. (2013), Value at Risk is the most widely used method for managing trade risk in the financial sector and is well-liked by regulators for figuring out how much capital banks and insurance companies need to hold against certain risks. It can be interpreted as, how much could we lose with an X% probability in one day. If we were to turn this around, we would have 1-X% confidence that our daily losses would be kept within this range. Because we do not define a proper value that we will invest we should state our results, not Value-At-Risk, since it is not in value, but Return-at-Risk. According to the referred authors, Expected Shortfall considers the anticipated losses in the case that the VAR level is exceeded rather than just focusing on the percentile loss level.

It is important to review the liabilities monthly and regularly monitor cash flow matching. Additionally, at the end of each month, the Investment Committee should have a meeting to refresh their understanding of the market landscape. This update should encompass inflation trends, global macro indicators from pertinent markets, major indices, yields of relevant countries, and the progression of credit quality investment. Furthermore, it is advisable to track Return-at-Risk and Conditional Expected Shortfall on a weekly basis.

3 Investment Design

3.1 Investment Philosophy

The recommended portfolios are based on immunisation and optimisation strategies. The immunisation strategy is done to ensure that the portfolio has cashflows that can match the liabilities the company have in the future as well as a match in terms of duration. The optimisation strategy is carried out to achieve the required return on the investment, always having in mind the restrictions arising from the immunisation strategy. Table A4 provides a summarized overview of both portfolios.

The following investment follows an Asset Liabilities Matching (ALM) Strategy. According to Luckner et. al (2003), it is the ongoing process of developing, putting into practice, reviewing, and updating asset and liability management strategies to meet an organization's financial goals while taking into account its risk tolerance and other constraints.

In the insurance industry, where companies have to make long-term commitments to policyholders, matching the assets with liabilities is vital since these companies need to be able to meet those commitments, even if market conditions change.

According to Grundl et al. (2016), the Cash-flow matching aligns cash flows from assets with the maturities of each position in the liabilities portfolio. It seeks to eliminate the consequences of fluctuations in interest rates. Cash Flow matching has its flaws, the first one that should be considered is that when the timing and amount of claims are uncertain, cash flow matching may not be precise. Another point that should be considered when applying this method is that it can be costly since this strategy requires selecting types of assets in which to invest for their cash flow needs.

The same authors refer that the Duration matching balance between the duration of an insurer's assets and the duration of its liabilities. The main goal of this strategy is to immunise the firm’s value against interest rate changes. It only works accurately if cash flows are known with a high degree of certainty. Another limitation of this strategy is that the portfolio will need to be re-immunised frequently when interest rate changes occur.

This investment also follows an optimisation strategy, using the Mean-Variance Theory (MVT). It was developed by Markowitz (1952) and is now widely used in modern portfolio theory.

According to Weigand (2014), MVT assumes that typically, investors exhibit a risk-averse behaviour, making portfolio decisions primarily based on the trade-off between risk and expected return. They assess risk by measuring the variance (or standard deviation) of expected returns., thus by combining assets with different expected returns and volatilities, investors can build portfolios that fulfil their expected goals. According to Michaud (2008), the MVT most traditional criticisms of this strategy are the assumption of normal distributions, the limitations regarding the representation of the investor, a single-period framework for investors with long-term investments and the challenges arising from the accuracy of estimation of expected returns and variances, that can make the optimal portfolio not well defined.

The investment strategy has a major allocation on fixed-income assets, as they provide a reliable source of income through both capital and coupon payments. Fixed-income assets are the most popular asset among insurers, as they tend to invest a significant portion of their assets in fixed-income securities. According to Autoridade de Supervisão de Seguros e Fundos de Pensões (2022), 74,7 percent of the overall investments from insurance companies are held in fixed-income assets. Nevertheless, investments in Real Estate and Equities will also be considered, as well as a percentage for cash and equivalents so that we can fulfil eventual liquidity issues.

We will use two main categories for fixed-income assets: Sovereign Bonds and Corporate Bonds.

According to the Corporate Financial Institute, sovereign bonds are issued by governments or supranational institutions. Sovereign bonds serve to finance spending programs, cover interest payments, or repay existing debts. As other bond types, a sovereign bond guarantees regular interest payments to the investor and repayment of the principal amount upon maturity. The creditworthiness of a sovereign bond is typically linked to its rating, reflecting the perceived ability of the issuing government to fulfil its financial obligations.

This IPS focuses the investment on sovereign bonds in countries from Eurozone or government bonds hedged to Euro since Lusitania is a Portuguese company and does

not want to be exposed to currency risks. This type of fixed-income asset is considered very conservative but not entirely risk-free. The major risk arising from these investments is the risk of default.

The risk arising from interest rates should also be considered. There is a negative relation between the price of a bond and interest rates, making this risk extremely important to understand. The price of any bond is computed based on the present value of the cash flows (coupons and principal at maturity), so when interest rates increase, the discount rate used to compute the present value increases, leading to a price fall.

As a result, when interest rates hike investors demand a higher yield on bonds that are already in the market. Since yields are computed based on coupons and price, and most coupons are fixed, the price of the bond tends to decrease, otherwise, it would not be interesting for the investor to keep this asset. When interest rates decrease, the opposite happens. Prices increase since the returns of the newly issued bonds are lower, and investors demand a lower yield.

The second type of fixed-income asset used is corporate bonds. The main difference between sovereign bonds is the issuer. In the case of corporate bonds, the issuer is a company. According to Blackrock, it is perceived as riskier than government bonds, so yields are necessarily higher. Usually, yields are correlated with the credit quality rating given by agencies, like Standard&Poor's or Moody's, the higher the credit quality, the lower the spread paid by the company to investors, since it is perceived as more secure.

According to the National Association of Real Estate Investment Trusts (NAREIT) Real Estate Investment Trusts (REITs) are a good asset to diversify our portfolio, offering exposure to the real estate market with the benefits of diversity, liquidity, and potential capital appreciation. Geographic diversification can also help align the portfolio with investment goals and risk tolerance. However, REITs are not without risks, including changes in interest rates, property values, and tenant occupancy rates, as well as the quality of management and industry performance.

According to Blackrock, equities provide investors with partial ownership of a company, offering potential profits and assets. However, they also carry higher risks than fixed-income investments.

3.1.1 Macroeconomic Analysis

A macroeconomic analysis of the current environment revealed economies characterized by higher yields, which lead to lower valuations. This can potentially result in higher long-term returns. There is an expectation of higher inflation over the next two years and the possibility of a recession or a few quarters of below-average growth soon.

According to JP Morgan, it is anticipated that inflation will cool down in the coming years, following the increase in interest rates observed worldwide. In the United States, the Federal Reserve raised the Fed funds rate by 25 basis points to a range of 5%-5.25% during its May meeting. This marked the 10th rate increase, bringing borrowing costs to their highest since September 2007. Similarly, the European Central Bank raised its key interest rates by 25 basis points during its May meeting, although at a slower pace. As a result, borrowing costs have reached their highest level since July 2008.

Figure 2 illustrates the yields across the Eurozone, as of April 2023. According to JP Morgan (2023), the combination of factors such as scarcity of key goods, supply chain issues, and the conflict in Ukraine has put pressure on prices. This is due to a combination of fiscal policies implemented to stimulate economies in response to the pandemic crisis and the optimism generated by reopened societies, which has increased demand and strained the supply chain, thereby leading to inflationary pressures. Despite experiencing abnormal volatility in the previous quarter, bonds have shown some stability.

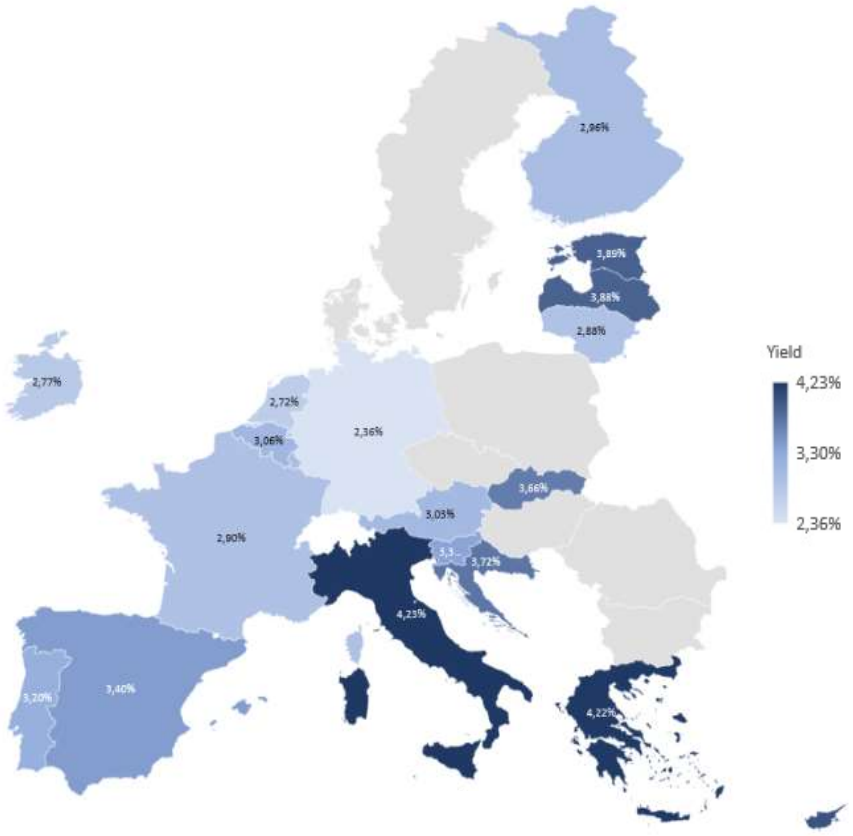


Figure 2 – Long Term Interest Rates *Source: European Central Bank*

The Bloomberg U.S. Aggregate Bond Index ended with positive returns over the last three and six months. In the first quarter, corporate investment-grade and high-yield credit produced the highest returns. Real return forecasts for sovereign bonds are currently positive, indicating that they offer good return projections and diversified portfolios. Following a sharp negative return in 2022, equity returns are projected to rebound, as illustrated in Figure 3.

Sources: Bloomberg indexes and J.P. Morgan EMBI Global Diversified Index, as of March 31, 2023.

Figure 3 – Fixed-Income Sector Returns and Yields

3.2 Immunisation Portfolio

Despite being a separate process from the optimisation portfolio, we construct an immunisation portfolio, which is the base to assess responsibilities regarding interest rates and liquidity. The immunisation portfolio aims to match cashflows and durations while accounting for potential reinvestment opportunities. In its construction, we incorporate the liability in year 40, along with the present value at year 40 of liabilities exceeding 40 years. Figure 4 shows the differences in Cash Flows (Cash Inflows represented by assets and responsibilities as liabilities), as well as the percentage of the investment that needs to be done each year.

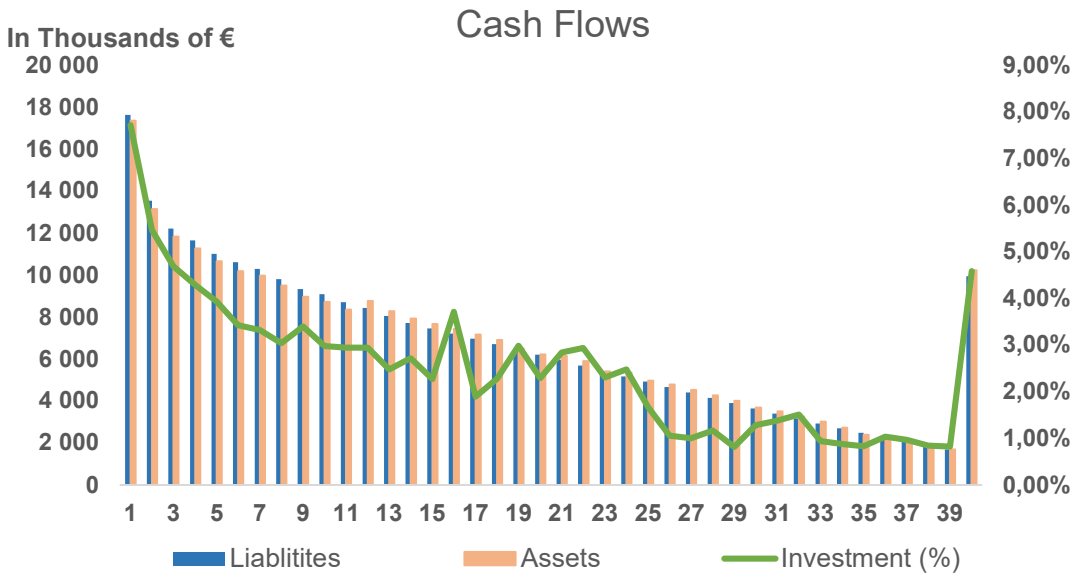


Figure 4 - Cash Flow Matching *Source: Made by Original Author*

The immunisation portfolio comprises a total of 43 bonds, spanning seven countries within the eurozone. These bonds encompass both sovereign bonds and corporate bonds that are considered to have a high credit quality risk.

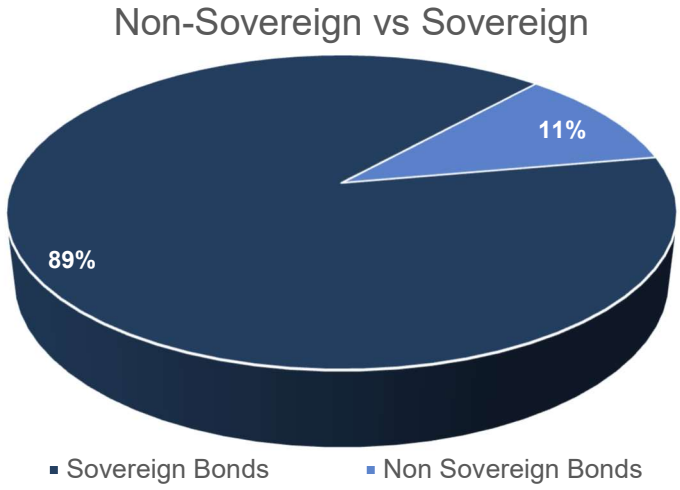


Figure 5 - Exposures Immunisation Portfolio *Source: Made by Original Author*

Based on Figure 5, it can be observed that this portfolio has significant exposure to sovereign bonds, accounting for 89 percent of the total portfolio. The remaining 11 percent of the portfolio is allocated to non-sovereign bonds.

In this specific portfolio, sovereign bonds dominate the allocation, constituting 89 percent of the total. This 89 percent can be further divided into seven different parts, with each part representing a different country. Figure 6 illustrates the distribution resulting from the allocation to sovereign bonds.

The largest shares within the sovereign bonds allocation are held by France (35 percent) and Germany (24 percent), amounting to a total of 59 percent of the sovereign bonds portion, which corresponds to approximately 53 percent of the entire portfolio. Smaller stakes are allocated to Spain (3 percent), Portugal (3 percent), and Italy (2 percent).

This allocation strategy reflects a preference for investing in countries that are considered relatively safe in terms of credit quality. The major investments are concentrated in countries with higher perceived stability, while countries perceived as riskier have smaller stakes within the portfolio.

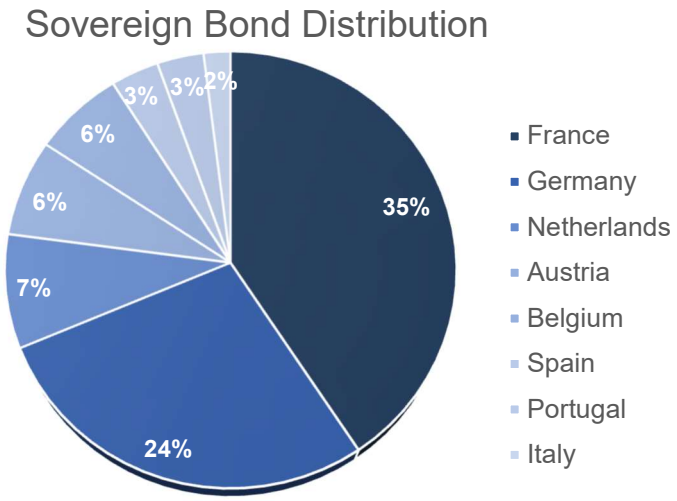


Figure 6 - Sovereign Bond Distribution *Source: Made by Original Author*

Figure 7 provides an overview of the distribution of credit quality within the immunisation portfolio. Notably, there is a significant inclination towards AA-rated bonds, which account for 51 percent of the portfolio. This indicates a substantial allocation to bonds with high credit quality.

Additionally, the portfolio has a minor stake in BBB-rated bonds, suggesting a cautious approach towards lower-rated securities. This allocation choice further reinforces the portfolio's focus on relatively safe investments.

Overall, the portfolio demonstrates a bias towards higher-rated bonds, which contributes to its positioning as a relatively safe and conservative portfolio.

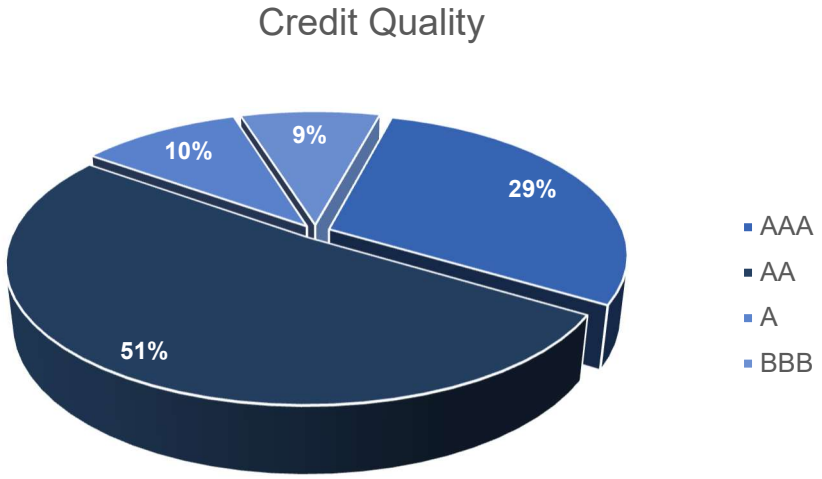


Figure 7 - Credit Quality Immunisation Portfolio *Source: Made by Original Author*

Year	Liquidity	Year	Liquidity	Year	Liquidity	Year	Liquidity
2024	-282 633 €	2034	-347 915 €	2044	182 009 €	2054	104 420 €
2025	-408 063 €	2035	334 528 €	2045	211 135 €	2055	93 904 €
2026	-381 415 €	2036	225 723 €	2046	-13 507 €	2056	84 299 €
2027	-367 657 €	2037	215 823 €	2047	175 307 €	2057	25 390 €
2028	-347 442 €	2038	208 131 €	2048	53 590 €	2058	-78 795 €
2029	-423 954 €	2039	228 108 €	2049	133 394 €	2059	-72 422 €
2030	-327 134 €	2040	194 620 €	2050	125 638 €	2060	-14 396 €
2031	-307 864 €	2041	197 177 €	2051	123 587 €	2061	-57 653 €
2032	-369 882 €	2042	48 881 €	2052	110 456 €	2062	3 602 €
2033	-359 782 €	2043	12 665 €	2053	50 651 €	2063	297 799 €

Table 3 – Liquidity *Source: Made by Original Author*

It is crucial to consider the potential liquidity risks and interest rate risks when aiming for a perfect match between cash inflows and outflows, as well as duration alignment between assets and liabilities.

Table 3 provides a detailed analysis of the differences between responsibilities (liabilities) and cash inflows over the years. The objective is to ensure that the difference between cash inflows and outflows does not exceed 4 percent of the responsibilities for each year. This objective has been successfully achieved, as well

as a similar duration (11.46 and 11.91 for assets and responsibilities, respectfully), indicating effective management of liquidity risks.

The table reveals liquidity challenges during the initial ten years of the immunisation investment. However, these challenges are partially mitigated in the subsequent years. It is important to note that if the Net Present Value of the Liabilities is approximately 177 million euros, the liquidity issue in the last year would only amount to 0.39 percent. This indicates that the portfolio has been able to effectively address liquidity risks over time, reducing the magnitude of the issue to a minimal level.

By closely managing liquidity risks and striving for a close match between cash flows and obligations, the portfolio has been successful in maintaining liquidity within acceptable limits and ensuring the stability of cash flows in relation to the responsibilities over the investment horizon.

3.3 Optimisation Portfolio

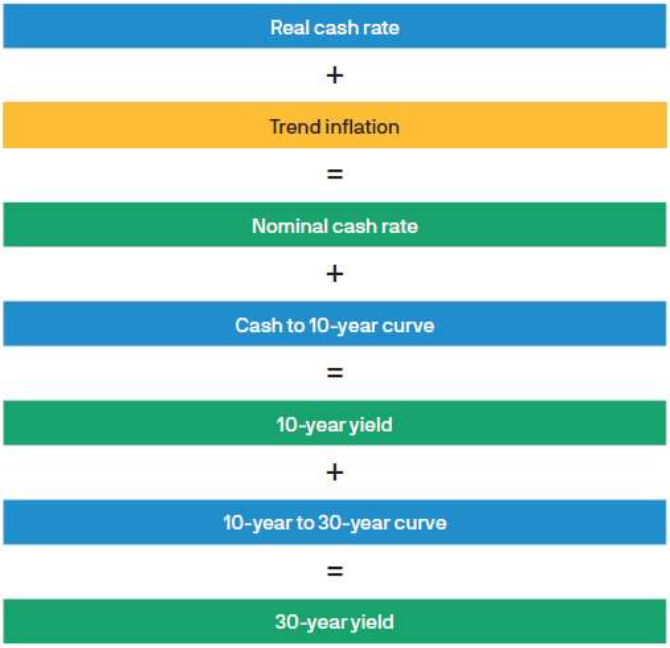
3.3.1 Return and Volatility computations

The expected returns and volatility are based on the Long-Term Capital Market Assumptions (LTMCA), from JP Morgan. The computation of the compounded returns differs from asset to asset.

To calculate fixed income returns, JPMorgan estimates the Euro Cash Rate and combines it with the expected inflation, as defined in the latest LTCMA. This gives us the nominal cash rate, which forms the basis for the calculations. Next, JP Morgan predicts the future curve slopes of government bonds.

In addition to government bonds, they also consider corporate credit in the analysis. JP Morgan incorporates the forecasted spread to account for the additional risk associated with corporate and non-sovereign bonds. This spread reflects the anticipated difference in yield between these bonds and government bonds.

Finally, the returns of the entire fixed-income market are determined by the projected changes in bond yields over time. JP Morgan compares the actual yield to the projected yields and calculates the returns based on this expected path. Figure 8 illustrates this process.



Source: J.P. Morgan Asset Management; as of September 30, 2022.

Figure 8 – Fixed-Income Returns

The real cash rate is computed based on JP Morgan's view "on each economy's economic equilibrium rate (R*) and how dovish or hawkish that central bank would need to be, on average, relative to this level to achieve its objectives." The forecasted government bonds yield curve "reflects our estimate of the term premium and average rate expectations over a cycle. Both depend heavily on expected monetary and fiscal policy and the net supply outlook for each part of the curve."

To forecast corporate credit, JP Morgan begins by examining historical long-term spreads. Spreads refer to the difference between the yields on corporate bonds and government bonds. By analysing these spreads over time, we can gain insight into the potential risks and returns associated with corporate credit. However, historical spreads may not always be an accurate predictor of future trends. Therefore, JP Morgan adjusts for any structural changes that may impact spreads over time. Structural changes could include shifts in the overall economic landscape or changes in market conditions that affect the supply and demand for corporate bonds.

For equity returns, as illustrated in Figure 9, JP Morgan starts by forecasting Earnings Per Share, considering the growth revenue, the margins, possible buybacks and gross dilution.

Then, the Price to Earnings ratio is also forecasted and combined with the present Price to Earnings. The expected path arising from the present and combined Price to Earnings gives the expected Price Return.

Finally, the Dividend Yield is also forecasted, generating the total expected returns for all equities markets.

Source: J.P. Morgan Asset Management; data as of September 30, 2022.

Figure 9 – Equities Return

For Real Estate Investment Trusts (REITs), JP Morgan starts with the returns from properties unlevered and then adjusts for sector composition, leverage and amortization-to-net asset value discounts (or premiums) projected.

To compute volatility, JP Morgan's analysis spanned from 2006 to 2022. Liquid assets, relied on monthly data. Quarterly data was used for private assets. To ensure unbiased volatility estimates, they removed outlier data points that could potentially skew the results. This was achieved by capping and flooring the data within 99.5% confidence intervals.

To align forecasts with a forward-looking long-term perspective, JP Morgan incorporates historical return series. However, they assigned varying weights to each data point based on its relevance, considering the expected frequency of different economic regimes.

3.3.2 Strategic Asset Allocation

Indices	Weights
Bloomberg Euro Government Bond 30-Year Term Index	45,30%
Bloomberg Euro Corporate Bond Index	2,40%
EUR Money Market VNAV Fund	1,00%
J.P. Morgan EMBI Global Core Index hedged to Euro	12,04%
J.P. Morgan Corporate Emerging Markets Bond Index Broad Diversified (Total Return Gross) Hedged to EUR	4,39%
Bloomberg US Aggregate Index Hedged to EUR	18,01%
FTSE EPRA Nareit Developed Index (Total Return Net) Hedged to EUR	3,30%
MSCI World Index (Total Return Net) Hedged to EUR	13,56%

Table 4 – Indices Weights *Source: Made by Original Author*

The Optimised Portfolio weights are computed based on the Mean-Variance Theory. To compute it we use the expected returns and volatility from Table 4. After that, we also used the correlations from Table A2. From there we include all the constraints and solve the optimised portfolio by maximising the Sharpe Ratio.

As outlined in Table 4, we have a significant investment in the Bloomberg Euro Government Bond 30-Year Term Index. This allocation can be attributed to the duration of the index. As one of our key constraints is to maintain a minimum duration of 10, which aligns with our liabilities' duration of 12, the index with the highest duration becomes particularly important for our portfolio. Considering that the Bloomberg Barclays Euro Government Bond 30-Year Term Index has a duration of 16.22, it becomes a crucial component of our portfolio. It is the only index among those considered that surpasses the minimum duration threshold of 10, making it essential for effectively managing our duration risk and meeting our liability requirements, thereby mitigating potential risks associated with duration mismatch.

It is also clear that J.P. Morgan EMBI Global Core Index and Bloomberg US Aggregate Index hold significant importance within our portfolio. This can be attributed to the combination of high duration and high forecasted returns that these indices offer, particularly within the bond segment. By including these indices in our portfolio, we aim to capture the potential benefits of their high duration and expected returns, thereby optimizing our risk-return trade-off within the bond asset class.

By including the FTSE EPRA Nareit Developed Index, we are seeking exposure to Real Estate investments that align with our investment strategy and can contribute to the overall performance of the portfolio. The decision to allocate a portion of our investment to Real Estate is driven by the objective of diversification both in segment and geographically since it is exposed to a huge variety of countries and seeking opportunities for enhanced returns beyond fixed-income investments. Real Estate has the potential to generate income through rental yields and capital appreciation, making it an attractive asset class to meet our return targets.

For Equities, we have selected the MSCI World Index as the representative index. This index offers diversified exposure to global equities, providing us with broad coverage across various markets worldwide. The MSCI World Index is chosen due to its ability to capture the overall performance of equity markets across different countries and sectors. One of the key factors influencing our decision to include the MSCI World Index in our portfolio is its potential to provide the expected return we are targeting. The index's historical performance and expected return characteristics make it an attractive choice for our investment.

3.3.3 Security Selection

The investment plan, aims to maximize the Sharpe Ratio while adhering to the constraints. The optimised portfolio consists of eight indices, encompassing government and corporate bonds from developed and emerging markets, as well as exposure to equity and real estate markets. This diversified portfolio is designed to achieve the maximum expected return while minimising risk through broad market representation. For each asset class, we have carefully selected indices and calculated forecasted returns and volatility, as outlined in Table 5.

Indices	$\bar{R}$	σ
Bloomberg Euro Government Bond 30 Year Term Index	2,80%	4,88%
Bloomberg Euro Corporate Bond Index	3,60%	5,10%
EUR Money Market VNAV Fund	1,30%	0,61%
J.P. Morgan EMBI Global Core Index hedged to Euro	6,00%	10,31%
J.P. Morgan Corporate Emerging Markets Bond Index Broad Diversified (Total Return Gross) Hedged to EUR	5,80%	9,22%
Bloomberg US Aggregate Index Hedged to EUR	3,50%	4,12%
FTSE EPRA Nareit Developed Index (Total Return Net) Hedged to EUR	4,90%	13,43%
MSCI World Index (Total Return Net) Hedged to EUR	6,40%	13,93%

Table 5 - Indices, Asset Class, Forecasted Return and Volatility *Source: Made by Original Author*

The optimised Portfolio is built using the indices and computed through the Single Factor Model, which is based on the principles of Modern Portfolio Theory. This model identifies the most efficient combination of the eight indices to optimise the portfolio's risk-return profile.

The theory suggests that investors should diversify their portfolios by allocating investments across different asset classes, such as equity, fixed income, or alternative investments. By diversifying, investors can reduce the overall risk of their portfolio while potentially increasing the expected return. Mean-Variance Theory emphasizes that asset allocation is a key determinant of portfolio performance. It suggests that a significant portion of a portfolio's risk and return is determined by the strategic allocation of assets across different asset classes, rather than the selection of individual securities.

One of the key outputs of Mean-Variance Theory is the efficient frontier, which represents the set of portfolios that offer the highest expected return for each level of risk. Portfolios that lie on the efficient frontier are considered optimal because they provide the maximum return for a given level of risk or the minimum risk for a given level of return.

3.3.4 Portfolio Composition

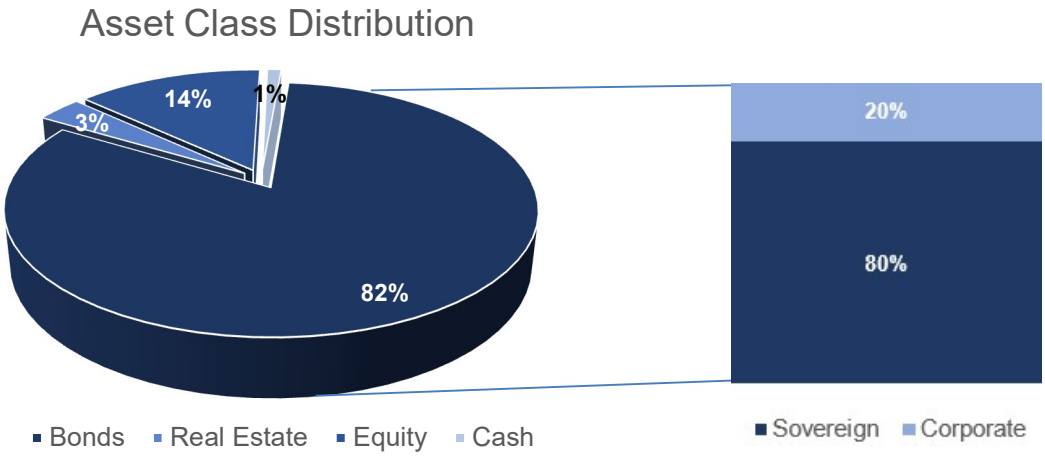


Figure 10 – Asset Distribution *Source: Made by Original Author*

Figure 10 illustrates the asset distribution of the optimised portfolio. As stated before, the fixed-income market would be the one with a major allocation. It has a percentage of 82 percent of our portfolio and it can be divided into sovereign and corporate bonds. Sovereign bonds represent 80 percent of our bond portfolio, which means 66 percent of our total portfolio.

On the other hand, corporate bonds make up the remaining 20 percent weight on our bond portfolio, which totalizes 16 percent of our portfolio.

Regarding Real Estate and Equity, since we have only chosen one index for each asset class, the weight of those indices in our portfolio directly represents the exposure of each asset class within our overall portfolio. This allocation reflects our intentional investment decisions in terms of Real Estate and Equity.

Furthermore, cash holds a representation of 1 percent within our portfolio. This allocation is set for liquidity purposes, ensuring that we maintain a certain level of readily available funds.

By maintaining a small portion allocated to cash, we aim to have the flexibility to meet any immediate liquidity needs that may arise without compromising the overall investment strategy.

Figure 11 provides the country exposures within the portfolio. It indicates that the major investment is allocated to the United States, accounting for 30 percent of the portfolio. It is important to note that the client's specified guideline is to not exceed 30 percent exposure to countries outside Europe. However, it is worth mentioning that there may

be circumstances where this limit could be surpassed if approved in the annual investment strategy.

By having a significant allocation to the United States, we acknowledge the potential opportunities and returns offered by the US market. The US market is one of the largest and most influential in the world, providing a diverse range of investment options across various sectors.

Maintaining a diversified country's exposure is crucial to managing risks and capturing potential returns from different regions. While the portfolio has a higher allocation to the United States, it may also have allocations to other countries within Europe and possibly beyond, as long as they adhere to the established guidelines and investment strategy.

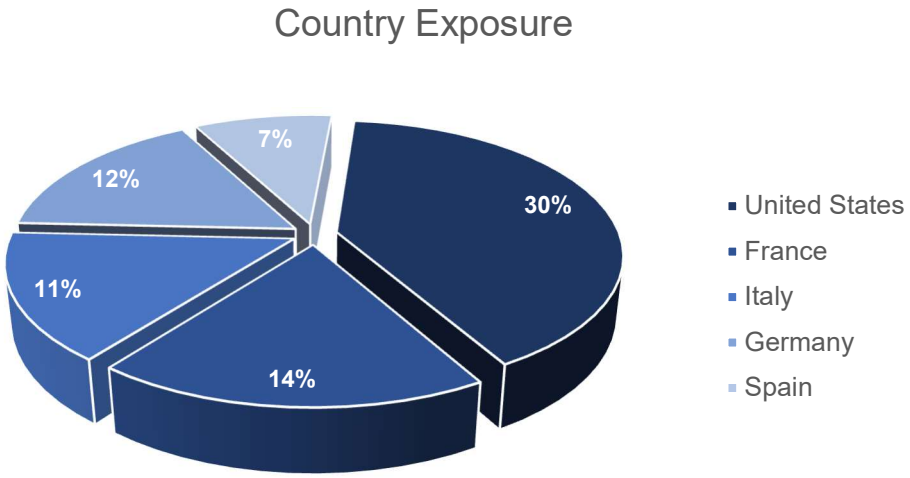


Figure 11 – Country Exposure *Source: Made by Original Author*

Figure 11 highlights significant investments in Germany (12 percent), France (14 percent), and Spain (7 percent) within the portfolio. These countries are widely perceived as relatively safe markets in the financial market due to their high credit quality scores, which are A or above.

These countries have established strong economic fundamentals, stable political environments, and sound financial systems. Their credit quality ratings reflect their ability to meet financial obligations and mitigate credit risks, making them attractive investment destinations.

By allocating a considerable portion of the portfolio to these countries, we aim to capture the potential benefits of investing in relatively safe and stable markets. This

helps in diversifying country-specific risks while seeking investment opportunities with favourable risk-return profiles.

Alongside Italy, with a percentage of 11 percent of our portfolio, these five countries represent 74 percent of our investment. According to the European Central Bank, Italy is the country with the highest yield in the Eurozone (4,23), as of April 2023. The sharp rise in Italy's yields reflects not only the general increase in yields but also the market's response to Italy's overall 2022 debt level is estimated at 145% of gross domestic product, the second highest ratio in the eurozone after Greece.

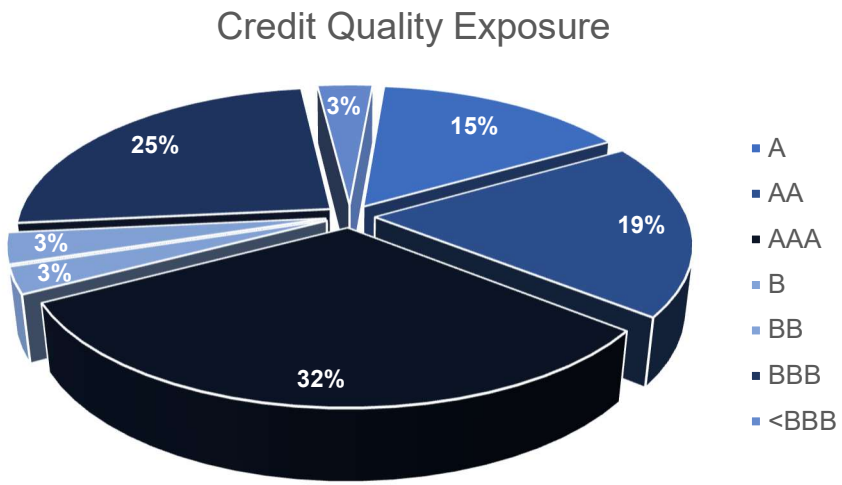


Figure 12 – Credit Quality Exposure *Source: Made by Original Author*

The credit quality score of a portfolio is determined by considering the ratings provided by Moody's, Standard & Poor's or Fitch. In Table 6, two primary credit classifications are presented: Investment Grade and High Yield. Investment Grade means safer investments, while High Yield represents riskier investments. Figure 12 illustrates the exposure of the optimisation portfolio to the different credit quality classifications.

For the optimisation portfolio, only 3 percent of the investments are allocated to High Yield bonds, indicating a conservative approach. The remaining 97 percent of the portfolio is invested in Investment Grade category.

Within the Investment Grade category, approximately 32 percent of the investments are in assets with the highest level of safety, represented by an AAA rating. This allocation focuses on the most secure assets according to rating agencies. On the other hand, 25 percent of the investments are allocated to assets with a BBB rating, which is considered riskier within the Investment Grade category. This allocation is aimed at potentially capturing higher returns.

By maintaining most investments in the Investment Grade class and diversifying within that category, the optimised portfolio aims to strike a balance between safety and the opportunity for higher returns.

Class	Moody's	S&P	Fitch
Investment Grade	Aaa	AAA	AAA
	Aa1	AA+	AA+
	Aa2	AA	AA
	Aa3	AA-	AA-
	A1	A+	A+
	A2	A	A
	A3	A-	A-
	Baa1	BBB+	BBB+
	Baa2	BBB	BBB
	Baa3	BBB-	BBB-
High Yield	Ba1	BB+	BB+
	Ba2	BB	BB
	Ba3	BB-	BB-
	B1	B+	B+
	B2	B	B
	B3	B-	B-

Table 6 - Credit Rating Scores *Source: Made by Original Author*

3.3.5 Expected Performance

To determine the optimal portfolio, we considered the Risk-free rate obtained from the EIOPA Risk-Free Rate Term Structure. Figure 13 represents the current EIOPA Risk-Free Rate curve, which shows a short-term yield higher than the long-term yield. According to Bruce-Lockhard et al. (2022), this can be an indicator of a recession, corroborating JPMorgan's expectations.

We used the rate for year 81, which aligns with the maturity of the last liability considered for Portugal. We use this value because Insurance companies need to comply with Solvency II requirements. According to RFR Technical Documentation, the methodology to derive EIOPA's risk-free interest rate term structures has been guided by the following principles:

a) Adherence to the fundamental elements outlined in the political agreement of Directive 2014/51/EU (Omnibus II Directive).

b) Ensuring transparency across all aspects of the calculation process, providing clear visibility into each element involved.

c) Striving for replicability of the calculations, thereby minimizing or eliminating the need for expert judgment, to the greatest extent possible.

d) Emphasizing market consistency, employing a cautious assessment of the technical provisions and making optimal use of market information.

By adhering to these principles, EIOPA aims to establish a robust and reliable methodology for determining risk-free interest rate term structures, fostering confidence, and facilitating effective decision-making within the regulatory framework. To ensure the accuracy and reliability of the relevant risk-free interest rate term structure, it is crucial to base it on relevant financial instruments that are traded in deep, liquid, and transparent (DLT) markets.

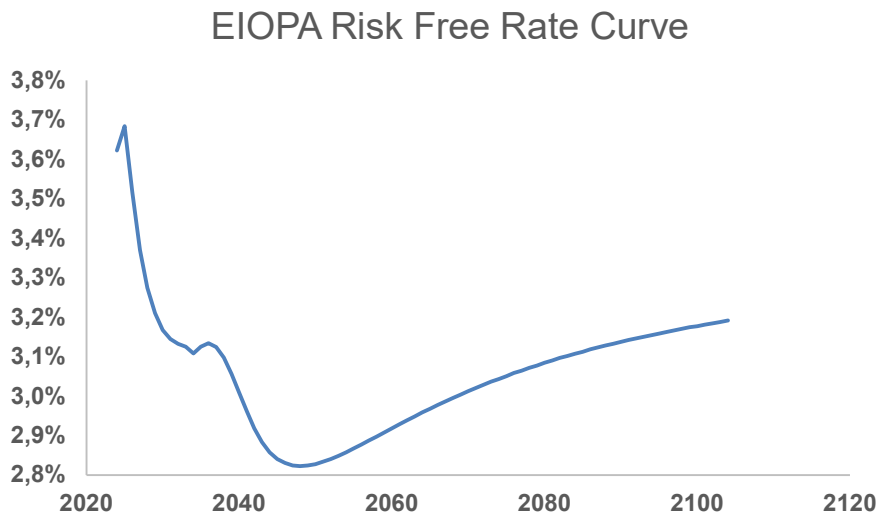


Figure 13 – EIOPA Risk-Free Rate Curve *Source: EIOPA, as of 28th February*

EIOPA has made specific decisions regarding the selection of data providers for different categories of financial instruments to mitigate operational risk and reduce dependence on a single provider. The chosen providers for each category are as follows:

a) Swaps and Overnight Indexed Swaps: Refinitiv

b) Government bonds: Refinitiv and ECB (European Central Bank)

c) Bonds other than government bonds: Markit – iBoxx indices, except for Danish covered bonds, for which Refinitiv is used

d) Default statistics: Standard & Poor's. The RFR uses as input for the market interest rates of the relevant financial instrument the data specified in Table A1

The analysis concluded that the Optimisation Portfolio, the one with the highest Sharpe Ratio, that satisfies all the constraints above mentioned has an annual expected return of 4% and an expected volatility of 3,32%. A further analysis implied computing the Efficient Frontier, having all the constraints considered.

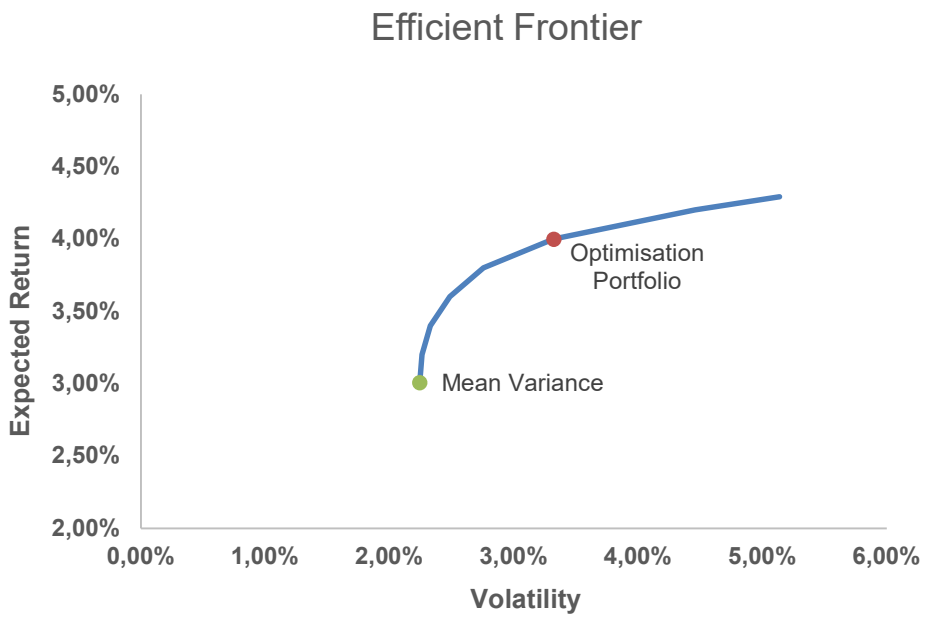


Figure 14 – Efficient Frontier *Source: Made by Original Author*

In Figure 14, we can observe that the Optimisation Portfolio falls within the efficient frontier border. This indicates that the portfolio is considered efficient in terms of risk and return trade-offs. By analysing various combinations of the eight indices, we were able to identify the portfolio that offers the highest Sharpe Ratio value, which is 0.25.

$$SR = \frac{\bar{R}_p - R_f}{6_p} \quad (2)$$

The Sharpe Ratio was computed as Equation (2): where $\bar{R}_p$ is the expected return of the portfolio, R_f the risk-free rate and 6_p the volatility of the portfolio.

Detailed information on the composition of the Optimisation Portfolio, including the weights assigned to each index, can be seen in Table A5. It provides a breakdown of the allocation across the various indices.

3.3.6 Risk Analysis

To ensure higher robustness and confidence in our results, we computed the Return-at-Risk using two different approaches, both utilizing a confidence interval of 99.5 percent.

The first approach involved computing Return-at-Risk based on historical data. We used the same historical data as in our robustness test for the exposures, specifically the monthly returns of our portfolio from 2014 to 2023 while employing the optimised portfolio weights. As illustrated in Table 7, the calculated Return-at-Risk from this approach was 4.59 percent. This implies that, according to our computations, there is a 0.5 percent probability of experiencing returns lower than -4.54 percent in one month. The second approach, using the Monte Carlo Simulation, provided a Return-at-Risk estimate of a 4.53 percent loss in a month. This approach adds a layer of confidence to our results, as it corroborates the findings obtained from the historical data approach.

The small difference of 0.06 percent between the two approaches indicates a consistent assessment of the potential downside risk in our portfolio. The difference does not represent a substantial deviation between the two methods. This convergence between the results reinforces the reliability and robustness of our findings.

	Historical	Monte Carlo
Return at Risk at 99,5%	4.59%	4.53%

Table 7 - Return-At-Risk at 99,5% *Source: Made by Original Author*

We have also computed Conditional Expected Shortfall(CES). According to Joshi et. al (2013), it offers several notable advantages, the most significant being its ability to reflect information beyond the VAR (Value at Risk) level. Unlike VAR, CES considers the probability of large, unexpected losses even if they remain below the predetermined VAR level. This means that if the likelihood of a significant unexpected loss increases, CES will capture and reflect this information by calculating the mean of these events, increasing CES.

Again, to ensure more robustness and confidence in our results, we have computed CES in two different ways, one based on historical data and the second way based on the Monte Carlo Simulation. Both used a confidence level of 99,5 percent. The results

were interesting, as observed in Table 8, indicating a small difference between historical CES and Monte Carlo CES. The historical CES value is 6.31 percent, while the Monte Carlo CES value is 5.5 percent. The interpretation is straightforward: in the worst 0.5 percent of scenarios or extreme market conditions, the average loss is estimated to be 6.31 percent for historical data and 5.5 percent for Monte Carlo simulations. This suggests that if the portfolio or investment were to experience a loss beyond the Return-at-Risk threshold, the average magnitude of that loss would be around 6.31 percent.

	Historical	Monte Carlo
CES at 99,5%	6,31%	5.50%

Table 8 - Conditional Expected Shortfall at 99,5% *Source: Made by Original Author*

3.4 Robustness Tests

To assess our optimised portfolio, we have performed two robustness tests. The first one is based on the computation of a portfolio relying solely on historical data. Our analysis spans from January 2014 to February 2023. We calculate the average returns based on 110 observations, and the volatility is determined by the standard deviation of those returns.

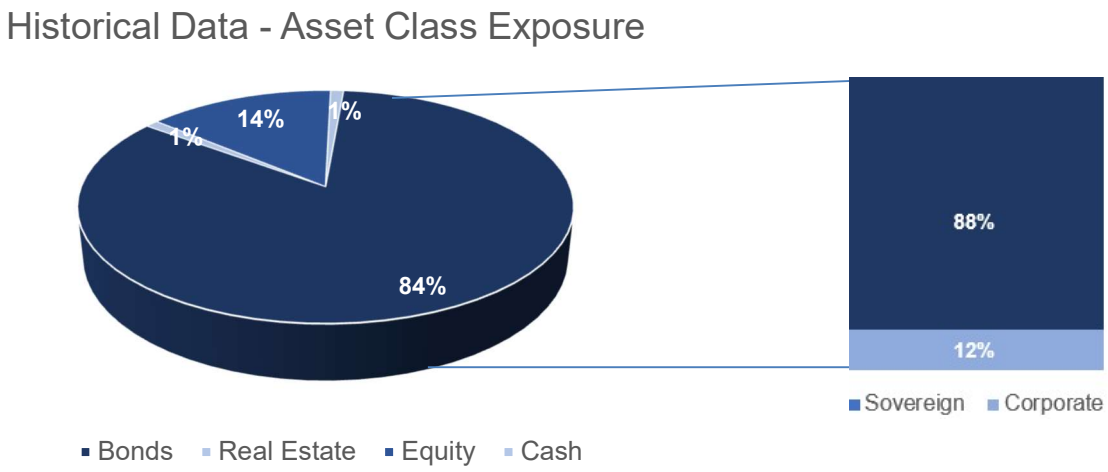


Figure 15 – Asset Class Exposure – Historical Data *Source: Made by Original Author*

Throughout this process, we have adhered to the predefined constraints, which have been successfully upheld, except for Duration, which totals 9. Our primary objective is the same as in our optimised portfolio, which is maximising the Sharpe Ratio.

Figure 10 and Figure 15 illustrate the asset distributions from our optimised portfolio and the portfolio derived from historical data. Both are remarkably similar, with the main difference being a 2 percent decrease in real estate and a corresponding 2 percent increase in bonds. The allocation for sovereign and corporate bonds differs, there is a higher allocation towards sovereign bonds, with 88 percent, while our optimised portfolio has 80.

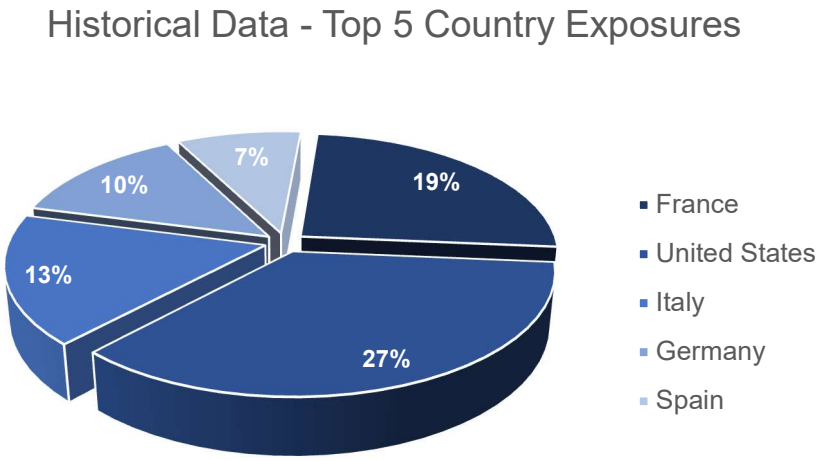


Figure 16 - Country Exposures – Historical Data *Source: Made by Original Author*

When considering country exposures, we observe similarities with some slight differences. Figure 16 shows the most significant change is a reduction in exposure to the United States, which decreased from 30 percent to 27 percent. This adjustment facilitated an increase in exposure to countries within the eurozone.

Specifically, Germany's exposure has decreased from 12 percent to 10 percent. France increases its exposure from 14 percent to 19 percent. Italy also experienced an increase, from 11 percent to 13 percent. Lastly, Spain maintained 7 percent in portfolio exposure.

Overall, the countries with the largest exposures remain the same. These five countries together collect 76 percent of this portfolio, 2 percent more than our optimised portfolio.

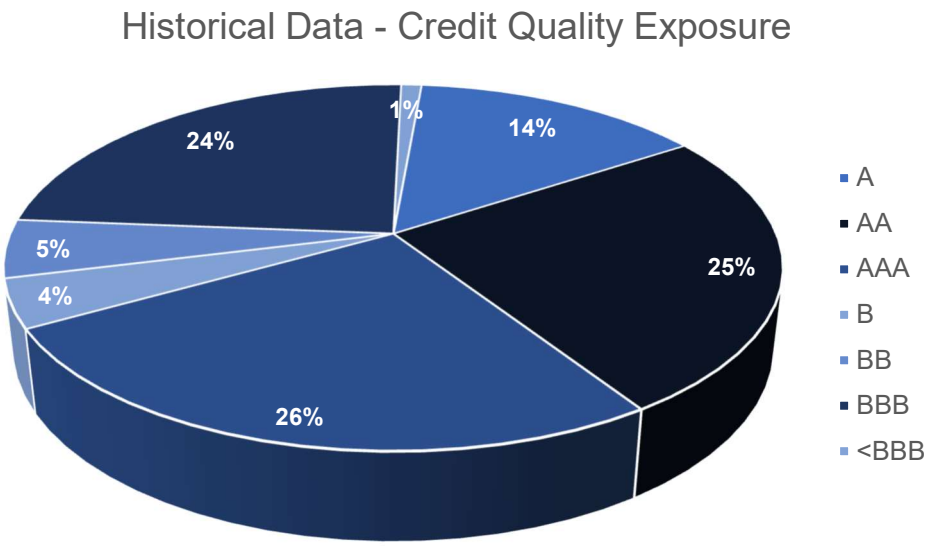


Figure 17 – Credit Quality Exposure – Historical Data *Source: Made by Original Author*

Here is where we can highlight the significant distinctions. The historical data portfolio, as illustrated in Figure 17 exhibits an even lower inclination towards High Yield bonds, accounting for 1 percent, in contrast to our optimised portfolio, which stands at 3 percent. Additionally, AAA exposures change, with figures shifting from 32 percent to 26 percent. In this case, the primary exposures lie at the extremes of the investment grade scale (BBB and AAA), as well as in AA.

It is also worth noting that Bonds with a credit quality of A and above display a similar level of exposure, comprising 65 percent for historical and 66 percent for the optimised portfolio. In the case of bonds with a credit quality of B, there exists a 3 percent discrepancy (34 percent and 31 percent), thereby explaining the variation in High Yield exposure.

The second robustness test is the Monte Carlo Simulation. According to DeFusco, et al. (2007) “Monte Carlo simulation, it involves the use of computer software to represent the operation of a complex financial system. A characteristic feature of Monte Carlo simulation is the generation of a large number of random samples from a specified probability distribution or distributions to represent the role of risk in the system. Monte Carlo simulation is widely used to estimate risk and return in investment applications”.

Thus, we conducted a Monte Carlo Simulation to evaluate the distribution of our investment returns. Figure 18 illustrates the results of this simulation, which involved

10,000 observations where we simulated the returns of our portfolio. To achieve this, we utilized the weights from the optimal solution obtained through our Mean-variance theory computations.

For each asset, we simulated its returns based on the mean expected return of the portfolio and the standard deviation of that particular asset. The probability values were generated randomly. The outcomes of this simulation revealed intriguing findings. The median and the average are very similar, 4 percent and 3.99 percent respectively. This means that throughout our observations we have a similar distribution, indicating no significant skewness. Moreover, there were 5,008 observations below the mean value and 4,992 observations above the mean, further affirming the relatively symmetric nature of the Monte Carlo Simulation results.

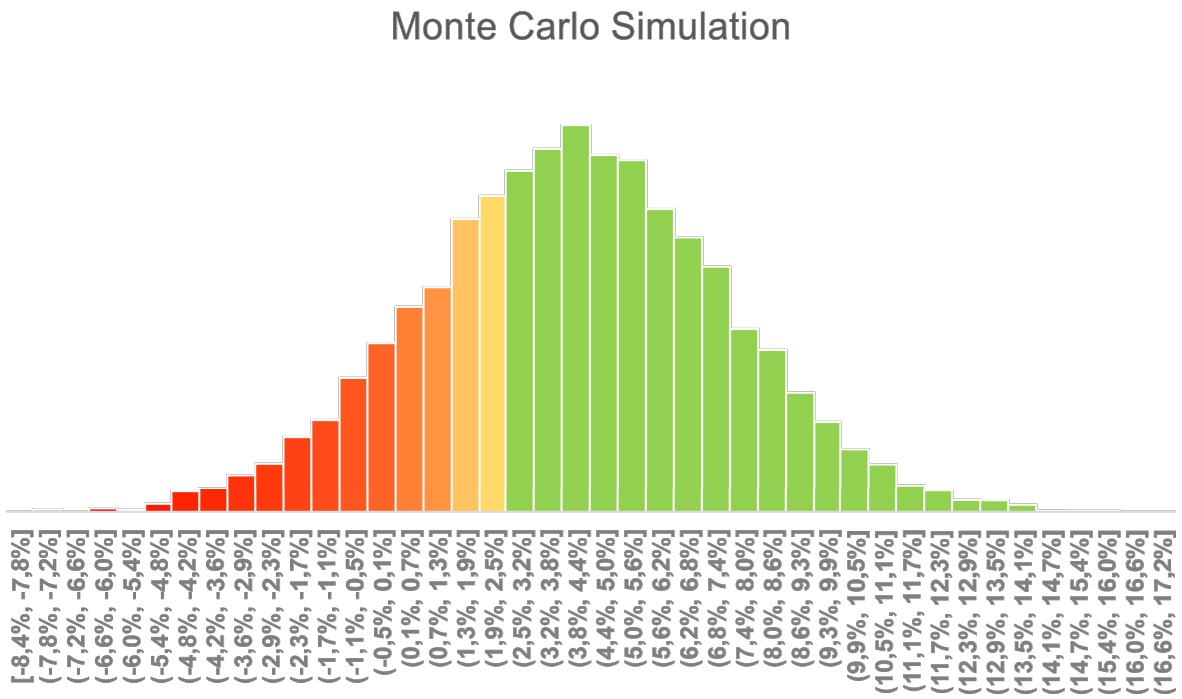


Figure 18 – Monte Carlo Simulation *Source: Made by Original Author*

By using fixed weights, we can ensure that almost all the constraints of our clients are satisfied. One of the most significant constraints given by Lusitania is that our portfolio should have, at least, a 2,5 percent of return. In green, we have all the outcomes that give a return of 2,5 percent return or more. According to this Monte Carlo Simulation, the probability of having, at least, a 2.5 percent return is 69 percent. As returns deviate further from 2.5 percent, in a negative way, the colour transitions towards reddish tones, indicating a diminishing likelihood of those outcomes.

Median	4,00%
Average	3,99%
St.Dev	3,33%
Min	-8,44%
Max	16,72%
Percentile 10	-0,29%
Percentile 25	1,78%
Percentile 75	6,23%
Percentile 90	8,28%

Table 9 – Statistics from Monte Carlo Simulation *Source: Made by Original Author*

Table 9 shows us that, according to our Monte Carlo Simulation, the Minimum return that we could have is -8,44% and a maximum of 16,72%. These represent the best and worst scenarios possible.

The percentile 10 tells us that there is a 10 percent chance that our portfolio will have a return of -0.29 percent or less, thus a probability of 90% of having a return superior to -0.29 percent. The same can be applied to all percentiles.

The percentile 25 shows us that there is a 25 percent probability of having a 1,78 percent of return or less, thus a probability of 75 percent of having, at least, a 1.78 percent return.

For percentile 75, we can conclude that there is a 25 percent probability of having returns of 6.23 percent or above and, finally, for percentile 90, we can conclude that we have a 10 percent probability of having a return equal to or higher than 8.28 percent.

Appendices

Table A1- Swap and government bond RICs

COUNTRY	ISO 3166	ISO 4217	GVT/SWP	SWP RIC	SWP FREQ	GVT RIC
EURO	-	EUR	SWP	EURAB6EIRS=	1	ECB (see 5.3.8)
AUSTRIA	AT	EUR	SWP	EURAB6EIRS=	1	0#ATXZ=R
BELGIUM	BE	EUR	SWP	EURAB6EIRS=	1	0#BEXZ=R
BULGARIA	BG	BGN	SWP	EURAB6EIRS=	1	0#BGXZ=R
CROATIA	HR	EUR	SWP	EURAB6EIRS=	1	0#HRXZ=R
CYPRUS	CY	EUR	SWP	EURAB6EIRS=	1	
CZECHIA	CZ	CZK	SWP	CZKAM6PRIRS=	1	0#CZXZ=R
POLAND	PL	PLN	GVT			0#PLXZ=R
PORTUGAL	PT	EUR	SWP	EURAB6EIRS=	1	0#PTXZ=R

Table A2- Correlation Matrix

Correlation	Bloomberg Euro Government Bond 30 Year Term Index	Bloomberg Barclays Euro Government Inflation-Linked Bond	Bloomberg Euro Corporate Bond Index	Euro Cash	J.P. Morgan EMBI Global Core Index hedged to Euro	J.P. Morgan Corporate Emerging Markets Bond Index Broad Diversified (Total Return Gross) Hedged to EUR	Bloomberg Euro Aggregate Index	Bloomberg US Aggregate Index Hedged to EUR	FTSE EPRA Nareit Developed Index (Total Return Net) Hedged to EUR	MSCI World Index (Total Return Net) Hedged to EUR
Bloomberg Euro Government Bond 30 Year Term Index	1,00	0,65	0,66	0,30	0,41	0,33	0,98	0,70	0,19	0,08
Bloomberg Barclays Euro Government Inflation-Linked Bond	0,65	1,00	0,64	0,14	0,50	0,43	0,67	0,43	0,46	0,34
Bloomberg Euro Corporate Bond Index	0,66	0,64	1,00	0,12	0,73	0,75	0,78	0,62	0,51	0,52
Euro cash	0,30	0,14	0,12	1,00	0,07	0,04	0,30	0,31	-0,15	-0,15
J.P. Morgan EMBI Global Core Index hedged to Euro	0,41	0,50	0,73	0,07	1,00	0,90	0,52	0,59	0,47	0,48
J.P. Morgan Corporate Emerging Markets Bond Index Broad Diversified (Total Return Gross) Hedged to EUR	0,33	0,43	0,75	0,04	0,90	1,00	0,46	0,53	0,46	0,51
Bloomberg Euro Aggregate Index	0,98	0,67	0,78	0,30	0,52	0,46	1,00	0,75	0,26	0,18
Bloomberg US Aggregate Index Hedged to EUR	0,70	0,43	0,62	0,31	0,59	0,53	0,75	1,00	0,20	0,09
FTSE EPRA Nareit Developed Index (Total Return Net) Hedged to EUR	0,19	0,46	0,51	-0,15	0,47	0,46	0,26	0,20	1,00	0,61
MSCI World Index (Total Return Net) Hedged to EUR	0,08	0,34	0,52	-0,15	0,48	0,51	0,18	0,09	0,61	1,00

Table A3 – IPS information

Executive Summary	
Name	Lusitania Companhia de Seguros
Portfolio Type	Institutional
Country	Portugal
Return Goal	2,50%
Objectives	Return seeking and Covering Liabilities
Risk Profile	Conservative
Time Horizon	81 Years
Liquidity Needs	None
Rebalancing of Asset Allocation	Annual
Performance Monitoring	Monthly

Table A4 – Portfolios Selection Guideline

	Optimisation Portfolio	Immunisation Portfolio	Minimum Weights	Maximum Weights
Asset Class Exposure				
Fixed Income	82%	100%	45%	100%
Sovereign Bonds	66%	89%	36%	100%
Corporate Bonds	16%	11%	0%	20%
Equity	14%	0%	0%	20%
Real Estate	3%	0%	0%	8%
Cash & Equivalents	1%	0%	0%	10%
Duration	10	11,46	10	14
Credit Quality Exposure				
AAA	32%	29%	-	-
AA	19%	51%	-	-
A	15%	10%	-	-
B	3%	0%	-	-
BB	3%	0%	-	-
BBB	25%	9%	-	-
Lower than BBB	3%	0%	-	-
Expected Return	4,0%	-	2,5%	-
Expected Volatility	3,3%	-	-	7,5%

Table A5 – Asset Class Detailed Weights

Asset Class	Weights
Equities	
Information Technology	3,3%
Health Care	1,8%
Financials	1,7%
Consumer Discretionary	1,5%
Industrials	1,4%
Communication Services	1,0%
Consumer Staples	1,0%
Energy	0,6%
Materials	0,5%
Utilities	0,4%
Real Estate	0,3%
Total Equities	**13,5%**
Bonds	
Europe	48,6%
North America	18,5%
Central & South America	4,7%
Asia & Pacific	7,4%
Africa	1,4%
Others	1,6%
Total Bonds	**82,2%**
Real Estate	
Residential	0,5%
Industrial	0,5%
Diversified	0,7%
Retail	0,5%
Office	0,2%
Self Storage	0,2%
Specialty	0,1%
Healthcare	0,2%
Data Centers	0,2%
Lodging/Resorts	0,1%
Industrial/Office Mixed	0,1%
Total Real Estate	**3,3%**
Cash & Equivalents	**1,0%**
Total	**100,0%**

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