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Master's Thesis

Optimal portfolio of European sustainable investment funds based on mean-variance optimization model

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Abstract

In a world where sustainability is on everyone's radar, the financial market is increasingly offering products that integrate ESG criteria. Europe is the epicentre of European sustainable funds, accounting for 83% of all funds worldwide. It is becoming increasingly imperative for investors to recognise which investment funds are aligned with these criteria, as well as to select the one(s) that strike the right balance between risk and return, considering ESG features. The first task is covered by the rating agencies and, since 2018, the regulations imposed by the European government to classify sustainable funds. The second task, of building a portfolio that optimizes risk and return, is carried out by this thesis using a rigorous quantitative method. In this way, by means of the mean-variance optimization, an optimal sustainable portfolio is obtained that is aligned with both ethical and financial goals. This portfolio, combined with the risk-free asset, allows the creation of numerous allocation proportions aligned with the investor's profile. The findings demonstrate that the optimal composition can achieve a high return, while maintaining the risk below the average risk of all European sustainable funds of the sample. The presence of highly positive correlations, especially arising from large-growth and large-blend equity allocation strategies, demonstrating that investing in sustainability implies investing in the long-term, are sufficient to create an optimal mix, but not to reduce risk by a large proportion. However, the portfolio offers diversification that spreads risk across sectors and countries, reducing the impact of underperformance in any single fund. This portfolio provides the best risk-adjusted return of any portfolio consisting of the sample's European sustainable funds. Any type of investor can invest in it in different proportions, when combined with a risk-free asset, to obtain a volatility and return in accordance with the risk aversion. Apart from that, fund managers should seek further alternatives to gain differentiation in equity allocation strategies, while European policymakers must ensure that the regulations in the sustainable field do not restrict the diversification of European sustainable funds.

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List of abbreviations

APSF	Action Plan on Sustainable Finance
AUM	Assets under management
CAL	Capital allocation line
ESG	Environmental, social and governance
ESMA	European Securities and Markets Authority
EU	European Union
FMC	Fund management company
FMP	Financial market participants
MPT	Modern Portfolio Theory
MVO	Mean-variance optimization
MVP	Minimum-variance portfolio
NAV	Net asset value
OECD	Organization for Economic Cooperation and Development
PRI	Principles for Responsible Investment
RTS	Regulatory Technical Standards
SFDR	Sustainable Finance Disclosure Regulation
SRI	Socially responsible funds
UK	United Kingdom
UN	United Nations
US	United States

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1 Introduction

This thesis focuses on the combination of practice, theory and sustainability in the framework of European funds aligned with this criterion, in order to link their impact and presence in the capital market with the benefit of their returns, to seek for an optimal portfolio. This first chapter serves as a gateway to understand the intricacies of the research, beginning with a precise delineation of the research problem, followed by the determination of the research question and objectives of the study. At the end the study's significance and relevance in the context of contemporary financial paradigms is pointed out. In order to understand the theoretical context of the topic, the second chapter is presented, which concentrates on mean-variance optimization, sustainability and investment funds. This is followed by the methodology chapter as well as the outline of the characteristics of the fund's sample. Finally, the optimal portfolio obtained is interpreted, as well as the impact of its diversification particularly and globally.

1.1 Definition of the research problem

The growing awareness of the importance of sustainability and social responsibility has led to a significant increase in demand for ethical and sustainable investments. The number of funds dedicated to sustainable investment has also grown and gained more prominence over the last few years. Each fund has its own characteristics in terms of diversification, asset allocation, investment objective, professional management and class. Normally only one fund is chosen that meets the characteristics of the person who wants to invest. But this thesis argues, why choose only one of them, if funds that pursue sustainable objectives can lead to a better risk-return if they are combined in an efficient way. Therefore, the selection and combination of these funds is carried out with the objective of maximizing the expected return of the portfolio, while controlling volatility, using as a basis the particular characteristics of each one of them. Through the mean-variance optimization (MVO) method it is possible to assemble diversified portfolios based on the returns and correlations of the assets. Beyond the quantitative part, the portfolio of this thesis highlights the benefits and downsides of current diversification in the context of sustainable investment in Europe, to provide visibility on what people need to face nowadays when willing to invest in sustainable

funds.

As Europe is the epicentre of sustainable funds, where most of them are available, this thesis focuses on this particular location. Here, a large number of sustainable investment funds have emerged as key players in promoting ESG practices while seeking attractive financial returns. When diving into this area, it is important to take into account the new regulations being proposed by the European Union (EU) in terms of transparency and uniformity of information. Therefore, this research sheds light on the performance of the different investment funds considered, mostly quantitatively, but also qualitatively. Emphasis is placed on the risk-adjusted return, volatility and performance of the sustainable funds and the optimal portfolio, while also interpreting them in terms of the context to which they are exposed. In other words, the portfolio will not be interpreted in isolation according to its own characteristics, but the sample of funds also plays an important role. By considering all these aspects, the representative sample together with the portfolio can be interpreted from a broader perspective in the sustainable context.

The return and risk-adjusted performance of the fund's optimal portfolio provides a basis for investors who want to invest in sustainability to know that the return and risk provided by this thesis is the optimal that an investor should assume regardless of their risk aversity. Furthermore, it is essential for investors who do not have advanced portfolio construction tools to not only know the methodology provided by this thesis, but also to access effectively diversified investment opportunities. Through the historical returns, risk and correlations of the funds, it was possible to determine this portfolio and analyse it against the EU framework of sustainable norms and strategies.

Throughout this thesis, the methodology used for the construction of the portfolio, as well as the detailed analysis of the individual characteristics of each fund and their interactions, will be discussed. Always keeping in mind that MVO's methodology brings into play the idea of why choosing only one investment funds, if a portfolio that leads to a better risk-return objective can be built. In addition, possible areas for improvement and future development in this evolving field will be

examined.

1.2 Research question

In order to focus the development of the analysis on the main idea, a research question has been established and remained present at all times to keep the analysis focused and with a purpose:

> "What is the optimal investment portfolio of European sustainable investment funds suitable for any risk tolerance?"

In essence, this research seeks to find the equilibrium between risk and return within the context of sustainable investment.

1.3 Objectives

A general objective has been set which determines the final scope of the project. In addition, specific objectives are detailed, which focus on particular goals to achieve the general objective.

1.3.1 General

Determine and analyse the optimal investment portfolio given by the mean-variance optimization method, providing the best mix of assets that leads to the best and least volatile returns over time and can be used by any risk type of investor.

1.3.2 Specifics

- Explore and define the European sustainable investment funds with which the analysis will be carried out.
- Determine the number of years that make the study representative and meaningful, in order to search for the monthly returns of the funds.
- Carry out the mean-variance optimization model, taking into account historical returns and risk of each investment fund.
- Obtain the optimal combination of European sustainable investment funds.

1.4 Significance and relevance of the study

Using the result of this thesis investors can make investment decisions with more tools up their hand. They can either select the best proportion between risk-free rate and optimal portfolio based on their investor profile or build their own portfolio taking into account the results. Not only the use of the MVO method is clarified, but also the construction of new portfolios in a changing and continuously growing environment such as sustainability is evaluated. The **individual investor** can use this technique for the construction of his own portfolio at his own convenience or use the risk and return obtained in this thesis as a basis for creating other portfolios that obtain a better return at a lower risk. It has the advantage that it is an easy and accessible method for any individual.

Sustainable funds, in particular, allow access to investment opportunities that would otherwise be more difficult to access for those who are not financially experienced. This investment instrument mainly seeks to diversify risk through the different assets in which it invests, with the aim of achieving a desired return at a lower risk. All of this is aligned with ethical values. A portfolio constructed with these funds further diversifies risk if the allocation is done efficiently. This is enabled by mean-variance analysis, which provides investors with a structured approach to build optimal portfolios. Combined with sustainable objectives, it not only delivers financial returns but also supports sustainability. Those wishing to invest in sustainable European funds can opt for the portfolio, which helps to reduce risk based on expected returns.

By analysing the characteristics of the funds and the portfolio obtained together with those of the European sustainable market from a holistic point of view, the findings are also valuable for **fund managers** and **policymakers**. The main reason is that the first ones have the responsibility to create diversified funds that seek the best returns for an acceptable risk in the sustainable segment. And the second, impose the rules within a sustainable regulatory framework. It is important that both are aligned for a correct management of sustainable policies and adequate diversification. Therefore, not only the characteristics of the portfolio obtained are useful for them, but also the interpretation of the portfolio based

on the current context of sustainable investment. This thesis also provides interesting data for **financial advisors**, who will be able to offer the portfolio, or even build new portfolios for different types of risk averse investors based on the optimal risk and return resulted from this thesis.

Overall, this thesis contributes not only to investor's education and awareness, but also to fund managers, financial advisors and policymakers that are involved in the construction of portfolios or release or adaptation of regulations in the sustainable development.

2 Theoretical framework

To begin this chapter, it is essential to highlight the importance of Modern Portfolio Theory. The way to proceed to find the optimal portfolio for any type of investor risk according to the authors of the mean-variance optimization methodology will be developed. The importance of the correlation of the assets in finding the portfolio will be described. However, as the final investment decision depends on the investor's profile, the different types are mentioned so the selection is properly made. The second section begins by describing the concept of sustainability, discussing the plausibility of the application of ESG ratings, as a result of which the European standards for the classification of sustainable financial products were introduced. The Morningstar Sustainability Rating, which is useful for selecting funds according to their level of sustainability, is also presented. Finally, the development and characteristics of European sustainable funds and what to consider when selecting them as an investment instrument are discussed in more detail.

2.1 Mean-variance optimization: seeking the optimal portfolio

2.1.1 Modern Portfolio Theory

In 1952, Harry Markowitz introduced his theory about the efficient frontier of optimal portfolios. A few years later, in 1958, James Tobin added the risk-free rate. The two are known as the pioneers of the Modern Portfolio Theory (MPT), which performs a mean-variance analysis for portfolio selection.

Markowitz (1952) studied the effects of asset risk, correlation and diversification on expected investment portfolio returns (POMS, 2009), basing the model on the fact that investors seek maximum returns at a low level of risk. As exhibited in “The Journal of Finance”, the investor does (or should) consider expected return a desirable thing and variance of return an undesirable thing (p. 77). Through MVO, he proposes to reduce the risk of a portfolio by benefiting from diversification, arguing that it is not sufficient to look at the expected return and risk of particular assets. The return in MVO represents the expected return, since it is a measure of the average expected profit. The variance represents the volatility and it is a measure of how much the actual return of the portfolio are expected to

deviate from the expected return. The expected return of a portfolio is calculated as follows:

$$E(r_p) = \sum_{i=1}^{N} w_i E(r_i) \quad (1)$$

where N is the number of assets and w_i the weight of asset i, meaning that the weight of all assets must be equal to 1.

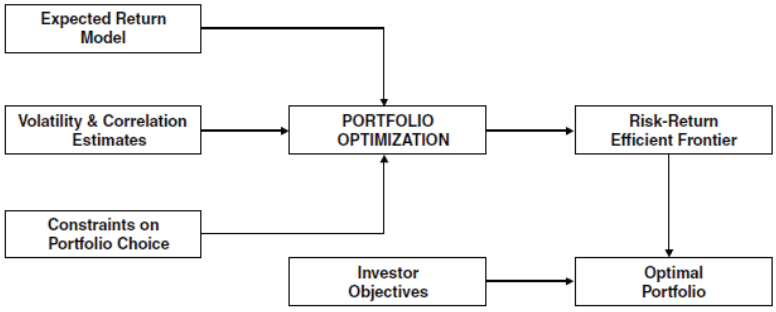
The level of risk is measured using standard deviation (σ), which is calculated as the square root of the variance (σ^2):

$$\sigma_p^2 = \sum_{i=1}^{N} \sum_{j=1}^{N} w_i \, w_j \, \sigma_{ij} \quad (2)$$

The notion of "not putting all the eggs in one basket" had been around before, but MPT quantified the concept of diversification, or "undiversification", by introducing the statistical notion of a covariance (σ_{ij}), or correlation (Fabozzi, Gupta, & Markowitz, 2002). It is not efficient to diversify by choosing assets at random, but by choosing those that are uncorrelated. In this way, the risk to which the investor is exposed can be significantly reduced. The importance of asset correlation is clarified in the next section.

Given estimates of the returns, volatilities, and correlations of a set of investments and constraints on investment choices (for example, maximum exposures and turnover constraints), it is possible to perform an optimization that results in the risk/return or mean-variance efficient frontier (Fabozzi et al., 2002). That is the first step of the investment process (Figure 1) of MVO, through which it is possible to arrive to a set of w_i and σ_{ij}.

Figure 1: The MPT investment process

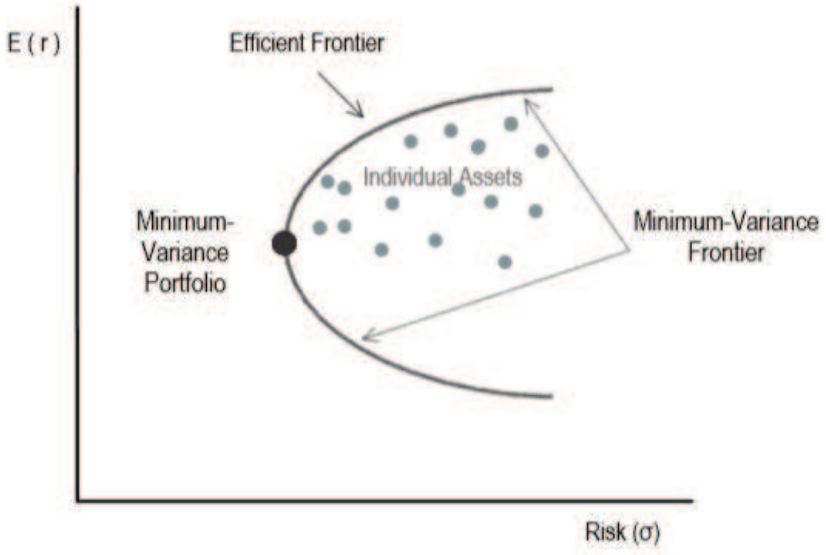


Source: *(Fabozzi, Gupta, & Markowitz, 2002)*

The **efficient frontier** contains a series of portfolios that minimize the variance for a given level of return, or provide the maximum return for a given risk. It is illustrated in Figure 2. The whole curve determined by all risk-return opportunities available is called **minimum-variance frontier** of risky assets, because it contains all portfolios with the lowest possible variance. The **minimum-variance portfolio** (MVP) is composed by the combination of assets that have the lowest variance. The entire curve that lies from the MVP downwards is considered inefficient, due to the fact that there are other portfolios with higher return for the same level of risk. In other words, the MVP is the starting point of the efficient frontier.

The individual assets are dispersed to the right inside the frontier, which means that combining them yields a higher return than choosing them separately. This explains the diversification effects.

Figure 2: Minimum-Variance and Efficient frontier



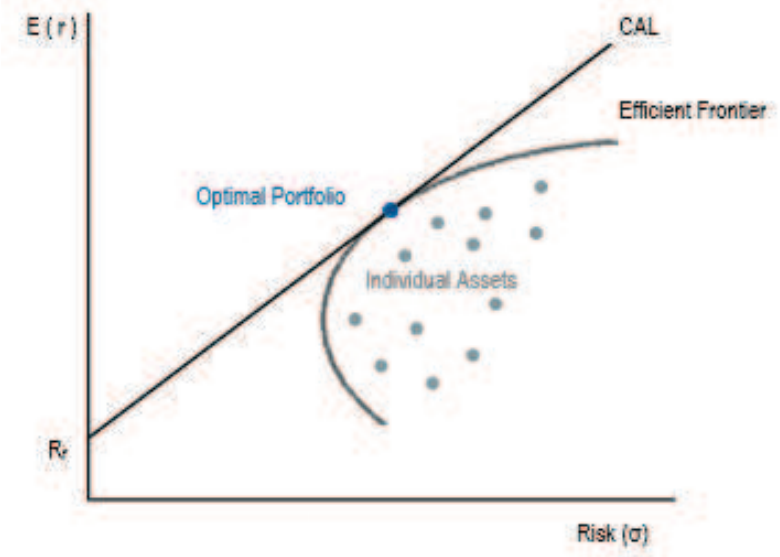
Source: own illustration based on Bodie (2012)

Markowitz thus indicates that investors, based on their risk aversion, can choose any portfolio that lies on the efficient frontier, which would be named **optimal portfolio**. In addition, all portfolios that lie on the efficient frontier make up efficient portfolios.

Tobin (1958) extended Markowitz's MPT by introducing the concept of risk-free rate. Thanks to his Separation Theorem, he was able to create a model that identifies a single optimal portfolio on the efficient frontier, which can be used by any type of investor regardless of their level of risk. A risk-free asset means that it has no variance. In practice, government bonds issued by a stable and creditworthy country are typically used as risk-free rate. The reasoning behind using these bonds as a risk-free rate is that they are considered to have minimal credit risk and their yield is used as a benchmark for the minimum return an investor should expect without taking on additional risk.

When introducing the risk-free asset, the investor must end up deciding his allocation between the asset with 0 variance and the optimal portfolio. Figure 3 illustrates the combination of risk-free rate and optimal portfolio.

Figure 3: Risk-free asset and Optimal Portfolio



Source: own illustration based on Bodie (2012)

As a consequence, the efficient frontier now becomes a straight line, called **the capital allocation line** (CAL), which contains all possible combinations of risk-free asset and risky assets. This line is more efficient than the efficient frontier itself because for each risk level there is a combination of risk-free asset and risky assets that has a higher return, with the exception of the optimal portfolio. The optimal portfolio, also called **tangency portfolio**, is the combination of risky assets that has a perfect balance between return and risk and does not include risk-

free assets. All portfolios between the risk-free rate and the tangency portfolio contain proportions of risk-free assets and the risky portfolio, while portfolios above the risky portfolio include leverage. In a nutshell, the optimal portfolio is the one that can be used by any investor, regardless of the risk aversion. The investor's level of risk aversion comes into play when selecting what percentage to invest in the risk-free asset and what percentage to invest in the optimal portfolio. Therefore, according to the Separation property, the choice of the portfolio should be made in two independent successive steps (Bodie, 2012):

- Determination of the optimal risky portfolio is purely technical
- Allocation of the complete portfolio to risk-free rate versus the risky portfolio depends on personal preference.

The slope of the CAL is named **Sharpe ratio**, also called by its author reward-to-variability ratio. According to Sharpe (1966), the author, selecting a portfolio with the highest ratio uniformly produce better opportunity sets than picking any with lower ratios. This ratio is a widely used method for measuring risk-adjusted returns. A higher Sharpe Ratio indicates a better risk-adjusted return, as it implies that the investment or portfolio is delivering more return for the same level of risk or the same return for lower risk. The higher the Sharpe Ratio, the better the risk management and therefore the fund's performance compensates for the risk taken. The underlying objective is to find the portfolio on the efficient frontier that has the maximum Sharpe ratio (or maximum slope) and the formula is as follows:

$$S_p = \frac{E(r_p) - r_f}{\sigma_p} \tag{3}$$

When having two alternatives, in particular, the whole portfolio and risk-free assets, then the investor should look at the ratio of the expected difference between the two returns divided by the standard deviation of the difference between the returns (Sharpe, 2004). The upper term of the Sharpe ratio formula is called the **risk premium**, which is the excess return obtained by investing in assets that are riskier than the risk-free one. When implementing the MVO, a quantitative approach, the optimal portfolio of assets that balances risk and return wants to be found. In this way, the mean in the mean-variance framework is considered as the compensation for risk, which can be interpreted as the risk premium. And the variance, as mentioned, is measured as the standard deviation of the returns.

2.1.2 Correlation analysis and its relevance for asset allocation

Correlation analysis is a fundamental input in MPT and the mean-variance framework. As indicated, MVO helps investors create efficient portfolios and seek an optimal one. The correlation between securities directly impacts portfolio optimization and the allocation of assets by generating diversification and, thus, reduce risk. It is measured as a coefficient (ρ), which value can range from -1 to 1. The greatest diversification benefit and, therefore, the greatest possible risk reduction, is generated when the securities are perfectly negatively correlated, i.e. when $\rho = -1$ (Titman, Keown, & Martin, 2018). If $\rho = 1$, the securities are perfectly positively correlated and risk reduction is not possible. Hence, the diversification of a portfolio depends on the extent to which assets are related to each other.

Highly correlated securities would increase the variance of the portfolio making the portfolio allocation less optimal. However, holding a single asset is not optimal if by adding a security, the portfolio risk decreases whilst maintaining its return, or the portfolio return increases by maintaining its risk (Cantillo, 2013). In other words, it is convenient to invest in many different securities and types of assets to avoid a highly dependence on any single investment.

A risk-free asset has a largely stable value, which means its price is unlikely to move significantly up or down at any point. Therefore, its correlation to any other assets would be zero (Phipps, 2022).

The correlation coefficient is applied to derive the covariance of the assets:

$$\sigma_{ij} = \rho_{ij}\sigma_i\sigma_j \tag{4}$$

where ρ_{ij} is the correlation between the return of the assets. The covariance is presented as a positive or negative term. If both securities are positively correlated, the covariance is positive, and vice versa if it is negative. Therefore, as stated by Bodie et al. (2012): “[…] variance is reduced if the covariance term is negative. Even if the covariance term is positive, the portfolio standard deviation still is less than the weighted average of the individual security standard deviations, unless the two securities are perfectly positively correlated” (p. 200).

2.1.2.1 When diversification is not enough

According to Perold (2004), Markowitz had the insight that, because of broad economic influences, risk across assets were correlated to a degree. Based on the fact that investors could eliminate some but not all risk by holding a diversified portfolio, Markowitz (1952) stated “diversification cannot eliminate all variance” (p. 79). Even though diversifying investments across different assets or securities can spread risk and reduce overall portfolio volatility, it cannot completely eliminate all forms of risk or uncertainty. The risk that remains even after extensive diversification is called market risk, risk that is attributable to market wide risk sources. Such risk is also called **systematic risk**, or non-diversifiable risk. In contrast, the risk that can be eliminated by diversification is called unique risk, firm-specific risk, **non-systematic risk**, or diversifiable risk (Bodie et al., 2012). The following table 1 summarises the differences between the two types of risk.

Table 1: Systematic and Non-systematic Risks

	Systematic risk	Non-systematic risk
IMPACT	Large number of securities associated with the entire market or segment	Restricted to a specific industry, segment, company or security
NATURE	Cannot be controlled, minimized, or avoided by a business's management	Can be controlled, minimized or avoided by a business's management
FACTORS	External factors or macroeconomic factors, including geopolitical, economic and sociological	Internal factors or microeconomic factors
PROTECTION	Allocation of assets	Diversification of the investment portfolio
AVOIDABILITY	Cannot be avoided	Can be avoided and resolved
TYPES	Purchasing power risk, interest rate risk and market risk	Business-specific risk and financial risk

Source: own illustration based on Upwork (2022)

2.1.2.2 Computing portfolio variance from the covariance matrix

When many assets are taken into account in portfolio construction, the **bordered covariance matrix** is used to calculate the variance of each portfolio. It is also known as variance-covariance matrix. Its particularity is that it includes the weights of each asset in the calculation, thus the result is the variance of the portfolio.

Table 2: Bordered covariance matrix

Portfolio weights	w_1	w_2	…	…	w_n
w_1	$Cov(r_1, r_1)$	$Cov(r_1, r_2)$	…	…	$Cov(r_1, r_n)$
w_2	$Cov(r_2, r_1)$	$Cov(r_2, r_2)$	…	…	$Cov(r_2, r_n)$
…	…	…	…	…	…
…	…	…	…	…	…
w_n	$Cov(r_n, r_1)$	$Cov(r_n, r_2)$	…	…	$Cov(r_n, r_n)$
Portfolio variance	$w_1 w_1 Cov(r_1, r_1) + w_2 w_1 Cov(r_2, r_1) + \cdots + \cdots + w_n w_1 Cov(r_n, r_1) +$ $+ w_1 w_2 Cov(r_1, r_2) + w_2 w_2 Cov(r_2, r_2) + \cdots + \cdots + w_n w_2 Cov(r_n, r_2) +$ $+ \cdots + \cdots + w_1 w_n Cov(r_1, r_n) + w_2 w_n Cov(r_2, r_n) + \cdots + \cdots + w_n w_n Cov(r_n, r_n)$				

Source: own illustration

As shown in table 2, the portfolio's variance is determined by a combination of weighted covariances, where each weight corresponds to the product of the portfolio proportions for a specific asset pair involved in the covariance calculation. Each covariance is multiplied by the corresponding weights from the row and the column in the borders. As mentioned previously, the variance of a portfolio is reduced if the covariance is negative. Even if the covariance is positive, if the securities are not perfectly positively correlated, the portfolio standard deviation will still be less than the weighted average of the individual security standard deviations (Bodie et al., 2012).

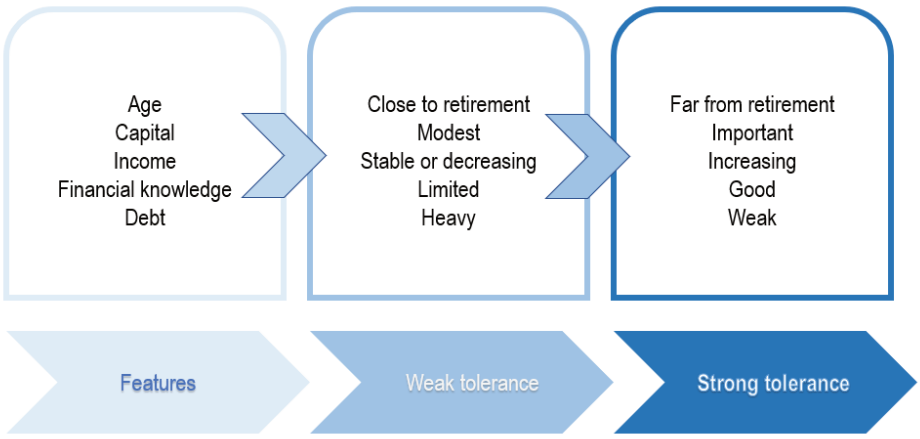
2.1.3 Investment decision based on investor risks

For Markowitz, the investor should choose an optimal portfolio that lies on the efficient frontier according to his level of risk (the optimal portfolio is determined by the level of risk). With the introduction of the risk-free rate into the theory, the investment portfolio would now be made up of the optimal portfolio and the risk-

free asset to the extent of his level of risk aversion. Therefore, a more risk-averse investor would allocate more capital to the risk-free asset and less to the optimal risky portfolio. In contrast, a risk-bearing investor would be willing to invest most of his capital in the optimal portfolio. He could even invest all of it in the optimal portfolio.

The investor's level of risk aversion depends on many factors, including his or her financial and family situation, educational level, age, character or emotional state. Figure 4 shows the level of risk tolerance according to each investor's circumstances.

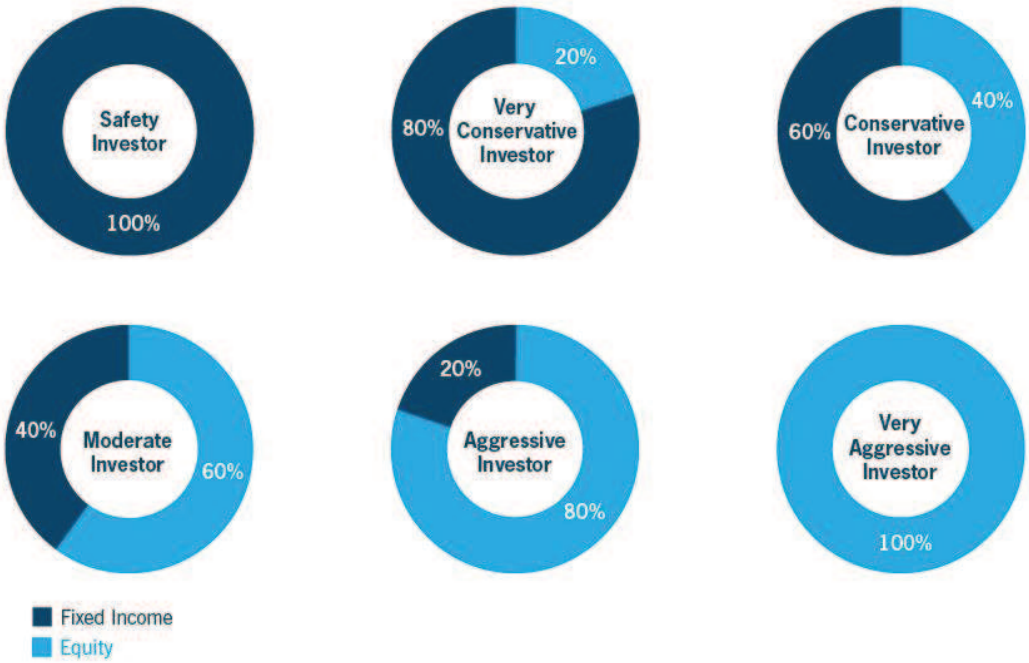
Figure 4: Risk tolerance levels



Source: own illustration based on Durango, G. M. and Delgado, V. L. (2017).

In the 1980s and 1990s, as the financial industry evolved and diversified, various financial institutions and advisors started utilizing structured questionnaires and assessments to categorize investors based on their risk tolerance, investment objectives and financial circumstances. Indeed, "according to Droms and Strauss (2003), the first financial risk tolerance questionnaire was published in 1984" (Roszkowski, Davey, & Grable, 2005, p. 66). These assessments aimed to provide a systematic way of understanding an investor's risk profile and preferences. Nowadays, investor profile tests are a standard practice in the financial industry to help tailor investment recommendations and advice to individual investors based on their unique circumstances and preferences. In Appendix 1 an investor's profile test model is illustrated. The result of these tests give rise to different investor profiles, as shown in figure 5.

Figure 5: Investor profiles



Source: Cooperators (2023).

In essence, there are six types of investor profiles that are ranked according to the level of risk. The more aggressive the profile, the more the investor would invest in risky assets (equity), and the more conservative the profile, the more the investor would invest in fixed income. Equity primarily encompasses ownership in stocks, whereas fixed income comprises bonds, money-market funds, or certificates of deposit. Investing in equity carries a higher level of risk, marked by increased volatility compared to fixed-income investments. Fixed-income investments are susceptible to interest rate risk, causing their value to decrease as interest rates rise.

Depending on the age of the investor, young investors can also be described as more aggressive, while those close to retirement will seek to maintain their capital and will therefore be more conservative. Moreover, as Bogle (2010) stated, “to invest with success, you must be a long-term investor”. In addition, he identified that “practices of professional and individual investors demonstrate that short-term investment strategies are inherently dangerous”. In the long term a person is predisposed to accept market volatilities for higher returns and is able to control risk, cost and time. Which in the short term are troublesome to foresee.

In summary, more conservative profiles will invest most of their capital in less volatile and thus less risky assets such as fixed-income investments. In contrast, aggressive profiles will invest more capital in stocks, which are much more volatile but at the same time have higher expected returns.

2.2 Sustainability in the capital market

Sustainability within the capital market has evolved over several decades in response to increasing awareness of ESG issues. The Organization for Economic Cooperation and Development (OECD) (2020) states that the demand for ESG products reflect desire for long-term value. Indicating that investing in sustainability implies a future-oriented perspective. The same guarantees the United Nations (UN) (2023): “we believe that an economically efficient, sustainable global financial system is a necessity for long-term value creation”. An article published by Zumente, I. and Bistrova, J. (2021) supports this concept: “Companies with higher sustainability awareness ensure shareholder value creation via improved financial performance, management quality as well as reduced risk metrics” (p. 1).

This section provides an insight of the ESG factors to consider while investing sustainably, as well as an overview of the European’s sustainability framework development. Moreover, the methodology used by Morningstar to rank funds according to their level of sustainability will be introduced. This rating is used as a filter to select the funds to be considered for the optimal portfolio. The reason for using this rating will be explained in the methodology chapter.

2.2.1 Sustainability development and European standards

ESG stands for Environmental, Social and Governance and companies that apply these criteria to develop their activities are better positioned in the market and generate more interest among investors, as their goals and objectives are considered to be sustainable in the long-term. There are different factors to consider in ESG investing. Figure 6 reveals them.

Figure 6: Key ESG Factors

Source: own illustration based on CFA Institute.

Sustainable investing implies considering these company's practices alongside traditional financial metrics when making investment decisions. Investors and other financial market participants (FMP) evaluate how a company manages its impact on the environment, treats its employees, interacts with communities and governs itself. Research has shown that there is a positive relationship between sustainability and performance. Therefore, sustainable investment became more attractive for investors and FMP, as there is a growing interest in aligning investment objectives with ESG factors. As a result of this growing interest, it became necessary to assess which investments can be called sustainable and many rating agencies and data providers started to develop their own ESG rating methodologies. However, the reality is that the different methodologies they carry out lead to very different ratings for the same company or investment fund. A study by the CFA Institute (2021) and mentioned in a Harvard article (2022), compares the different correlations between the ESG ratings of the most important rating agencies. Table 3 shows these correlations. This comparison shows obvious disconnects among the ESG ratings themselves (Prall, 2021). The highest correlations are between S&P and Sustainalytics (65%); and S&P and Bloomberg (74%). Nevertheless, these are still very low correlations for the same assessment.

Table 3: Correlations across ESG ratings providers

	MSCI	S&P	Sustainalytics	CDP	ISS	Bloomberg
MSCI	x	36%	35%	16%	33%	37%
S&P	36%	x	65%	35%	14%	74%
Sustainalytics	35%	65%	x	29%	22%	58%
CDP	16%	35%	29%	x	7%	44%
ISS	33%	14%	22%	7%	x	21%
Bloomberg	37%	74%	58%	44%	21%	x

Source: CFA Institute (2021)

While ESG has become central to the capital allocation process for investors and corporations alike, the disparities between today's ESG ratings limit their usefulness in extracting meaningful insights about a company's financial resiliency and long-term value (Prall, 2021). These ratings, being based on different criteria, generate the need for a framework or regulation to judge ESG implementation in the capital market.

The UN is leading the way on sustainable initiatives in the international framework. It has established a not-for-profit company named Principles for Responsible Investment (PRI). The PRI works to achieve a sustainable global financial system by encouraging adoption of the Principles and collaboration on their implementation; by fostering good governance, integrity and accountability; and by addressing obstacles to a sustainable financial system that lie within market practices, structures and regulation (United Nations Global Compact, 2023). The six principles are shown in figure 7.

Figure 7: Principles for Responsible Investment (PRI)

Source: Dcarbon (2020)

As a global standard, each country or union of countries should take these principles into account when creating their own regulations. This gave rise to initiatives in Europe. In March 2018, the EU implemented the Action Plan on Sustainable Finance (APSF) that aims to promote sustainable investment. In order to implement the APSF, it was essential to base it on a regulation called EU Taxonomy. The EU Taxonomy Regulation, which was published in 2020 and became applicable in January 2022, establishes an EU-wide classification system or framework intended to provide businesses and investors with common language to identify the extent to which economic activities can be considered sustainable (Davison, McNally, & North, 2023). It is closely linked to the Sustainable Finance Disclosure Regulation (SFDR), which sets out transparency requirements for investors and financial advisers (United Nations Global Compact, 2022). The SFDR released a regulation with certain standards to maintain an equal framework while assessing under ESG criteria: Regulatory Technical Standards (RTS). As of 1 January 2023, the so-called RTS started to apply, whereby FMPs shall publish, and maintain on their websites, sustainability information under these standards. It is important to highlight that at the time of writing this thesis, this information is extremely recent.

In the context of the SFDR, European products should be classified as under the following key concepts:

- **ARTICLE 6:** products which do not have a sustainable investment objective or do not promote environmental and/or social characteristics.
- **ARTICLE 8:** products that promote, among other characteristics, environmental and/or social characteristics, provided that the companies in which the investments are made follow good governance practices.
- **ARTICLE 9:** products that have a clearly defined sustainable investment objective.

There are many funds that include the term ESG or similar in their name to imply that they are sustainable. However, until November 2022, there were no standards in place to define what requirements a fund must meet to have sustainability-related words in its name. Therefore, to address any misuse of such terminology in fund names and prevent greenwashing, the ESMA (European Securities and

Markets Authority) published guidelines, in which mainly the following criteria must be met (Davison et al., 2023):

i. For any fund names that include any ESG-related words, a minimum proportion of 80% of the investments should be used to promote the E/S characteristics or sustainable investment objectives.
ii. For any fund names that include the word 'sustainable' (or derivatives thereof), within the 80% mentioned in point one above, FMPs should allocate a minimum of 50% of these investments to sustainable investments.

These regulations provide a framework that facilitates the classification of products according to the same criteria, beyond the rating agencies' methodologies. This will help harmonize regional standards and enhance market transparency. Funds that respond quickly and proactively to regulatory changes around sustainability performance and disclosure will also have a competitive advantage over other players in the market. Thus, regulation also provides a financial incentive for the fund market to embrace sustainability (United Nations, 2021).
What is certain is that the more sustainability filters are applied to the assets in which one wishes to invest, the more sustainable they will be. This thesis will filter the funds that pursue sustainable objectives according to the Morningstar Sustainability Rating (Sustainalytics), for which it is essential to understand beforehand.

2.2.2 Morningstar Sustainability Rating

The Morningstar Sustainability Rating is designed to support investors in evaluating the relative environmental, social, and governance risks within portfolios (Morningstar, 2021). This Rating has been published since 2016 and has evolved to the present day, where it measures the level of ESG risks in a fund compared to similar funds. The data used comes from Sustainalytics, a company acquired by Morningstar in 2020. At least 67% of the portfolio's assets must be qualified to be rated. This means that it must be composed of at least 67% equity, fixed-income, commodities, real estate, and alternatives. Cash and currency are excluded. Until 2021, only the ESG rating of the companies was used for the calculation. Since that year, the Sustainalytics' Country Risk Rating, which assess the risks to the socio-economic well-being of a sovereign entity, was also

incorporated. Before this change, only holdings in corporations through stocks or corporate bonds were in the Rating calculation, meaning many funds with significant sovereign exposure were not meeting the coverage threshold to receive Ratings (Morningstar, 2021). Hence, each fund receives its Corporate and Sovereign Sustainability Rating, and with respect to the fund's proportion of corporate and sovereign securities, is assigned a Morningstar Sustainability Rating. Finally, they are compared with fund peers in the same category[1] to assign globes, ranked on a scale of 1 to 5. Thus, as shown in Figure 8, funds assigned with 5 globes are the most sustainable within a category and those with 1 globe are the least sustainable.

Figure 8: Morningstar Sustainability Rating

Source: Sustainalytics (2023).

2.3 Development and characteristics of European sustainable funds

2.3.1 Preparing for sustainable investment choices: considerations before investing in funds

Investment funds are institutions that pool monetary contributions from different investors to form a portfolio that may consist of stocks, bonds, short-term money-

[1] Appendix 2 contains the categories into which Morningstar separates the funds.

market instruments, other securities or assets, or a combination of them. The most important of these financial intermediaries are open-end investment companies, more commonly known as mutual funds (Bodie et al., 2012). Each investor buys or sells a part of this fund, which is divided into shares, whose value is called net asset value (NAV). The NAV is calculated at the end of each business day on a per-share basis:

$$NAV = \frac{Market\ value\ of\ assets - Liabilities}{Shares\ outstanding} \tag{5}$$

These companies thus provide both small and large-scale investors with the benefits of large-scale investing in the proportion that they have invested in the portfolio. Investing in mutual funds has several advantages such as:

- They are **managed by professionals** in the field.
- **Well diversified**, which greatly helps reduce risk. Investments are spread across a wide range of companies or industry sectors.
- The investment company keeps **periodic record and administration** of capital gains distributions, dividends, investments and redemptions.
- Investor can **save on transaction costs**, since the investment company can achieve lower fees and commissions.
- Some mutual funds have **low minimum investment** for the initial purchase.
- They **are regulated**, hence the investment company has to respect certain rules.

But they also have downsides:

- Investors to **not** have **decision power** over which securities are included in the fund's portfolio
- Since the NAV is calculated when the market is already closed, there could exist **price uncertainty** when the purchase order is placed. This does not happen when an investor buys an individual stock, because the price is a real-time information.

- **Management fees** and other expenses must be paid depending on each funds' regulation. They must be paid regardless of negative or positive returns.

Each fund has a different fee structure and the investment choice should consider it along with the investment policy and past performance. There are four general classes of fees (Bodie et al., 2012):

Operating expenses are the costs incurred by the mutual fund in operating the portfolio, including administrative expenses and advisory fees paid to the investment manager.

Front-End Load commissions or sales charge paid when the investor purchases the shares.

Back-End Load is a redemption fee incurred when the investor sells the shares.

Other expenses may include shareholder service expenses, custodial expenses, legal expenses, accounting expenses, transfer agent expenses or other administrative expenses.

The rate of return on an investment in a mutual fund is measured as the increase or decrease in net asset value ($NAV_1 - NAV_0$) plus income distributions such as dividends or distributions of capital gains expressed as a fraction of net asset value at the beginning (NAV_1) of the investment period (Bodie et al., 2012).

$$Rate\ of\ Return = \frac{NAV_1 - NAV_0 + Income\ and\ capital\ gain\ distributions}{NAV_0} \quad (6)$$

When choosing a fund, it is also important to look at the prospectus, which is a document that describes the investment objective, as well as all information related to risks, performance and expenses. It is essential to choose funds whose investment objectives are aligned with the own personal objectives. Furthermore, the prospectus outlines the organizational structure of the fund management company (FMC), which according to Bogle (2010), has an enormous impact on the returns. A study published in The Journal of Financial Research (2017), conducted by researches of the Universities of Cranfield and Middlesex, further highlights the major role of the FMC in the outperformance of both socially responsible funds (SRI) and conventional funds. Outperformance occurs when the fund

performs better than the market, while underperformance means the contrary, lower performance than the market. In order to measure a fund's performance, they use a **benchmark** as comparison, which provides an indicative value of how much the fund should have earned. They use indexes as benchmark, which are generally related to the purpose of the fund.

Related to portfolio outperformance is whether the fund is actively or passively managed. **Actively managed funds** are managed by professionals who make decisions regarding the selection, buying, and selling of securities with the goal of outperforming a specific benchmark index or achieving a particular investment objective. The portfolio managers actively analyse and research investment opportunities. They may adjust the fund's asset allocation, sector exposure, and individual holdings based on their analysis of market trends, economic conditions, and company performance. Active funds typically have higher management fees due to the active management and research involved. On the contrary, **passive funds** seek to replicate a particular market index's performance or a particular segment of the market. These funds seek to mirror the holdings and weightings of a chosen benchmark index, rather than trying to outperform it. They require less active decision-making and research, thus they have lower management fees. John Bogle (2010), in his book Common Sense on Mutual Funds, mentions that costs incurred by actively managed funds for buying and selling portfolio securities are hidden, but nonetheless real. He therefore recommends, if selecting actively managed funds, to select low-cost funds. Bogle believes that one of the most important factors affecting an investor's long-term returns is the cost of investing. Fees for actively managed funds are generally higher than those for passive index funds. These fees can significantly diminish returns over time. By choosing low-cost actively managed funds, the investor can potentially reduce the drag on the returns caused by fees and expenses. Moreover, when investing in actively managed funds, he assures it is unnecessary to choose much beyond four or five equity funds, since a large number can easily result in overdiversification.

Performance (higher or lower return) also depends on the type of fund. There are several types, such as fixed-income funds, equity funds, money market funds,

sector funds, index funds, international funds and balanced funds. But the most common are the first three or a combination of them:

Equity Funds invest principally in stocks, even though they may hold fixed-income or other type of securities. They can be categorized as taking a value approach to stock selection, or a growth approach (many funds also blend the two). Value funds look for stocks trading cheaply, (often paying relatively higher dividends), accepting that this may mean comparatively lower growth. Growth funds prioritize long term potential, accepting that stocks may be more expensive, with low or no dividend (Morgan Stanley, 2023). Blended funds seek to balance the two approaches. The goal of an equity fund is to generate capital appreciation by investing in companies expected to experience growth in earnings and share value.

Fixed-income Funds, also called bond funds, invest in government bonds, corporate bonds, municipal bonds and other debt instruments. The primary objective of fixed-income funds is to preserve capital and generate consistent income for investors.

Money-market Funds invest in short-term, low-risk debt securities like commercial paper, repurchase agreements or certificates of deposit. The main goal of money market funds is to provide investors with a safe place to park their cash and earn a modest rate of return. They are known for their stability, liquidity, and capital preservation. Money market funds typically aim to maintain a stable NAV per share, usually at $1,00, making them attractive to investors seeking a stable investment option for short-term needs.

As mentioned in section 2.1.3., investing in equity means being predisposed to take much more risk than investing in fixed-income or money-market. Therefore, before investing, the investor should contemplate the investor's profile. Equity funds carry a higher level of risk compared to fixed-income and money market funds due to market volatility, but they also offer the potential for higher returns over the long-term. On the other hand, bond funds provide regular income to investors through interest payments generated by the bonds held within the portfolio. For this reason, as the SEC (2016) assures, before investing in mutual funds, investors should determine their financial goals and risk tolerance, beware of the

risk associated with the fund(s), consider the FMC features and fund manager background and have a look at the prospectus.

Funds seek diversification in order to achieve their investment objective while minimising risk. Diversification is achieved through several ways, among others:

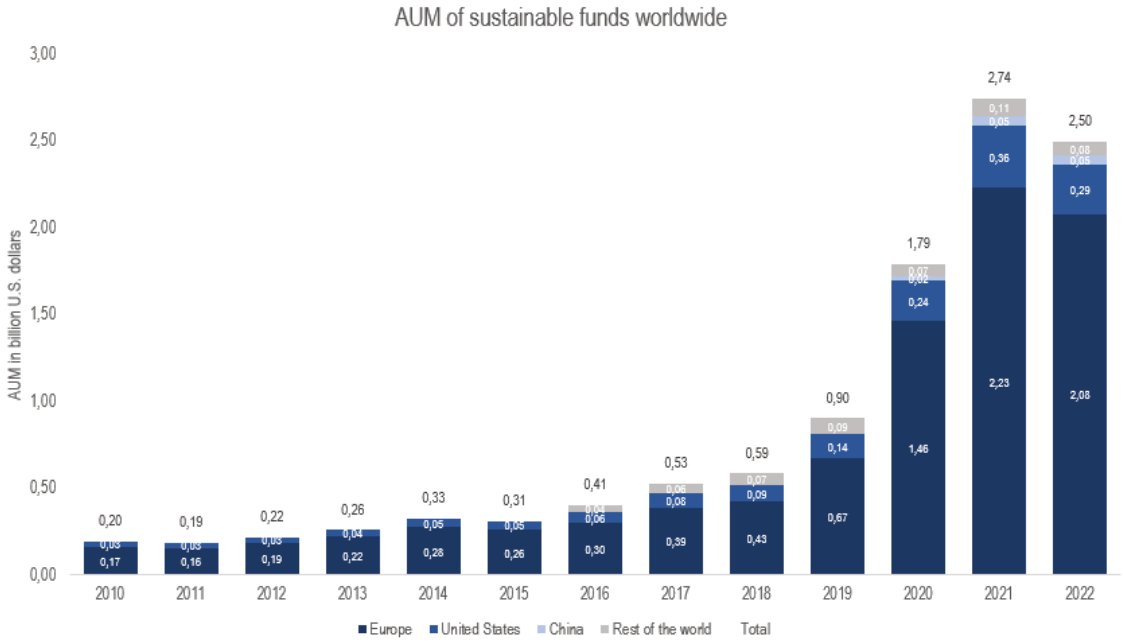
- **Sector allocation:** to invest in companies across industries to reduce exposure to sector-specific risks. This ensures that the fund is not overly dependent on the performance of a single sector. To classify sectors, Morningstar has a well-developed structure divided into three "Super Sectors": cyclical, defensive and sensitive. These are terms used to categorize different types of industries based on how they tend to perform in relation to the overall economic cycle. According to Morningstar (2011), "the cyclical sector is highly sensitive to business cycle peaks and troughs. To the defensive sector belong anticyclical stocks and sensitive sectors have moderate correlations with business cycles". Appendix 3 exhibits the sectors belonging to each Super Sector.
- **Country or geographic allocation:** it involves to spread investments across different countries and regions to minimize the impact of localized economic downturn, regulatory changes or geopolitical risks.
- **Asset allocation:** to not only invest in one asset class, but to invest in a mix of assets, such as equity, fixed income, etc.
- **Company size:** investing in companies of different market capitalization (large-cap, mid-cap and small-cap) to diversify exposure to different risk profiles and market dynamics.
- **ESG factors:** explore different sustainable factors, such as climate change and carbon emissions, gender and diversity or political contributions, to diversify the portfolio based on specific ESG criteria and trends.

2.3.2 Unveiling the traits of European sustainable funds

Europe is the key driver of sustainable funds worldwide, accounting for 83% of funds worldwide in 2022, as demonstrated in figure 9. This illustrates the current dominance of Europe in terms of market share of the sustainable fund industry

and is a reflection of the maturity of the market and the relatively advanced regulatory environment for sustainable investment in Europe (United Nations, 2021).

Figure 9: AUM of sustainable funds worldwide from 2010 to 2022 by region



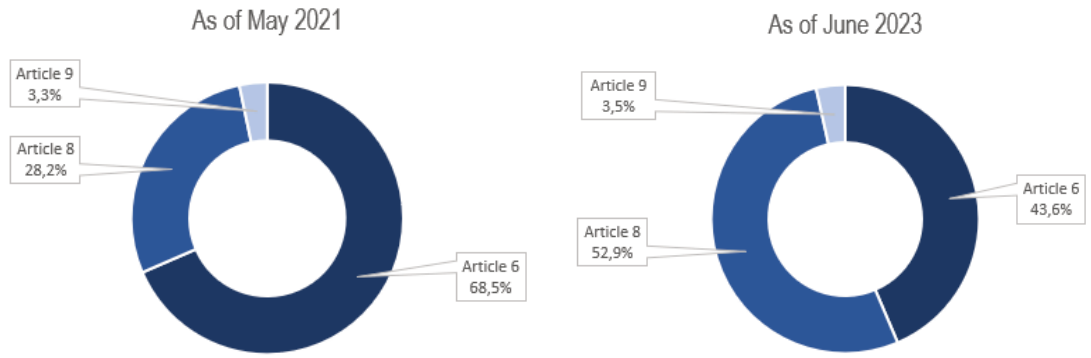
Source: own illustration based on Statista data.

The MSCI (2023) supports this, assuring that most assets under management (AUM) in Europe are invested in ESG funds or strategies with some sustainability-related focus. European sustainable funds have grown significantly over the years. One year to highlight is 2020, where they have more than multiplied in terms of AUM. Spurred by the COVID-19 crisis, many public companies, asset managers, and governments stepped up their commitment to sustainability in that year (Morningstar, 2021). In 2021, the market continued to grow, while in the following year it declined. The outbreak of the war in Ukraine, the sharp rise in inflation and interest rates, and the resulting slowdown in economic growth led to a sharp fall in the bond and stock markets in 2022 (EFAMA, 2022).

Prior to the implementation of the SDFR, where all funds in Europe were to be classified by Articles 6, 8 and 9, the reports and articles covered all sustainable funds equally, without taking this distinction into account. From 2021 onwards, when funds were to be classified according to this regulation, research on European sustainable funds is being carried out on the basis of this division.

Therefore, it is also necessary to be permanently informed about the EU disclosures in order to understand these investigations, due to the continuous changes that are taking place. According to a PwC (2021) study (figure 10), 32% of European funds were already classified in line with the SFDR fund type as of May 2021. Two years later, as of June 2023, this percentage grew to 56.4% according to a Morningstar study (2023). The growth of Article 8 funds, which pursue the promotion of ESG criteria, but do not have ESG as their main investment objective, is noteworthy. While Article 9 funds, whose investment objective is sustainability, have remained almost stable.

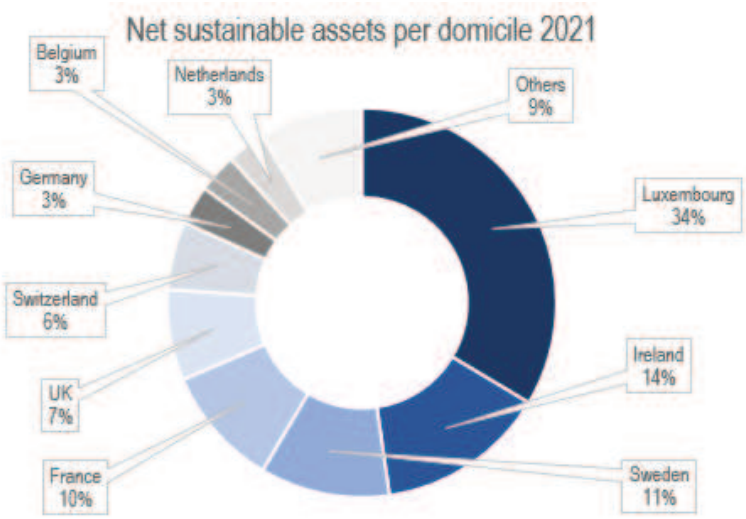
Figure 10: SFDR Fund Type Breakdown (percentages of AUM)



Source: own illustration with data from PwC 2022 & Morningstar 2023.

This corroborates the tendency of European funds towards sustainable investment. In addition, several surveys carried out by different institutions indicate that fund managers plan to continue to apply more sustainability criteria in the selection of fund portfolios, also due to the increasing pressure from investors for these financial products. The majority of European sustainable funds are domiciled in Luxembourg with 34%, followed by Ireland with 14% and Sweden with 11%. See Figure 11.

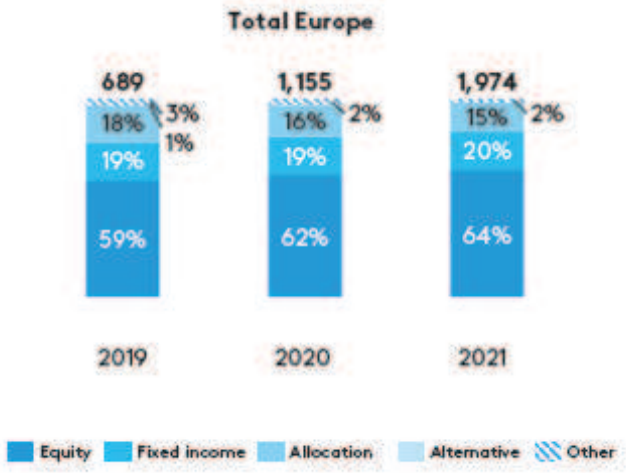
Figure 11: Net sustainable European assets per domicile in 2021



Source: own illustration based on ALFI, 2021.

A clear trend exists towards active sustainable funds over passive, holding 88% of the market share as of 2022. Furthermore, with regard to asset class (figure 12), the most important asset class is equity, followed by fixed income and allocation (divides the investment portfolio among the different asset classes).

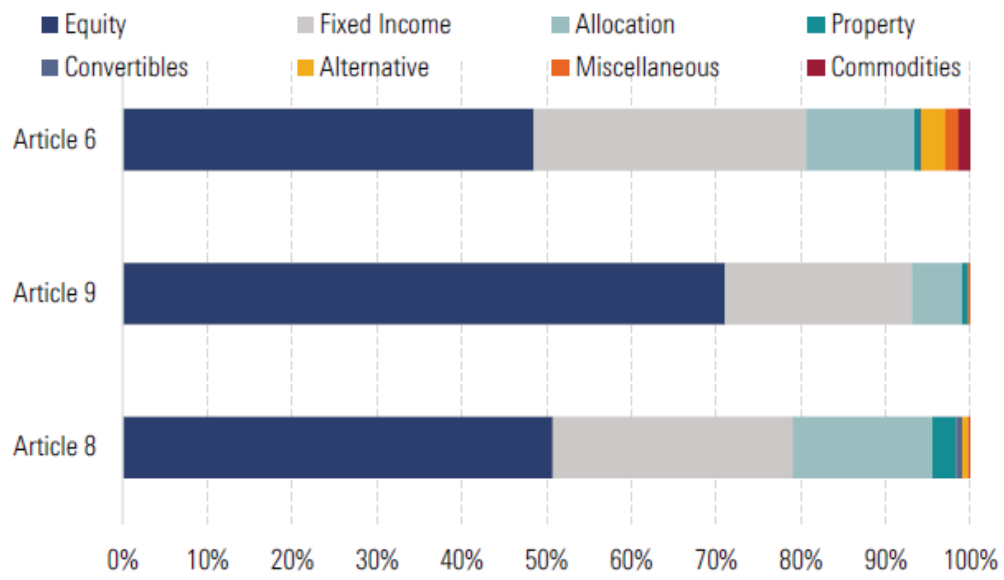
Figure 12: Asset class distribution by net assets



Source: ALFI 2021.

Under the SFDR framework, equity also has the highest weighting in both Article 8 and Article 9 funds (figure 13).

Figure 13: Article 8 and 9 Funds per asset class



Source: Morningstar 2023.

This could possibly relate to the desire for higher returns, even if the risk exposure is higher. A study states that sustainable funds are less risky than traditional funds (Yue, Han, Teresiene, Merkyte, & Liu, 2020). In addition, higher scored mutual funds offer better protection against extreme losses (Durán, Otero, Correia & Reboredo, 2019). As published in Wiley, Corporate Social Responsibility and Environmental Management (2021), a study of the performance of mutual funds in Europe found evidence of the superior efficiency of funds investing in high ESG-rated securities. In addition, investors who decide to allocate their resources in equity funds of European asset managers with a preference for ESG criteria would obtain superior financial efficiency than investing in similar funds with less sustainable investment policies (Abate, Basile and Ferrari, 2021). Hence, investment policies based on ESG criteria seem to enjoy a competitive advantage because of their inclusion of non-financial data. However, an increasing demand of socially responsible assets increases risks as well (Yue, Han, Teresiene, Merkyte, & Liu, 2020).

3 Methodology

After examining the theoretical part of the MVO, understanding the ESG context in Europe and getting to know the main characteristics of European sustainable funds, an overview was obtained that helps to determine how and which funds to select for portfolio construction. This chapter then moves on to the description of the methodological design and the examination of the collected data. Lastly, the last section describes in detail the whole process until the efficient frontier, and thus the optimal portfolio, is reached.

3.1 Research design and approach

In this section, it is elucidated the research design and approach adopted for this thesis, aimed at constructing an optimal portfolio of European sustainable funds through the MVO model, which can be used by any type of risk investor. This research employs a quantitative approach to rigorously analyse and quantify the financial data associated with European sustainable funds as well as carry out the method. Quantitative methods allow the systematic assessment of fund performance, risk characteristics and other quantitative variables.

Since the optimal portfolio, as mentioned in the theoretical part, is suitable for any type of risk investor, the analysis concludes with portfolio recommendations for each type of profile. Moreover, the study adopts an exploratory scope to investigate the diverse landscape of European sustainable funds and their associated performance. In conjunction with the longitudinal design, fund returns and related variables over an extended period are examined. This design is crucial for tracking performance trends, observing variations and evaluating the stability and persistence of returns. The fact that sustainability is aligned with long-term makes it necessary to orientate the study to this time horizon. For this reason, monthly returns for five years from European sustainable funds were collected. The period for the collection of the returns is from July 2018 to June 2023. Indeed, in 2018 the APSF was published and since then the conception of the importance of ESG in the capital market has changed forever. Many funds started to be launched and also many others were restructured (repurposed) to be stricter in this matter.

In 2021, about 14% of the net assets in sustainable funds domiciled in Europe originated from new fund launches and conventional funds that were repurposed to sustainable funds by asset managers (ALFI, 2022).

The optimal portfolio is determined through MVO and numerical analysis. MVO involves carrying out a correlational perspective to test relationships and dependencies between funds and their performance. The correlation between the European sustainable funds leads to a view on the degree of relationship between the funds, which is a fundamental principle for the selection of the funds to be included in the portfolio. Therefore, the scope is exploratory and correlational.

Panel data analysis is employed in this research to accommodate the longitudinal aspect and address the multi-dimensional nature of the data. The use of panel data allows for the assessment of fund performance across different funds and periods, enabling a comprehensive understanding of the risk-return profiles of European sustainable investment funds. This, in turn, aids in optimizing the portfolio effectively using the MVO model.

While there are many software packages for the construction of the efficient frontier, and hence the discovery of the optimal portfolio, the method in this thesis is carried out with Microsoft Excel. Mainly due to its global accessibility, but also because it is the only tool available to the author. This method of resolution is implemented by Bodie et al. (2012) in the book “Investments” (9th ed.) (p. 234-239). It will be explained step by step in section 3.3.

3.2 Source, data collection and its interpretation

The data necessary for the construction of the optimal portfolio was downloaded from the Morningstar Direct database. From there the monthly returns were collected, from the beginning of July 2018 to the end of June 2023 of the oldest share class of equity open-end funds, domiciled in Europe and denominated in Euro. The starting year of data collection is when the APSF came into effect and therefore when sustainability in investment assets started to be taken into account the most and, most important, as a regulatory level. Therefore, many funds

self-considered sustainable had to be framed according to these regulations, causing many to adapt themselves to be catalogued as sustainable. In this way, it is understood that this regulation in sustainability has been taken as essential in the creation and maintenance of the funds; as well as, it is understood that the returns obtained prior to this regulation did not come from 100% sustainable investments in some cases. Although investing in sustainability implies investing in the long-term and, therefore, the returns to be collected should be consistent with that time horizon, from a sustainability point of view it is indispensable to take into account that the real criteria has started in 2018. In this way the performance after they adopted "regulated" sustainable strategies can be assessed. Despite taking a more medium-term period, the sample includes a period of global crisis due to the coronavirus pandemic, which allows to observe how the funds performed in “normal” years, before, during and after the pandemic, which is used as a reference to understand future fund performance.

According to the previous chapter, the optimal portfolio is composed of risky assets. Therefore, the funds selected should correspond to this issue, which means that funds that invest in equity should be selected. In addition, to further unify the criteria, funds whose currency is the Euro were selected. In the research article "The level of sustainability and mutual fund performance in Europe: An empirical analysis using ESG ratings" (Abate et al., 2021), it is specified that this type of criterion when investigating European sustainable funds is typical.

In order to select sustainable funds, some filters had to be applied. Firstly, those that fall under the EU's SFDR were filtered out, thus Article 8 and 9 funds were selected[2]. Then a further selection was made based on the Morningstar Sustainability Rating. The use of this rating is related to the fact that the Morningstar platform is being used for data selection, which is a matter of ease of selection. But also on the other hand, the advantage of this rating, as mentioned, is that the globes are assigned by comparing all the funds in the same category. This relative assessment provides context and helps to understand whether a fund is a

[2] It should be noted that Article 8 and 9 funds selected to carry out the MVO method are those classified as such at the time of writing the thesis. Funds can be reclassified, specially when the SFDR was recently implemented.

leader or laggard in terms of sustainability within its investment universe and, thus, assess how well a fund is performing relative to its peers. Hence, all funds whose Morningstar Sustainability Rating was less than 5 globes were removed. In this way, it was confirmed that all the remaining funds were ranked with 5 globes. Even if they are classified as Article 8 and 9, this does not guarantee that the rating is the best. Therefore, thanks to this rating, the most sustainable funds of the categories are obtained, as explained in section 2.2.2. As a result of these selections, funds that not only align their investment objectives with sustainability, but also are classified and recognised as sustainable were obtained.

When getting deeper into the fund's monthly returns, many of the funds did not have them for several periods, meaning that they were launched within the five years of the analysis. To avoid bias and to have a uniform criterion, those funds were removed. Only funds that did not have a maximum of the first six months of returns were taken into account. It would be biased to consider the recently launched funds, because (1) this thesis wants to analyse how the funds behave over a long period of time and (2) funds that have just come on the market are very volatile. Regarding the second criteria, when a new fund is launched, it can experience heightened volatility in its early stages. This is a common concept in the world of finance and investing. This initial volatility may stem from uncertainties about the fund's investment strategy, asset allocation, market conditions and investor interest. Therefore, out of 310 European sustainable investment funds, 100 were eliminated from the sample (210 remaining). This means that almost half of them were launched between these 5 years, which demonstrates and relates to figure 9 which shows the large growth of these funds in recent years.

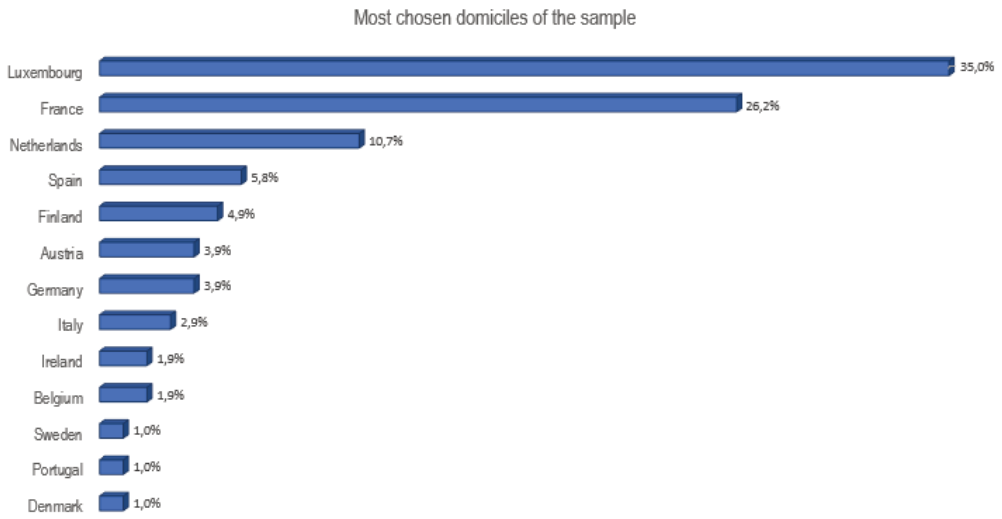
Moreover, to construct a portfolio of sustainable funds a distinction has to be made. In the previous chapter, John Bogle was mentioned, who is considered the "Godfather" of mutual funds. He recommends selecting low-cost funds when selecting actively managed funds, due to the cost of investing. The expense ratio would be the appropriate measure to separate low-cost from high-cost funds, since it determines the cost of owning a fund (based on AUM), including all the costs. However, this ratio is not provided by Morningstar Direct or at least not at the time of writing the thesis. As a result, the selection was made according to

the management fees. A study conducted by RIA in a Box (2019), has shown that the majority of the firms charge between 0,96%-1% of management fees. Therefore, in order to maintain both actively managed funds and passively managed funds into the sample and based on the fact that management fees usually vary anywhere from 0,20% to 2,00% (Corporate Finance Institute, 2023), funds with a fee of less than 1,00% have been selected as low-cost. Based on this selection, the total number of European sustainable funds is 103, which indicates that almost the half of the remaining funds has very high management fees. Overall, the MVO will be constructed with 103 low-cost European sustainable funds. In order to provide context and gain an appreciation of the sample of funds, the main characteristics are detailed hereunder.

The inception dates of the funds go from 1938 to 2018, i.e., there is a large range of years in which the funds have been launched. Knowing the inception date of the funds that make up the optimal portfolio will determine whether funds that have been in the market for a long time were able to adapt to today's conditions to perform well enough and become part of the portfolio. It will also determine whether more recently launched funds are better able to achieve better returns. Or whether a combination of old and new funds is the optimal choice.

In line with the traits of European sustainable funds described in the previous chapter, this sample also has 35,0% of the funds domiciled in Luxembourg, which is indisputably the number one domicile for mutual funds. This is followed by France with 26,2% and the Netherlands with 10,7%. Figure 14 shows the domiciles.

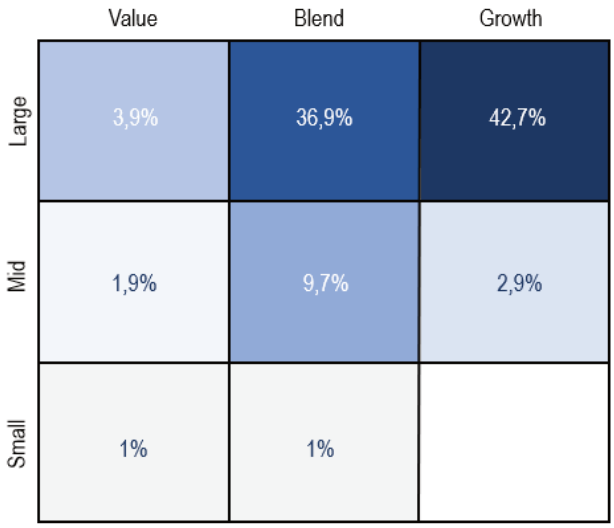
Figure 14: Most chosen domiciles of the sample



Source: own illustration with data from Morningstar.

There is a predominance of funds in the sample that aim for a growth approach in large cap companies, as figure 15 indicates. This is aligned with the sustainability strategy, which is to invest in the long term. Most funds have a focus on growth companies, which have a long-term vision and strategy. Investors who are willing to hold their investments over a longer period may find growth companies attractive, as their value can increase significantly over time as the company realises its growth potential.

Figure 15: Equity style of the fund's sample

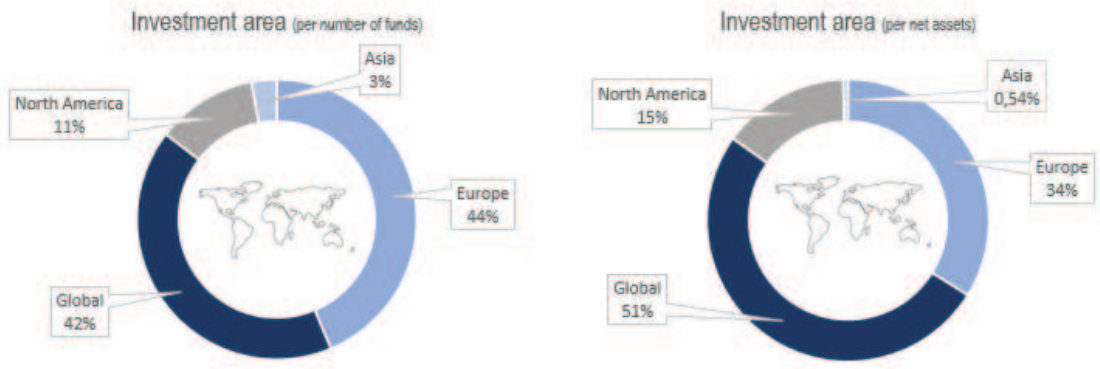


Source: own illustration based on Morningstar figure.

On the other hand, there are not many funds that concentrate 100% on the value approach, which look for stocks trading cheap and companies who pay large dividends. However, there are many funds that prefer a blend approach among large cap companies. They do not only seek potential growth or capital appreciation, but also dividend income as their investment objectives. Funds with large-cap focus, invest in companies with the highest market capitalization, thus these are typically well-established and financially stable companies. These are generally considered less risky compared to mid- and small-cap. Funds with a mid-cap approach invest in companies with market capitalization between large and small-cap and are considered to have a moderate level of risk and potential for higher returns compared to large-caps. Whereas the minority choose for small-cap options, opting for companies with the smallest market capitalization, often newer or less established in the market. These may experience the highest market fluctuations. In the sample there are also a few funds that select mid-cap options, which choose a blend approach, rather than selecting straight growth or value. Specifically in this market sector, European sustainable funds managers may choose more growth companies because they are associated with innovation, technology and forward-thinking solutions. They conduct their operations with the long-term in mind, aligning them with ESG criteria. This is corroborated by Morgan Stanley (2023), in whose analysis of sustainable funds, they assert that sustainable investment funds tend to lean towards growth stocks, due to the search for longer-term opportunities. The emphasis on large-growth companies reflects the belief that these companies can drive positive change and contribute to a more sustainable future.

Figure 16 reveals the areas where the European sustainable funds of the sample allocate the capital. The majority of the funds allocate their capital to countries in Europe, but there is not much difference between the amount they invest globally, i.e. they do not distinguish in a specific geographical area. This is followed by those investing in North America and finally in Asia.

Figure 16: Investment area of the fund's sample



Source: own illustration with data from Morningstar Direct.

Nevertheless, in terms of net assets, half of them are invested globally. If almost the same number of funds invest in Europe or globally, but in terms of net assets more than half invest globally, it means that funds with the highest AUM in the sample choose to invest globally. The allocation is quite diversified, even if the objective is sustainability. Although there is a clear tendency to invest in Europe or to have a global mix. The fact that there is diversification in the geographical area helps to reduce the risk due to the different economic cycles or geopolitical events faced by the different regions.

Historical return and return fluctuation, called risk and measured in standard deviation, are measures to consider when investing. Although the funds invest in different geographic areas, returns fluctuate along the same path. The table 4 reports the maximum and minimum return and standard deviation that a fund has achieved, but also the mean of the return and risk of each year. The last column summarizes the annualized return and risk of the whole years.

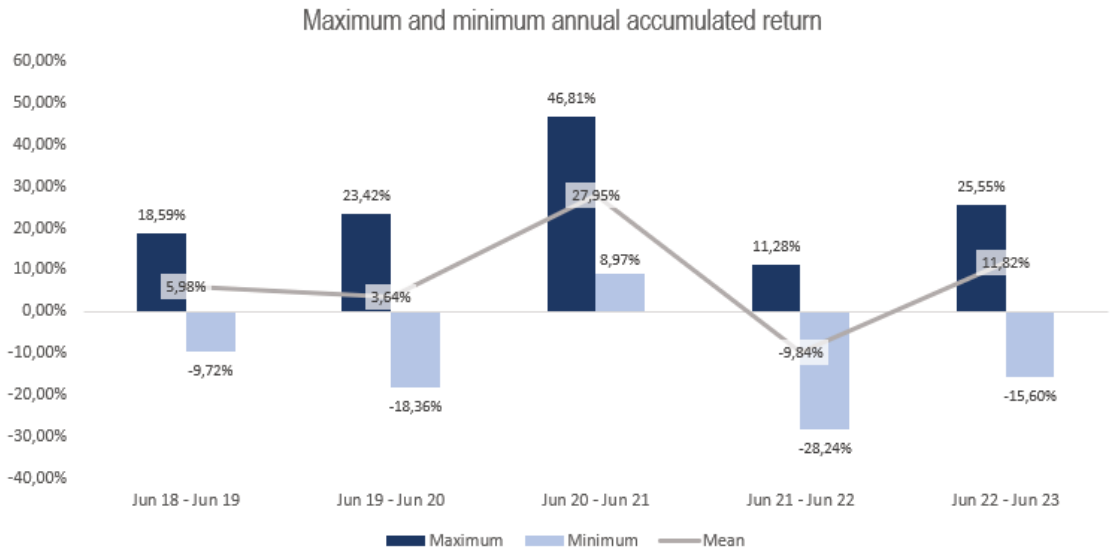
Table 4: Return and risk through the years

Annual accumulated		Jun 18 - Jun 19	Jun 19 - Jun 20	Jun 20 - Jun 21	Jun 21 - Jun 22	Jun 22 - Jun 23	Average
Expected return	Mean	5,98%	3,64%	27,95%	-9,84%	11,82%	7,91%
	Maximum	18,59%	23,42%	46,81%	11,28%	25,55%	16,53%
	Minimum	-9,72%	-18,36%	8,97%	-28,24%	-15,60%	-2,39%
Standard deviation	Mean	15,73%	21,69%	14,08%	14,70%	18,30%	17,16%
	Maximum	21,61%	34,91%	26,11%	21,43%	32,04%	24,93%
	Minimum	2,83%	9,30%	5,06%	6,37%	4,68%	7,24%

Source: own illustration with data from Morningstar Direct.

This last column indicates that the expected return can vary between 16,53% and -2,39% annually. While the standard deviation can vary between 24,93% and 7,24%. Analysing the periods, the first one did not present as much gap between the maximum and the minimum as can be observed in the others. Therefore, it could be considered a stable period, also taking into account that it was a period without global "anomalies". At the start of the pandemic in March 2020, the equity market declined globally due to the uncertainty of the coronavirus, creating a large gap between negative and positive return funds. Risk (or volatility) increased significantly. Over the course of the pandemic and early post-pandemic, the market experienced a dramatic rise, with none of the funds under analysis losing. But in the following period, in the post-pandemic, the market compensated downwards, where most of the funds had negative returns by an average of -9,84%. From June 2022 to June 2023, they are settling in, still with high volatility. Figure 17 illustrates these concepts for better visualisation.

Figure 17: Maximum and minimum annual accumulated return

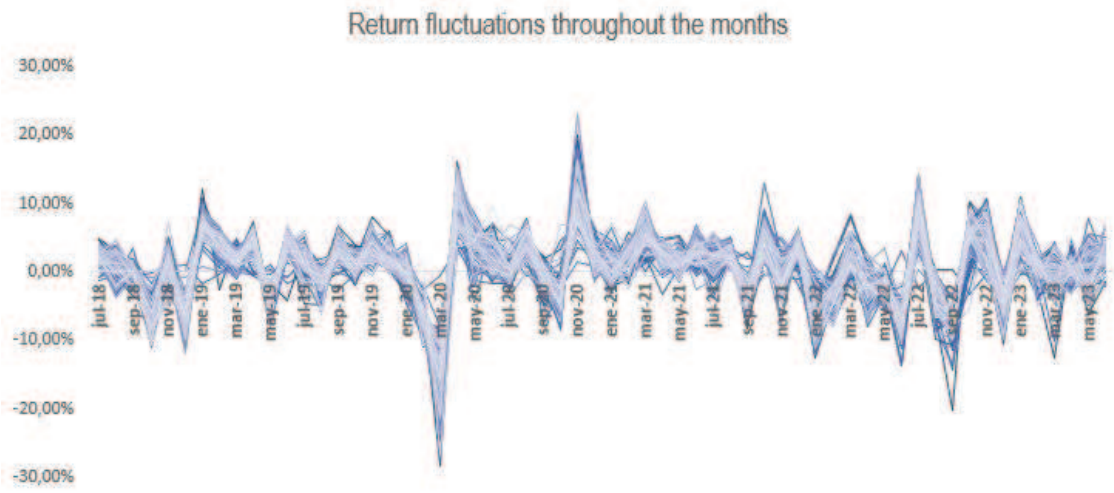


Source: own illustration.

Through the MVO, the combination of funds that generates the optimal portfolio maximising risk and minimising return will be found. This method, as explained in chapter 2, takes into account the covariance of the funds, which can also be illustrated by the correlations. While they will be calculated in the next section, figure 18 gives an indication of what these correlations look like, showing the

return fluctuations throughout the months under analysis. Since returns fluctuate mostly in the same direction, it could be anticipated that correlations are positive, although this would be corroborated with the calculation.

Figure 18: Return fluctuations throughout the months



Source: own illustration with data from Morningstar Direct.

The portfolio construction process must take into account these described characteristics of the sample, because it will then be necessary to understand why the result is the optimal combination among all the other funds that were not chosen. As well as evaluating the methodology according to the criteria it includes for this selection.

3.3 Optimal portfolio construction process

The goal is to find the portfolio weights that strike a balance between maximizing return and minimizing risk. The process is carried out on the basis of Figure 1, where the inputs are the asset returns and volatility (measured as the standard deviation of the returns). The calculation of correlation will be part of the process. Normally, portfolio constraints such as maximum weight, number of assets held, risk fraction, etc. should also be taken into account, but in this case, the portfolio is not being built for a specific profile and there are no requirements if the optimal risky portfolio of European sustainable funds in general wants to be found. The interest comes from knowing what is the optimal return and risk for this type of investment category.

As mentioned in the previous section, the total number of European sustainable funds included in the process is 103, which correspond to low-cost funds for the investor. The MVO methodology comes with the idea of why choose only one investment fund, if it can be built a portfolio of funds that leads to a better risk-return objective. The construction process is presented hereafter in a step-by-step manner.

3.3.1 Identify risk-return combinations

The phrase "past performance is not indicative of future results" is a standard disclaimer used in finance and investment contexts. It is included in almost all prospects of investments and it underlines that historical performance of an investment or financial product does not guarantee or predict its future performance. However, it is the best predictor of future behaviour in similar situations (Talogy Inc., 2023). When certain criteria or methodologies are used to assess prospective future outcomes, examining past performance can still be valuable. According to Bogle (2010), “the stock and bond markets are unpredictable on a short-term basis, but their long-term patterns of risk and return have proved durable enough to serve as the basis for a long-term strategy that leads to investment success. A study of the past, accompanied by a self-administered dose of common sense, is the intelligent investor’s best recourse”. Hence, it is for this reason that past returns should be used for the construction of an optimal portfolio.

To begin with, the first step of the process requires to identify the returns and risk of each fund. For this purpose, monthly returns from July 2018 to June 2023 were downloaded from Morningstar Direct database. With the monthly returns, calculated as formula 6 indicates, it is possible to calculate the average annual return of each fund, which is a part of the risk premium calculation. The risk is measured by the volatility; therefore, the annualised standard deviation of the monthly returns has been calculated. This leads to the next step.

3.3.2 Determine risk-free rate and risk premium of each fund

Introducing Tobin's contribution to the process, to calculate the risk premium it is

necessary to determine the risk-free rate. Although the risk-free rate is not relevant to portfolio construction itself, it is the one that will determine the Sharpe ratio and, therefore, the slope of the CAL. Therefore, it is necessary to give importance to it. Government bonds are used as a risk-free asset. The sample of funds comprise all funds with euro currency, therefore the risk-free asset used must be located in a country with Euro currency. There are government bonds in the Euro area issued by the European Central Bank, which refer to sovereign bonds issued by countries within the Eurozone with the highest credit rating of "AAA" from credit rating organizations. These bonds are considered to be among the safest investments in the Euro area. Credit ratings, however, can change over time due to economic and political factors. Events occurring in one member state can impact the performance of these bonds. For this reason, the German government bond is often considered a benchmark precisely because Germany's economic and political stability is relatively higher compared to some other Euro area countries. As stated by the OECD (2014), "[…] the German economy has proved remarkably resilient, outperforming other large, high-income European economies. The German government's consistent commitment to fiscal responsibility and financial prudence has earned it a strong reputation, minimizing the risk of default on its bonds. This solid credit profile, in addition to the long-term investment approach of sustainability, makes the 10-year German Government Bond a good indicator for a risk-free rate. Thanks to Germany's economic stability, creditworthiness, market acceptance, liquidity, historical stability and its representation of the euro area economy, the 10-year German government bond is taken as the risk-free rate in this case.

A representative risk-free rate for this case would be then the projection of the 10-year German government bond. In the current worldwide scenario, many conditions have affected the bond market and, as it may seem, many other events may arise that will keep the German bond at its actual yield, experiencing some fluctuations. Therefore, an average of the past and projected yield of the 10-year German government bond has been calculated. The projection has been made by Bankinter (2023).

Table 5: 10-year German Government Bond past and projection

10-year German Government Bond					
2021	2022	2023	2024	2025	Average
0,07	2,58	2,7	2,6	2,3	2,05

Source: own illustration with data from Bankinter and Trading Economics.

The average of these rates is 2,05%, which was used for the risk-free rate. For the calculation of the risk premium, the risk-free rate was subtracted from the annual return of each fund. As far as the risk premium of each fund was found, 5 funds in the sample were identified as having a negative risk premium. This indicates that the return of those funds is lower than the risk-free rate. No investor would want to obtain a return lower than the risk-free rate when taking a very high risk. Therefore, these funds were not taken into account in the following steps.

3.3.3 Build the covariance matrix – correlation between funds

As detailed in section 2.1.2, a covariance matrix reveals the covariance of each pair of assets. For building the matrix, the 60 monthly returns of the funds are needed, which are selected using the "Data Analysis" tool in Excel. Data Analysis is an add-in software in Excel, which helps to calculate specific parameters in less time, avoiding errors and repetitious work. Using the Covariance function from this tool, the covariance matrix is easily built. Once it is built, adding the asset weights on the borders of the matrix will lead to the bordered covariance matrix. When assets weights are known, the matrix will calculate as shown in table 2 the variance of the portfolio, which will lead to the calculation of the mean (risk premium) and standard deviation through the specific formulas. The risk premium calculation involves the return formula, but instead of using the returns, the risk premium calculated in the previous step is used. The weight of each asset is then multiplied by its risk premium, summing to arrive at the risk premium of the portfolio. The standard deviation is calculated using the variance obtained from the covariance matrix. The variance is the total sum of the weights of the assets multiplied by their covariances. The square root of the variance is the standard deviation, as shown in formula 2. To obtain the annualised volatility, the standard deviation must be multiplied by the root of 12. Lastly, the portfolio's Sharpe ratio is calculated by dividing the risk premium and the standard deviation, as shown

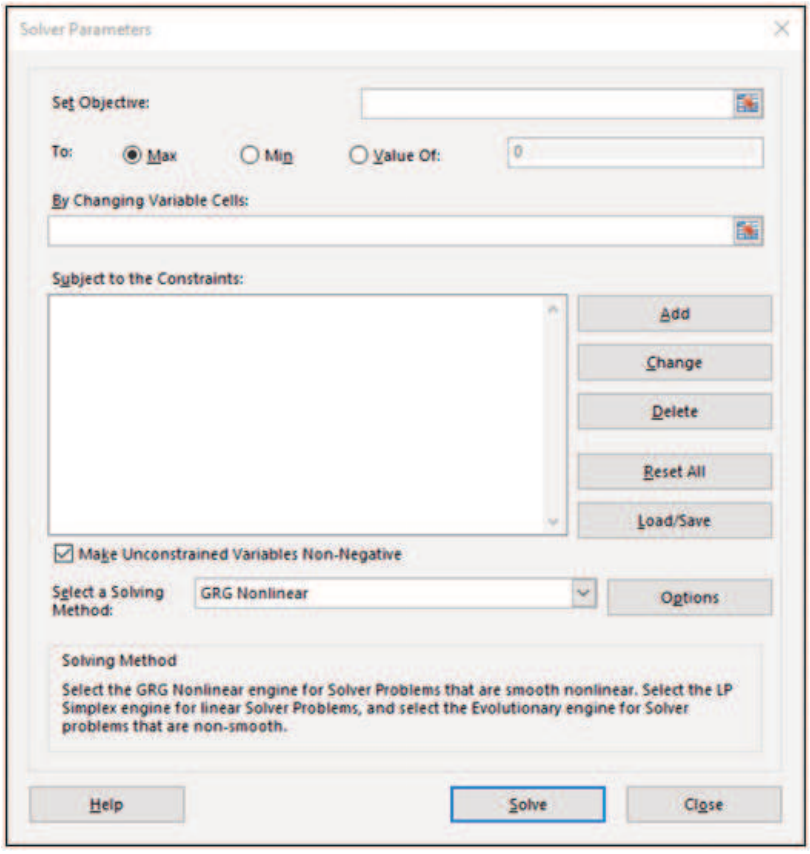
in formula 3. This ratio is the slope of the CAL and the optimal portfolio is the one that maximizes the Sharpe ratio. All these calculations are automated. Therefore, when the weights of the assets are changed, the risk premium, volatility and Sharpe ratio are automatically calculated. For the calculation of the weights the Solver tool is used, which will be explained in more detail in the next step.

In addition to these calculations the correlation coefficients between the funds have been computed, which helps to further identify the relationship of the funds and how they can influence each other. The coefficients are easily calculated using the Data Analysis tool, under the concept "correlation coefficient". Taking the 60 returns as the input, the result is a matrix with the correlations between funds.

3.3.4 The efficient frontier

The idea behind the efficient frontier is to find the ideal combination of assets that either provide the maximum expected return for a specific risk level or the lowest risk level for a specific expected return. As shown in Figure 3, it is represented by a graph where the x-axis is the standard deviation and the y-axis is the expected return. By including the CAL in the graph, the tangent point between the efficient frontier and the CAL refers to the optimal portfolio. Therefore, the efficient frontier will be formed to find this point. Thanks to Solver, another Excel add-in, it is possible to find optimal values (maximum or minimum) for certain already programmed formulas. According to Microsoft (2023), Solver works with a group of cells, called decision variables, that are used in computing the formulas in the objective and constraint cells. Solver adjusts the values in the decision variable cells to satisfy the limits on constraint cells and produce the result for the objective cell (Microsoft, 2023). This tool has many utilities and, in this thesis, it is used for portfolio optimization. Figure 19 shows the Solver tab, where the parameters must be adjusted according to what is to be optimized.

Figure 19: Solver Excel



In order to obtain the efficient frontier, it is necessary to understand the risk premium and risk of the portfolios that lie on it. These are the two variables that need to be optimized depending on the point one aims to achieve on the frontier: risk premium and standard deviation. The variables that are always in play are the portfolio weights, which will have values that meet the optimization objective. An important detail to emphasize is that each optimization must be subject to a constraint, in essence, the sum of the portfolio weights must equal 1. First and foremost, the desired risk premiums must be determined in order to graph the frontier. The extremes of the efficient frontier are the minimum-variance portfolio and the highest point is the highest risk premium from the funds. Table 6 helps in visualizing this concept. In the case of the minimum-variance portfolio, the goal is to find the point where risk is minimized and, therefore, the aim is to minimize the standard deviation. For the highest risk premium point, a constraint must be added, where the risk premium must equal the highest risk premium from the funds. Once both extremes are known, values of risk premium must be assigned between these points to form the frontier. Thus, the constraint now becomes that

the risk premium must equal the desired values on the efficient frontier.

Table 6: Solver Parameters for the efficient frontier construction

Solver Parameters	Portfolio		
	Minimum	Desired risk premiums	Highest risk premium
Set objective	Std	Std	Std
Max or Min	Min	Min	Min
Changing Variable Cells	Portfolio weights	Portfolio weights	Portfolio weights
Subject to the Constraints	Sum of the portfolio weights must equal to 1	Sum of the portfolio weights must equal to 1 Risk premium must equal the desired risk premium	Sum of the portfolio weights must equal to 1 Risk premium must equal the highest risk premium from the funds

The values obtained at each point, by automation of formulas, are then the standard deviation and the Sharpe ratio, since the input or set objective will be the risk premium. The portfolio weights in the bordered covariance matrix are also obtained. Each time Solver gives a solution to each of the required points, these must be copied to form a table that will be the input for the graph. Subsequently, the portfolio weights of each point and the total number of points along the efficient frontier are tabulated in the table. The following table provides an illustrative example.

Table 7: Table constructed by Solver's outputs

Portfolio	Min variance	Desired risk premiums	...	Highest risk premium
Risk premium				
Standard deviation				
Slope = Sharpe ratio				
Portfolio weights				
Fund 1				
Fund 2				
Fund 3				
Fund 4				
Fund 5				
Fund 6				
Fund 7				
Fund 8				
Fund 9				
...				

3.3.5 Identify the optimal portfolio

In this step the portfolio, located between the minimum-variance and the highest risk premium points, which has the highest Sharpe ratio, is searched for. To find it, two modifications have to be made to the Solver parameters. The target will now be the Sharpe ratio of the portfolio and it must be maximized. Besides, the constraint must only be that the sum of portfolio weights must be equal to 1. Table 8 shows these parameters.

Table 8: Solver parameters for optimal portfolio

Solver Parameters	Portfolio
	Optimal
Set objective	Sharpe ratio
Max or Min	Max
Changing Variable Cells	Portfolio weights
Subject to the Constraints	Sum of the portfolio weights must equal to 1

The optimal portfolio is tangent to the CAL. Hence, in order to graph all the points and create the CAL, the optimal portfolio has to be placed between the minimum-variance and the highest risk premium. The final table with Solver Parameters should look like the following table.

Table 9: Solver Parameters for all important points along the efficient frontier

Solver Parameters	Portfolio				
	Minimum	Desired risk premiums	Optimal	Desired risk premiums	Highest risk premium
Set objective	Std	Std	Sharpe ratio	Std	Std
Max or Min	Min	Min	Max	Min	Min
Changing Variable Cells	Portfolio weights	Portfolio weights	Portfolio weights	Portfolio weights	Portfolio weights
Subject to the Constraints	Sum of the portfolio weights must equal to 1	Sum of the portfolio weights must equal to 1 Risk premium must equal the desired risk premium	Sum of the portfolio weights must equal to 1	Sum of the portfolio weights must equal to 1 Risk premium must equal the desired risk premium	Sum of the portfolio weights must equal to 1 Risk premium must equal the highest risk premium from the funds

In order to plot the CAL on the same graph as the efficient frontier, the Sharpe ratio of the optimal portfolio must be used, since the slope of the CAL equals its Sharpe ratio. Therefore, it must be added to table 7 a last row with entries obtained by multiplying the standard deviation of each column's portfolio by the slope of the optimal portfolio (Bodie et al., 2012). The following table is the conjunction of all the previous steps, which is used to construct the Modern Portfolio Theory's graph.

Table 10: Data to build the graph according to the Modern Portfolio Theory

Portfolio	Min variance	Desired risk premiums	_	Optimal	Desired risk premium	_	Highest risk premium
Risk premium							
Standard deviation							
Slope = Sharpe ratio							
Portfolio weights							
Fund 1							
Fund 2							
Fund 3							
Fund 4							
Fund 5							
Fund 6							
Fund 7							
Fund 8							
Fund 9							
...							
CAL							

The following chapter analyses the resulting optimal portfolio.

4 Data analysis and results

After carrying out the MVO, the most efficient allocation of European sustainable funds has been found. Through the quantitative approach, the selection of the optimal portfolio that balances risk and return takes into account historical returns, volatility and correlations of the funds, which are interpreted in this chapter. Since the portfolio is of a risky nature because it considers funds that invest mainly in equity, the investor's risk tolerance will dictate the selection of proportions between the risky portfolio and risk-free asset. Many final portfolio options can be constructed according to the risk tolerance, as illustrated at the end of this chapter.

4.1 Interpretation of the optimal portfolio

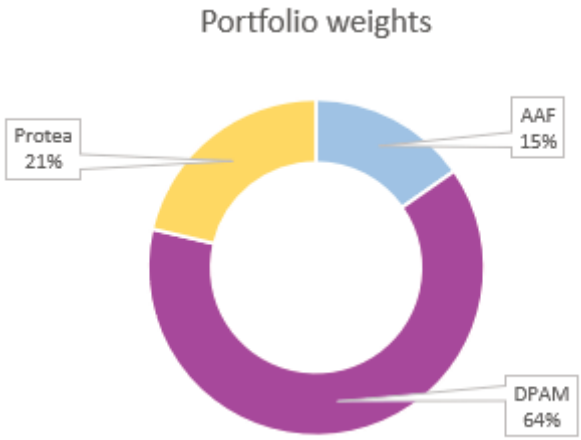
The optimal portfolio that aims to achieve a balance between financial performance and ESG considerations is integrated by three European sustainable funds, whose composition leads to the best possible risk-adjusted return. This indicates that among 103 funds, the combination of 3 of them[3] leads to the best balance between return and risk. The fact that the portfolio is composed of three funds already complies with Bogle's (2010) statement in section 2.3.1, that a portfolio of investment funds should not be composed of more than four or five funds in order not to result in overdiversification.

The main characteristic to highlight, of the portfolio's funds, is the inception date. Far from being funds that have been on the market for a long time, they are funds that have been created relatively recently, in 2016, 2017 and 2018. Possibly they have been created as a result of the high demand for sustainable products. Moreover, it can be interpreted as creating more diverse sustainable fund options that follow ESG regulations, despite targeting different objectives. This leads to the possibility of combining funds to seek better returns, due to low correlations. Beyond that, it is striking that no fund that has been on the market for a long time is making up the portfolio. This suggests that recently incorporated funds have a better capacity to adapt to market changes. In addition, it could be said that funds

[3] Appendix 4 describes the main characteristics of the funds composing the portfolio.

that were created close to the launch date of the APSF have a better risk-return performance than funds that have been on the market for many years. The three funds[4] that make up the portfolio are framed as Article 8 of the SFDR and domiciled in Luxembourg. Each fund has a corresponding weight in the portfolio, as determined by the MVO. Figure 20 shows the weight of the funds composing the optimal portfolio.

Figure 20: Fund's weights on the optimal portfolio



It is noticeable that there is a large dominance of the fund DPAM L Equities US SRI MSCI Index F (DPAM), which is an index fund that replicates the MSCI USA SRI Index. This index provides exposure to companies with outstanding ESG ratings in the US market. El DPAM is passively managed. The other two funds composing the portfolio are Protea Nao Responsible Europe Sd Cl (Protea) and AAF-Parnassus US ESG Eqs C€ (AAF), which are actively managed. Their characteristics are radically distinct to each other, being AAF a large-cap fund, DPAM a mid-cap fund and Protea a small-cap if compared each other.

Because funds that do not have a high management fee were taken into account when constructing the portfolio, this resulted in a fund that is not actively managed and has a very good performance dominating the portfolio. Although actively managed funds in general have a higher management fee for seeking higher returns, in this case, this passively managed fund has outperformed actively

[4] Funds' information is provided as of 31.10.2023.

managed funds that seek to outperform a benchmark. This may also be due to leaving out funds that have an above average, i.e. high, management fee. By leaving them out, passively managed funds that have a higher management fee for replicating indices that have very good returns, "compete" with actively managed funds that have a lower-than-average management fee. The result in this case is a portfolio dominated by an index fund consisting of 64% of the total allocation.

DPAM has a large-growth approach, where it allocates its assets to replicate the performance of the index it follows. It focuses on long-established companies with a long track record in the US (United States) market, as its name suggests. While the other two funds, which are actively managed, have a large-blend approach (see figure 21). While they look for companies that focus on long-term growth, they also look for stocks that are cheap and can yield good returns. AAF focused on the US and Protea focused on European companies.

Figure 21: Portfolio's style stock box

The investment emphasis of the sample funds on large-growth companies, mentioned in the previous chapter, shows that they perform better than value-growth, because the portfolio is mainly created by large-growth companies. Through this

approach, the aim is not only to maximize returns, but also to align them with the ESG objective that meets the long-term investment time horizon. The long-term view of the portfolio seeks, at the same time, to offset market volatility. The following section seeks to elucidate the return and risk of the optimal portfolio.

4.1.1 Risk and return

The allocation shown in figure 20 leads to certain annual risk and return of the portfolio. Table 11 shows the return and risk of the portfolio, 15,19% and 16%, respectively, and those of the component funds, while comparing with the annualized maximum and minimum of the sample funds.

Table 11: Annualized portfolio's risk and return

Annualized return					
Average	7,91%	AAF	DPAM	Protea	**Portfolio**
Maximum	16,53%	14,46%	16,53%	11,76%	**15,19%**
Minimum	-2,39%				

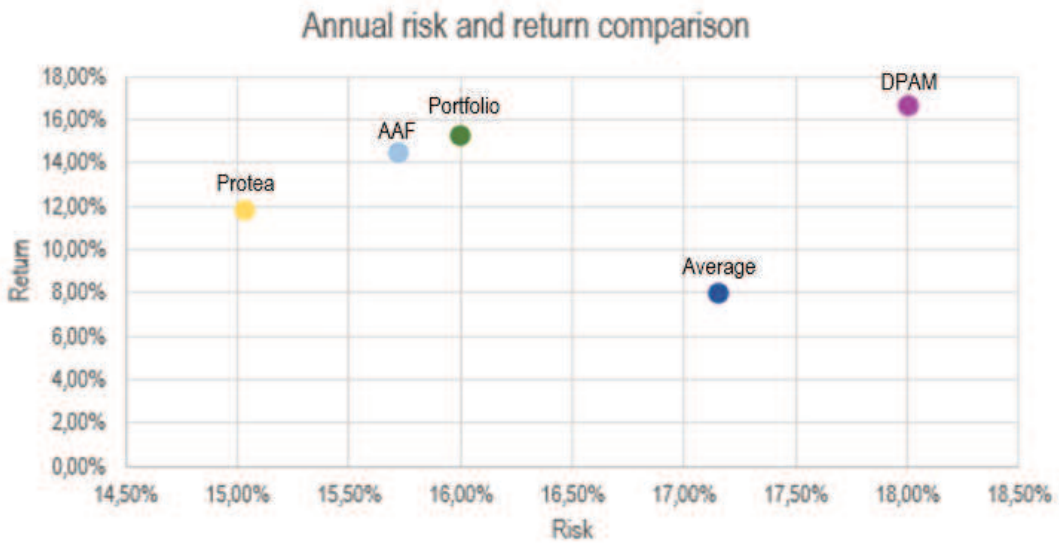
Annualized standard deviation					
Average	17,16%	AAF	DPAM	Protea	**Portfolio**
Maximum	24,93%	15,73%	18,01%	15,04%	**16,00%**
Minimum	7,24%				

- AAF (15% portfolio weight) has a return (14.46%) relatively close to the maximum and a risk (16%) lower than average.
- Protea (21% portfolio weight) has an annual return of 11.76% and a risk of 15.04%. It offers the lowest return at the lowest risk.
- DPAM (64% portfolio weight) has the highest return (16.53%), which is the maximum return in the sample, but also has the highest risk (18.01%). This means that it offers a potentially higher return, but at the cost of higher volatility.

Figure 22 illustrates these metrics in a graph. Allocating 100% of capital to DPAM means being prepared for greater fluctuations in value. For this reason, the portfolio is made up of two other funds that help to offset the risk significantly, keeping the return above that of these two funds and much better than the average. Through this diversification a balance is found between risk and return. In other words, this combination suggests that there is some level of diversification

benefit. Section 4.2. will go into detail regarding why the risk cannot be significantly reduced.

Figure 22: Annual risk and return comparison graphic



The portfolio thus has a return of 15,19%, which lies between the returns of the individual funds. The portfolio's risk at 16% is considered a moderate risk compared to the average and maximum of the sample. This suggests that the allocation has been balanced, whereby a return very close to the maximum return of the sample is achieved, decreasing the risk towards moderate. The volatility of the portfolio is reduced through diversification in the different sectors and countries in which it invests and, in addition, through a correct allocation in funds that maximize returns. At the same time, selecting funds that do not have such a high correlation and maximize returns.

The maximization of the return and, thus, minimization of the risk can be well appreciated through the risk-adjusted return. The table 12 gives an overview about this measure, the Sharpe ratio.

Table 12: Risk-adjusted returns

	Risk-adjusted return
AAF	0,7889
DPAM	0,8040
Protea	0,6456
Portfolio	0,8213
Average	0,3415

Notably, the portfolio's Sharpe ratio exceeds the average Sharpe ratio of the individual funds of the sample, indicating that the diversification and allocation strategy applied in the optimization process enhanced the risk-adjusted return of the overall portfolio. A Sharpe ratio of 0,82 suggests that, for each unit of risk, the portfolio is generating a return of 0,82 units above the risk-free rate. In addition, the optimal portfolio has the highest Sharpe ratio compared to the three funds composing it, which complies with what was described in the theoretical part. The portfolio provides a better return for the level of risk taken, optimising the trade-off between risk and return.

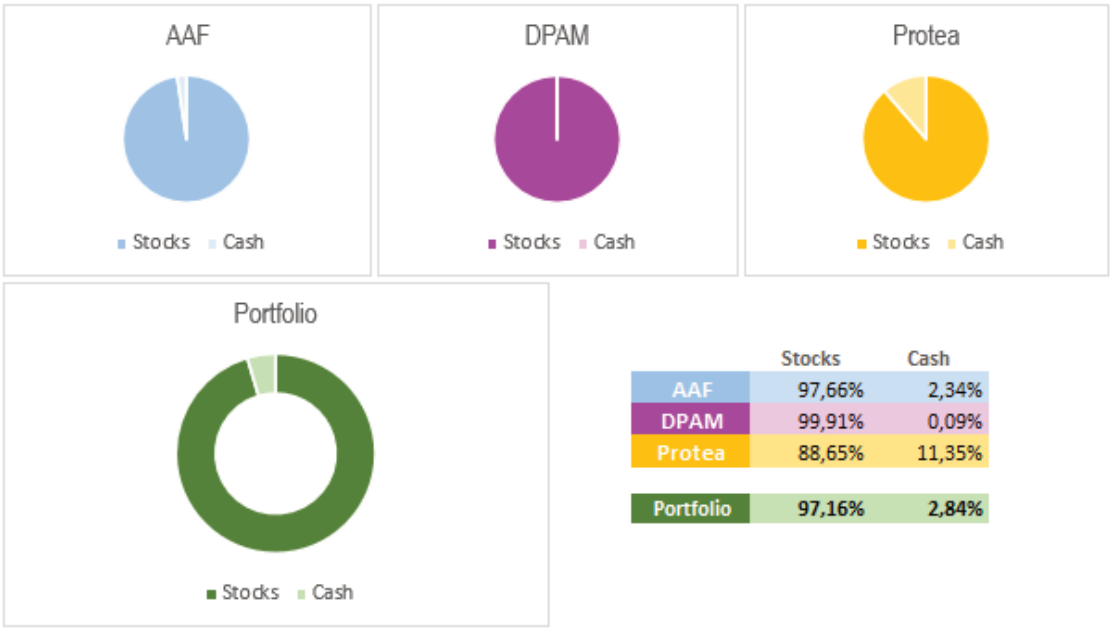
The process effectively balances the desired return against the associated risk, leading to a portfolio that offers superior risk-adjusted returns compared to the individual funds.

4.1.2 Asset allocation

Due to the fact that the sample funds used for the MVO process are equity funds, the optimal portfolio is mostly composed of stocks, which makes it risky. Figure 23 shows the asset allocation of each fund composing the portfolio and the optimal portfolio. The following are the key points:

- AAF has a high allocation to stocks, indicating a relatively aggressive investment approach. Since it has an active management, the fund managers are actively making decisions to outperform the market. For this reason, the cash may provide some liquidity to take advantage of investment opportunities that may arise unexpectedly or act as a defensive position when market volatility lights up.
- The index fund, DPAM, is heavily weighted in stocks, which is typical for a fund that aims to replicate the performance of a specific market index. With only 0,09% in cash, the fund is fully invested in stocks, mirroring the composition of the MSCI USA SRI Index.
- Protea has a lower allocation to stocks compared to the other actively managed fund. This suggests that the fund manager is more defensive believing that there are currently limited attractive investment opportunities in the market. It may also mean that he has a more uncertain view of what may happen in the market and prefers to hold liquid capital.

Figure 23: Funds' and portfolio's sector allocation



	Stocks	Cash
AAF	97,66%	2,34%
DPAM	99,91%	0,09%
Protea	88,65%	11,35%
Portfolio	97,16%	2,84%

According to the weight of each fund in the portfolio, it is composed of 97,16% in stocks and 2,84% in cash. As the main fund is the DPAM with 64% of the weight, it is expected that the portfolio will not face abrupt asset allocation variations, since the main objective is to track the index by holding a portfolio of securities that mirrors the index's composition. It may need to rebalance the composition to maintain the alignment with the index. However, while the index fund can experience some turnover, it is typically much lower than that of the two others actively managed funds. It is a kind of safeguard that the portfolio has, although it is risky.

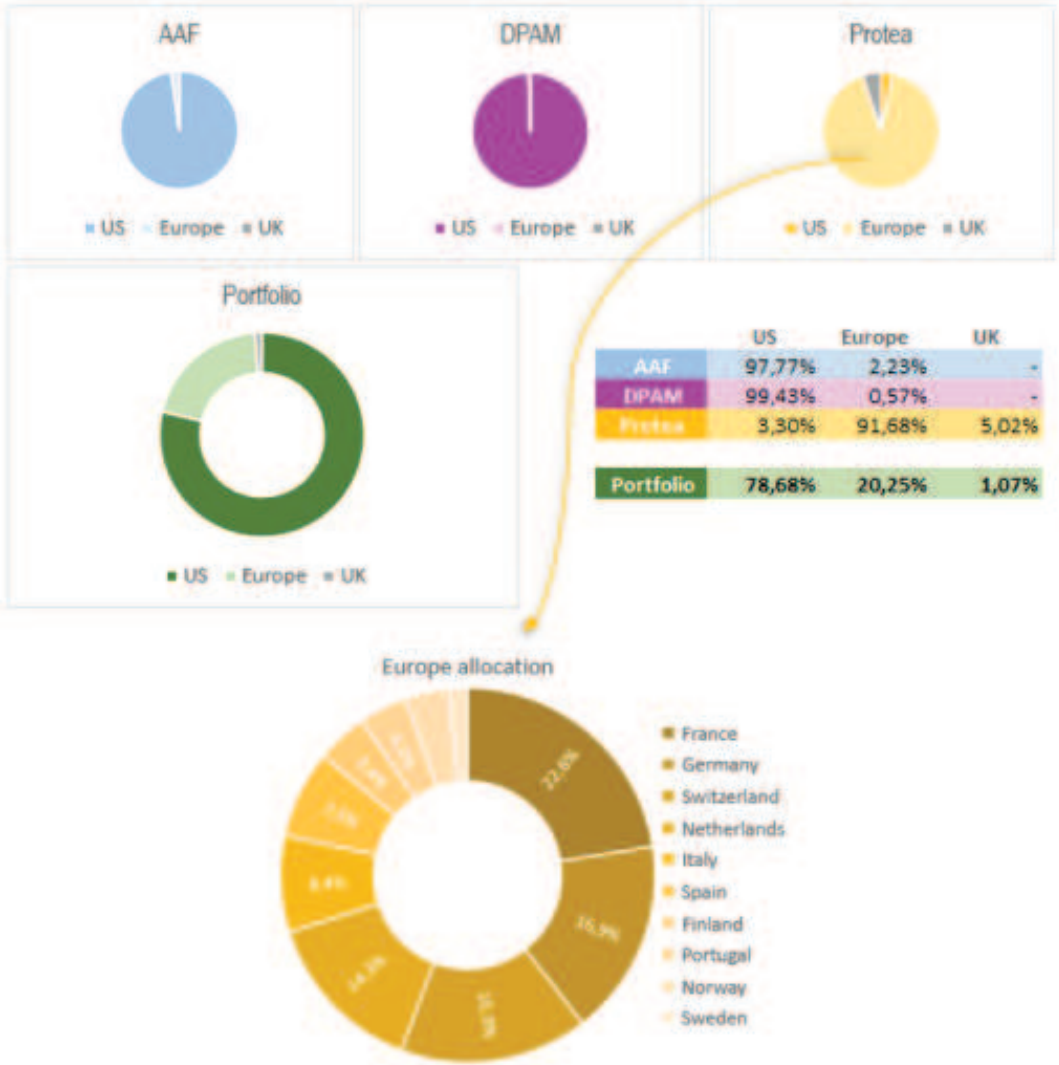
4.1.3 Country allocation

Before diving into the allocation of the three funds in particular, it is significant to retain that the sample funds have varied country allocation strategies. Most have three investment strategies: they invest globally, without maintaining a focus on a single market, or they concentrate on the US or European regions.

In the optimal portfolio, diversification through country allocation is divided into three locations: US, Europe and UK (United Kingdom). Figure 24 provides the information. Each fund's focus on specific markets is related to its investment objective. This may be one of the reasons why they can achieve better performance levels by focusing on only one or a few markets. Therefore, each

allocation is congruent with the investment objective of each fund, with two funds being US-dominated and one being European-dominated.

Figure 24: Fund's and portfolio's country allocation



The predominance of US and Europe in this portfolio has to do with several reasons. In principle, these funds were selected because of their high potential to achieve good returns and, thanks to their correlations, the optimal proportion of them can lead to better returns if they are combined. In addition, the fact that these funds invest mainly in Europe and the US is no coincidence. The US and Europe are home to some of the world's largest and most liquid financial markets. Moreover, these regions have well-established regulatory frameworks that support sustainable investing, as described in section 2.2. This transparency is crucial for sustainable funds that prioritise ESG criteria in their investment decisions.

Moreover, the adaptability of companies in these regions towards being up-to-date on ESG is predominant. In order to assess the ESG performance of potential investments it is essential to have reliable and robust information, which is more readily available in the US and Europe. On the other hand, these markets are the most familiar, which is a way of mitigating certain risks associated with investing in unfamiliar or emerging markets. Fund managers may be comfortable focusing their approach to these regions. Nevertheless, it is not excluded that some other markets may be found to be worth investing in, as sustainable investing is gaining importance globally.

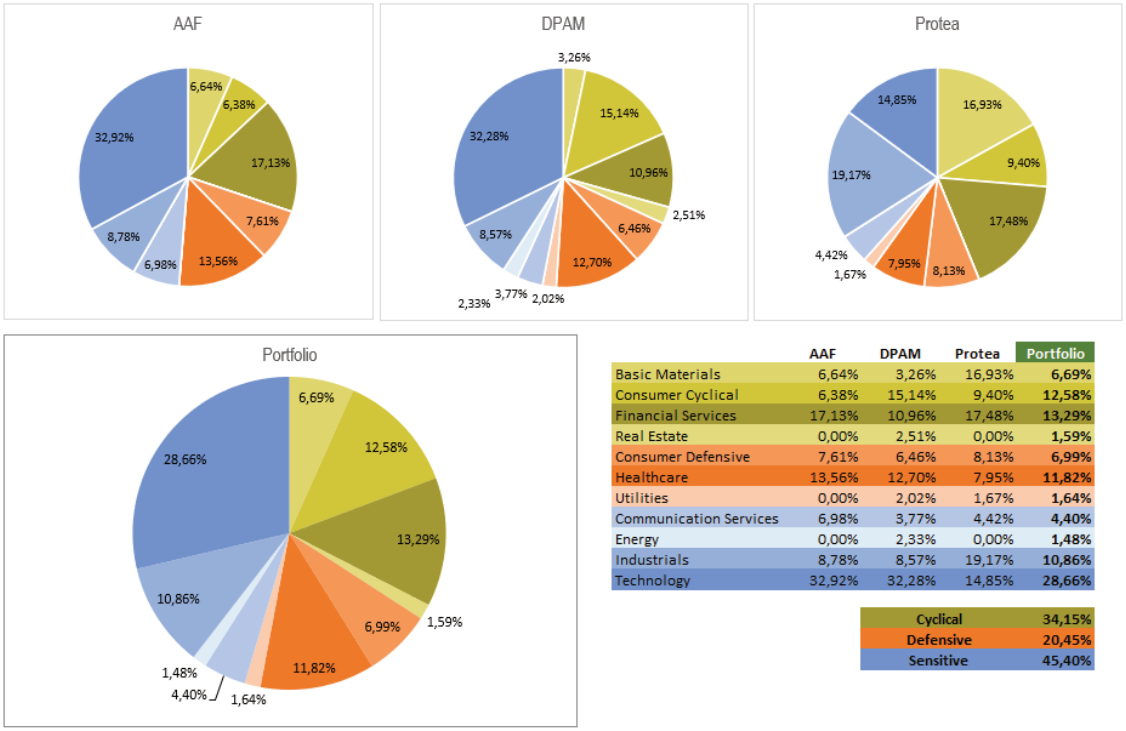
The US and Europe are different regions in which the funds invest. The countries in which the Protea fund invests also have different characteristics. The fact that the portfolio is diversified across the US, Europe and the UK helps to diversify risk across countries experiencing different economic cycles. While one country may be experiencing growth, another may be in a downturn. In addition, different countries may have varying degrees of exposure to different industries and sectors. By diversifying across these different countries, the portfolio is gaining exposure to a broader range of industries, what is explained in the next section.

The portfolio is heavily weighted towards the US market with 78,68%. Although 64% of the weight is from an index fund, which may provide more stability, having a large weight in a single country leads to greater exposure to risk. However, splitting the capital between these three funds reduces the risk of investing only in the one with the best return.

4.1.4 Industry sector

In the diversification across countries or regions there is a clear trend towards the US and Europe, which was explained in the previous section. This diversification brings with it the risk of significantly exposing the portfolio to the US with 78.68%. However, by diversifying across countries the portfolio is also spreading across sectors, which reduces the impact of a poor performance in a specific sector. It can be appreciated in Figure 25 that all three funds are broadly diversified, although greater exposure to certain sectors can be observed.

Figure 25: Fund's and portfolio's industry sector allocation



	AAF	DPAM	Protea	Portfolio
Basic Materials	6,64%	3,26%	16,93%	**6,69%**
Consumer Cyclical	6,38%	15,14%	9,40%	**12,58%**
Financial Services	17,13%	10,96%	17,48%	**13,29%**
Real Estate	0,00%	2,51%	0,00%	**1,59%**
Consumer Defensive	7,61%	6,46%	8,13%	**6,99%**
Healthcare	13,56%	12,70%	7,95%	**11,82%**
Utilities	0,00%	2,02%	1,67%	**1,64%**
Communication Services	6,98%	3,77%	4,42%	**4,40%**
Energy	0,00%	2,33%	0,00%	**1,48%**
Industrials	8,78%	8,57%	19,17%	**10,86%**
Technology	32,92%	32,28%	14,85%	**28,66%**

Cyclical	**34,15%**
Defensive	**20,45%**
Sensitive	**45,40%**

The technology sector is predominant in AAF and DPAM, which may be due to the fact that these types of companies are mostly located in the country of primary focus of these funds, the US. Companies in this sector are the ones that are always up to date with new technologies, which can lead to significant growth opportunities. Moreover, "technological innovations and transformations in the industry are also deeply affecting the financial sector. These challenges require large investments, redefinitions of the business models of every institution, and new ways of engaging with customers, suppliers and all stakeholders. [...] financial institutions have the capabilities to manage these changes" (European Banking Authority, 2022, p. 6). This key role that financial institutions are playing, also by helping with the expansion to a sustainable focus, is reflected in the sector allocation of these funds, being the second sector in which they invest the most. Another cyclical sector in which principally DPAM and Protea have a large weight is consumer cyclical. Being a sector that often profits from period of economic growth and expansion, it provides great diversification to the portfolio. On the defensive industry side, healthcare has the largest capital allocation, as it is a sector that is generally not influenced by economic conditions. It is important to note that only DPAM invests in the energy sector a small fraction. This may be

because commodity prices are influenced by global economic conditions, which makes it a very volatile sector. But it may also be that, by prioritising ESG factors, companies in this sector are not at the moment mostly associated with sustainability, even though Europe and the US are continuously launching regulations regarding this issue.

Based on the weighting of AAF, DPAM and Protea in the portfolio, the portfolio is diversified in industry sectors. It has a large weighting in the aforementioned sectors, as well as in industrials, a sector that is very similar to technology in terms of its behaviour when facing economic phenomena. The portfolio is heavily weighted in the sensitive and cyclical industries, which means that the defensive industry counterweight is not sufficient to counteract sudden changes in the market. During economic expansions, cyclical and sensitive industries are likely to experience a large fluctuation towards a profit, while they would experience losses in the face of recessions. The defensive sector will have almost no fluctuations in these events. This is also why the portfolio will be more focused on growth potential and this is what makes it risky. However, it also seeks to create a balance between this expansion capacity and stability.

Although the portfolio overall shows a fairly diversification, the MVO does not take into account diversification by asset, country or industry sector allocation, because it is based solely on historical returns. As a fully quantitative method, thanks to the optimal combination of AAF, DPAM and Protea, the best trade-off between return and risk can be achieved. The latter being reduced due to diversification in terms of market capitalization, type of funds and country and sector allocation. This way of allocating is not only determined by the returns, but also by the correlations of the returns, which is discussed in the next section.

4.2 Correlation analysis results and implications

As mentioned in the theoretical framework and according to Bogle (2012), “the variance of a portfolio is reduced if the covariance is negative. However, being the covariance positive, the portfolio standard deviation still is less than the weighted average of the individual security standard deviations”. This is only

invalid when the securities are perfectly positively correlated. Table 13 shows the standard deviation results. In this case the average standard deviation of the funds is slightly higher than that of the portfolio, which indicates that the funds are not perfectly positively correlated. However, it does indicate that they are positively correlated due to the closeness of these two values (16,26% funds' average and 16% portfolio's risk).

Table 13: Weighted average and portfolio's standard deviation

	Std
AAF	15,73%
DPAM	18,01%
Protea	15,04%
Average	16,26%
Portfolio	16,00%

The positive correlations shown in table 14 lead to positive covariances. The implication is that even if the latter are positive and very close to 1, there are still benefits to be gained from diversification. The correlations of the funds are indicating a relatively strong positive relationship between their returns.

Table 14: Funds' correlations

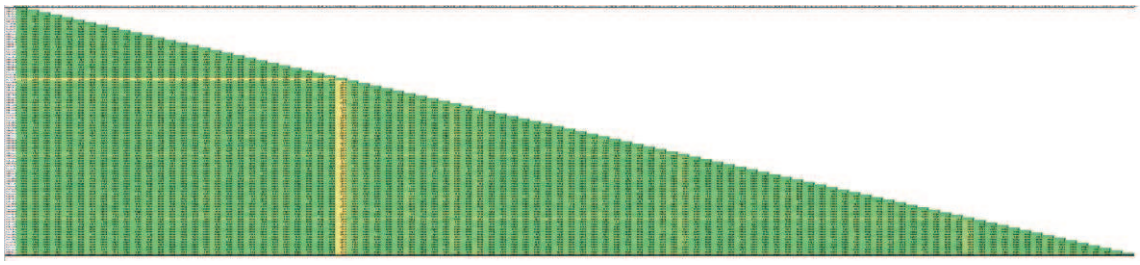
	AAF	DPAM	Protea
AAF	1		
DPAM	0,9565	1	
Protea	0,7183	0,686889	1

These non-low correlations suggest some level of commonality between funds that can lead to risk if the allocation between them is not adequate. Therefore, risk is mitigated when the perfect balance is found between these correlations to form the optimal portfolio, which provides some level of stability through their correlated behaviour.

Of particular importance to analyse are the correlations of all the funds taken into account for the construction of this portfolio, which make this result optimal. For this purpose, the heat map in figure 26 shows the correlations of the European sustainable funds in colour. Correlations that are perfectly positive or close to 1 are green, those close to -1 or negative are red, and those close to 0, indicating

that there is no linear relationship, are marked in yellow.

Figure 26: Heat map of correlations



Given a predominantly green map with only a few yellows, it can be noted that the correlations between European sustainable funds (equity) are very positive. This is the reason why the optimal portfolio cannot achieve a considerable diversification benefit. The high correlation of funds can be caused by several factors or a combination of them:

- Investment strategies: The investment strategy of each fund and its focus on specific sustainability sectors or factors may cause the funds to experience joint movements. If, for example, all funds focus on a specific area of sustainability or funds focus on specific market sectors. Further research is needed to find out if this is the case for all funds. However, for the three funds in the portfolio, there is a great deal of diversification by sector, although there is arguably a greater weighting in the technology sector. In terms of geographic areas, it was observed in figure 16 that the sample's funds were diversified across several of them.
- Homogeneity of portfolios: it is possible that funds are investing in similar companies with similar risk profiles and returns. In figure 15, it is notable that most funds choose a large-growth or large-blend approach. In this sense, it can be asserted that there is a tendency to invest in well-established and financially stable companies, which are considered less risky and reinvest the capital.
- Maturity of the sustainable market: the sustainable market could be considered relatively young, despite sustainability being discussed for a long time. The sustainability boom has occurred in recent years, giving rise to a large number of European sustainable funds. Therefore, it may be

primarily composed of a limited set of assets considered highly sustainable, making a high correlation of funds more likely.

- Non-consideration of funds with higher expenses: only considering funds with a relatively low management fee may limit the spectrum of European sustainable funds. Therefore, it is important to consider whether funds with higher management fees are also aligned with this correlation.
- Impact of regulations: regulatory decisions made within the framework of the EU Taxonomy have a significant influence on the construction of sustainable funds because fund managers seek to comply with these standards. Changes in sustainability regulations affect all sustainable funds similarly, contributing to higher correlations.
- Impact of market events: in response to macroeconomic or specific events, there is one global crisis during the sample years due to the pandemic. It could be argued that high correlations are due to this. However, a trend of higher correlations is observed in the pandemic year, but prior to the pandemic, there is also a predominantly green scenario[5]. The same is observed in the following years. Therefore, it can be affirmed that positive correlations go beyond specific events in time.

In terms of the previous, a specific or non-systematic risk identified is the large-growth/large-blend approach of funds. This is aligned with the long-term perspective of sustainable investment, involving reinvestment of capital, which implies a lack of diversification into companies with different management styles also future-oriented. Moreover, this is aligned with the strong dominance of technology in the funds. Many tech companies are considered growth oriented (Kunthara, 2022). In the framework of EU Taxonomy regulations, funds will align with them whenever necessary to remain sustainable. While the APSF is designed to promote sustainability and reduce risks, the potential for systematic risk in the European sustainable equity funds field exists and requires ongoing monitoring and adjustments to regulatory measures to address any emerging challenges. These are topics to be corroborated in future research.

[5] Appendix 5 shows the heat maps of correlations by year.

It is important for fund managers to explore alternative areas of sustainable diversification, seeking investments in industries, countries or stocks that exhibit negative or lower correlation with the typical ESG-driven trends. Even incorporating different investment strategies that are less influenced by similar ESG factors can help create more resilient funds. For instance, create funds that are focused on a single ESG factor. However, it is important to note that if there are more and more regulations regarding sustainable funds, this will create a stronger risk from which it will be difficult to escape, because it will lead to the continuous similarity of fund fluctuations over time. The US and Europe are at the forefront of these regulations, so it is primarily important that they take into account the potential risks of sustainable investment when implementing policies or rules, or further refining those already in place.

Relating the region allocation of the sample funds and the specific country allocation of the portfolio to the US and Europe, with the correlations between the three funds composing the portfolio, it can be affirmed that the specific strategies of allocation to specific regions have better returns. The portfolio is made up of these funds due to the strong positive correlations between all the funds in the sample. Because of these correlations, through the MVO, the funds with the best returns will always be chosen to form the portfolio. Due to the high correlations, it might be thought that it is convenient to invest in only one fund, but this thesis shows that the combination of the funds can reduce the risk by achieving better returns. This shows that negative correlations are not necessary for diversification to be beneficial. However, correlations must be monitored in order to maintain portfolio diversification and thereby manage portfolio risk. This is mainly because funds, while each having their own investment objective, can change their assets to redirect their strategy, which can be either positive or negative.

In this case there is no diversification by assets, because the sample funds are mostly composed of equity. But there is diversification by industries and sectors and geographic locations. It is important that countries or companies are explored to gain more diversification in that direction.

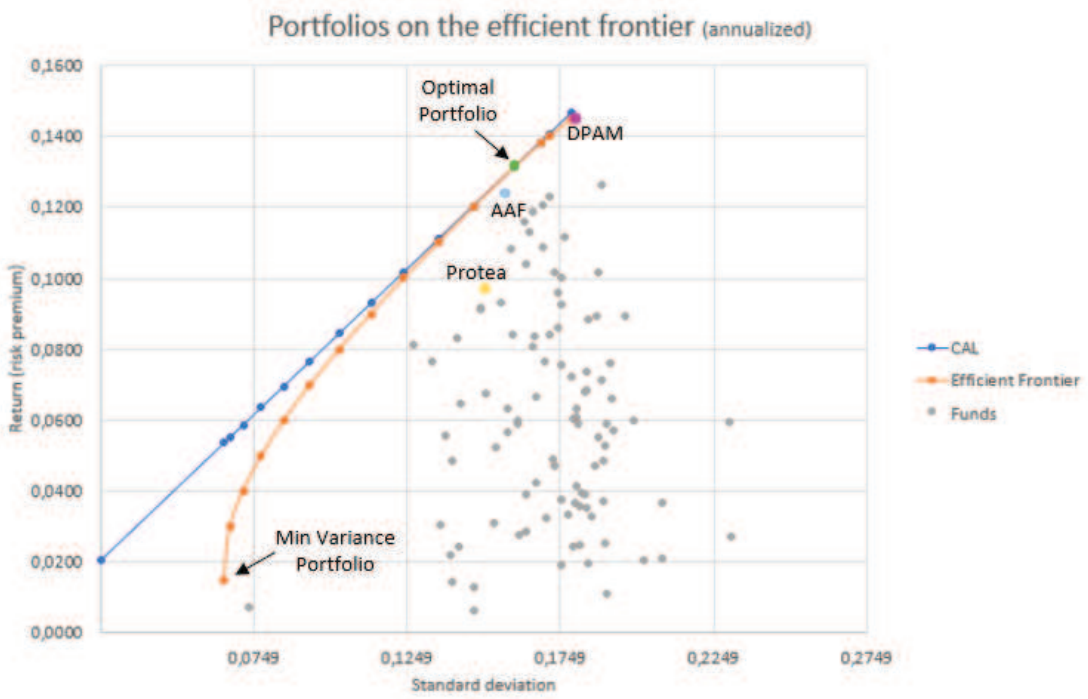
In order to reduce any systematic risks brought on by their shared positive

correlation, investors in the sustainable fund industry should exercise caution regarding potential vulnerabilities resulting from a lack of diversification in investment strategies.

4.3 Comparison with other allocation strategies on the efficient frontier and MVO's role in the selection of the optimal sustainable portfolio

Thanks to the process followed in the methodology, the graph shown in figure 27 can be obtained. Appendix 6 is the completed table 10, whose data make up the graph. As addressed in the theoretical framework, the main idea of the efficient frontier is to know the portfolios that maximize the return for a certain level of risk. These portfolios are located above the orange curve line in the graph.

Figure 27: Portfolios on the efficient frontier



The blue line is the CAL, which has the slope of the Sharpe ratio of the optimal portfolio (0,8213). It starts with the risk-free rate and ends at the point with the highest risk premium fund. The points inside the border of the frontier are the individual funds (in colour those that are part of the portfolio) that, optimally

grouped together, make up the portfolios on the efficient frontier. On the far left is the MVP, which, with a 1,49% risk premium and 6,52% standard deviation, minimizes the overall volatility of returns among all possible portfolios of funds. In other words, the standard deviation of the MVP is considerably lower than even the lowest standard deviation of the individual funds. However, the expected return is not high and it can even be seen from the graph that there are other portfolios with a slightly higher level of risk that offer the possibility of achieving a more desirable return.

At the rightmost end of the efficient frontier is the fund with the highest risk premium, which is DPAM, the fund with the highest weight in the optimal portfolio. This is mainly due to the very positive correlations among the funds, leading the portfolio to be much closer to the point with the highest risk premium. On the other hand, the range of risk is quite large, with a span of 10 points, and the portfolio being within the highest range of risk indicates that high correlations do not allow for a significant reduction in risk. If the correlations had been much closer to 1, there would have been no benefit from diversification and, therefore, the result would have been to allocate 100% to the fund with the highest risk premium (DPAM). In this case, however, diversification brings benefits. Thus, the portfolio tangent to the CAL is the optimal one, through which it is possible to achieve the best risk-return trade-off. In other words, it is the portfolio with the best risk-adjusted return, maximizing return for a given level of risk or minimizing risk for a given level of return.

Through the MVO it has been possible to create a portfolio with the best risk-adjusted return, however it is necessary to note that this is done in a completely quantitative way. The method is based on the analysis of historical returns, which limits a meticulous consideration of each individual fund. Because of this, it is particularly sensitive to input data, in conjunction with the assumption that returns are normally distributed. When assessing individual funds, more characteristics of the funds are taken into account, as explained in section 2.3.1. In that case, the following points would be taken into account, selecting the appropriate according to the characteristics of the investor:

- Whether a fund has higher transaction costs and taxes than other funds

- Whether the fund has underperformed or overperformed the benchmark in the past
- Whether it has an entry fee, exit fee or minimum initial investment and how this affects the fund's final capital
- Experience of the fund managers
- The fund's specific objectives and limitations
- Different investment strategies or philosophies, for example, sector and country allocation.

Market conditions can also change, leading to variations in the optimal portfolio over time. Knowing this and taking into account the very positive correlations of European sustainable funds, regular monitoring of the portfolio is necessary. The MVO also fails to take into account that the positive correlations may be due to the specific risk mentioned in the previous section, which would be aggravated by the continuous adaptation of the funds to European regulations. This could lead to a vicious circle from which it would be difficult to escape if the EU itself does not restrict it. Thus, the MVO is a good method to build portfolios with the best risk-adjusted return, but it is necessary to bear in mind that, in the context of European sustainable funds, it is likely that risky portfolios with significant risk reduction, due to positive correlations, will not be created. It may even be worthwhile to evaluate funds separately, find several funds with different strategies and then follow the MVO process with the selected funds to evaluate correlations. Also, the possibility of investing in a single fund is always there. On the other hand, it is always better to invest in diversification than to allocate all the capital to a single investment fund. Even if being invested in the same fund, the strategies of the funds are different and the fund managers are different. Investing in a single investment fund also limits returns and increases risk, where the MVO can help significantly.

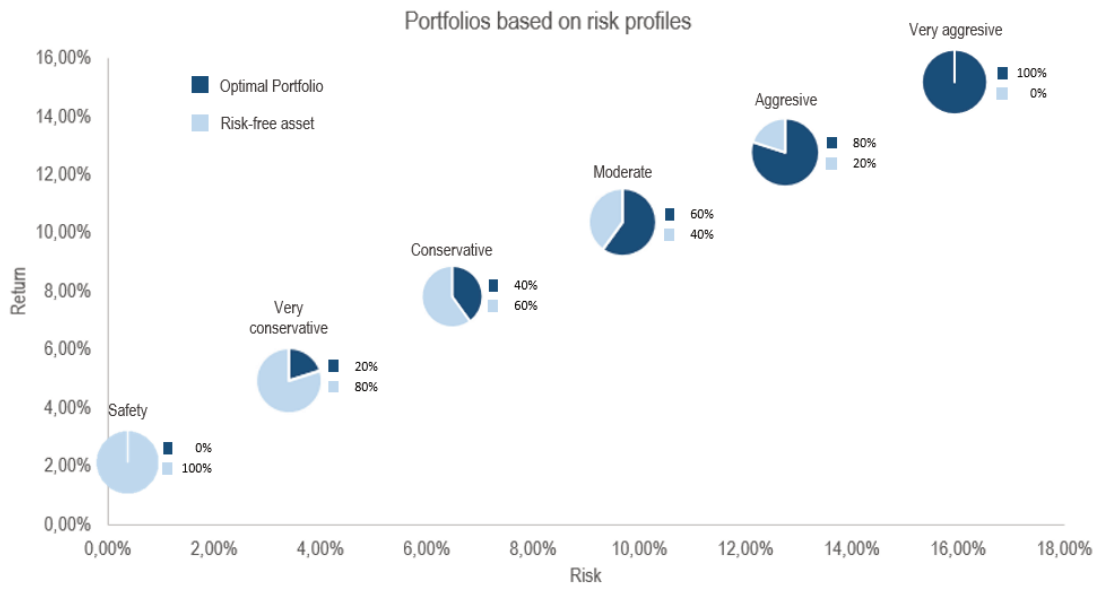
4.4 Tailored portfolios aligned with risk profiles

As outlined in the theoretical framework, the optimal portfolio obtained from the MVO is suitable for any type of investor risk. Any investor, regardless of their level of risk aversion, can invest in this portfolio. However, being an equity-dominated

portfolio, not all investors would be willing to invest 100% of their capital in it. Therefore, once the optimal portfolio is known, it is necessary to include the investor profile to form optimal complete final portfolios. Based on figure 5, which details the different types of risk profiles and, according to this, their recommended capital allocation, portfolios have been built. Each of them has different levels of return for a given risk. Figure 28 illustrates the risk and return that would be obtained depending on the type of investor who chooses to invest in the portfolio. This shows that the lower the risk aversion, the higher the return that can be achieved.

The optimal complete portfolios consist of different weights between the optimal portfolio and risk-free asset. Those investors with a higher risk tolerance are inclined to allocate a larger proportion of their portfolio to the portfolio of European sustainable funds, seeking higher returns despite increased volatility. On the other hand, investors with lower risk tolerance allocate more to the risk-free asset, aiming for capital preservation and a more stable and lower return.

Figure 28: Portfolios based on risk profiles



As already seen, the investor's profile changes over the course of a lifetime. The advantage of these optimal complete portfolios is that they can be easily adjusted as needed. It should be noted that this portfolio is recommended for the long-term. This means that people with a long investment time horizon could invest

100% of their capital in the optimal portfolio, which in theory would imply a very aggressive investor profile. However, the very aggressive profile is determined by the tolerance to return fluctuations, which implies tolerating the maximum risk that the portfolio brings. On the other hand, it must be taken into account that the financial markets tend to show a long-term upward trend, even if the fluctuations in the meantime are high. By investing in the long-term, investors can have more time to overcome short-term fluctuations and take advantage of the long-term growth potential of assets. As Siegel (1994) states in his book “Stocks for the Long Run”, "[...] the ability to create value springs from skillful management, a stable political system that respects property rights, and the capacity to provide value to consumers in a competitive environment. Swings in investor sentiment resulting from political or economic crises can throw stocks off their long-term path, but the fundamental forces producing economic growth have always enabled equities to regain their long-term trend" (p. 91).

5 Conclusion

Through the application of the MVO method, this thesis has delved into the intricacies of constructing an optimal risky portfolio of European sustainable funds. The findings of this study have not only revealed a portfolio with the best risk-adjusted return that can be employed as a reference for further portfolio construction, but also unveiled a complex environment in the field of sustainable investment funds, shedding light on some key aspects that demand careful consideration.

The process has been conducted with the 5-year monthly returns of 103 European sustainable funds, which invest mostly in equity and have a management fee of less than 1%. There are several reasons for this selection. On one hand, the idea behind the objective of the thesis was to create a portfolio that minimizes risk in order to still obtain a considerable return and is suitable for any type of investor. In order to combine it with a risk-free asset, the portfolio should be risky. That is the reason why funds that invest mainly in equity have been selected, which is also in line with the selection of European sustainable funds when conducting research. On the other hand, the recommendation of an expert in investment funds, John Bogle, has been taken into account when considering low-cost funds for portfolio construction.

The portfolio, based on the past returns of its component funds, is assumed to generate an annual return of 15,19%, undertaking a risk of 16%. This implies a moderate risk compared to the sample average and a return very close to the maximum return of the sample. The selection, which leads to the best risk-adjusted return, is composed of three funds with different investment objectives and very diverse characteristics, whose portfolios are accordingly diversified. The one with the largest weight in the portfolio, DPAM (64%), is a passively managed index fund focused on US companies. The second, Protea with 21% of the weight, is actively managed and is concentrated on European investments, although it has a small fraction in the US and UK. The third is AAF, with 15% weight, which is also actively managed, investing mainly in the US. Compared to each other, AAF is a large-cap fund, DPAM a mid-cap and Protea a small-cap. As can be

witnessed, the funds maintain their focus on either the US or Europe, which may be one of the reasons why they are able to achieve better risk-return levels by focusing on one or a few markets. It should also be noted that these regions have well-established regulatory frameworks that support sustainable investment. Remarkably, no fund that invests globally is part of the portfolio, whereas it would be better diversified in region allocation. Such a diversification would help to minimize underperformance due to the effect of significant events in Europe or the US. As the main weight of the portfolio is the index fund, it is expected that the portfolio will not suffer from abrupt changes in allocation, which is a kind of "safeguard". The optimal mix suggests that the recently added funds, i.e., incepted close to the launch of the APSF, have a better risk-return performance than funds that have been in the market for many years; being that the funds in the portfolio were added to the market in 2016, 2017 and 2018. The portfolio is heavily weighted in sensitive and cyclical industries, which means that the defensive industry counterweight is not sufficient to counteract sharp changes in the market. For this reason, the portfolio will be more focused on growth potential. It also tries to create a balance between this expansion capacity and stability through the defensive industry.

Concerning the sample funds, there is a clear trend to invest in large-growth and large-blend companies, which not only seeks to maximize returns through reinvestment of capital, but also to align them with ESG objectives that focus on the long-term investment horizon. In context with sector allocation, this is the reason for the high predominance of technology in the funds, as many tech companies are considered growth oriented. Due to the reasons mentioned above, the portfolio carries a long-term investment horizon.

Beyond this, large-growth and large-blend investment strategies can be attributed to the high correlations between not only the funds in the portfolio, but also the funds in the sample. This indicates a very strong degree of interrelation between them. This means that the focus on large-growth/blend would be a specific risk. It can be minimized by finding other ESG-aligned companies to invest in, which exhibit lower correlations with the typical ESG-driven trend. For which fund managers should take action and explore other countries and/or companies to gain

more diversification in that direction. Nevertheless, it is understood that this investment strategy is aggravated by the SFDR regulations in the European Union. As long as they exist and are amended, sustainable funds will continue to adapt to the changes in regulations in order to continue to be categorized as sustainable funds. This is a risk that leads to inefficient portfolio diversification due to the need to comply with certain standards. Further research is needed in this area to avoid potential unwanted systematic risk. The US and Europe are at the forefront of these regulations, thus they should take into account these risks and potential risks when implementing or refining certain standards.

Even if correlations are very high, there is still some level of diversification benefit that allows for an optimized portfolio. Through the MVO, when correlations are very positive, the funds with the highest returns will always be chosen to form the portfolio, because none counteracts the risk. This highlights that this method is very sensitive to correlations between assets. Nevertheless, the MVO is a good method to build portfolios with the best risk-adjusted return, but it is necessary to bear in mind that, in the context of European sustainable funds, it is likely that risky portfolios with significant risk reduction, due to positive correlations, will not be created. While the possibility of choosing a single investment always exists, investing in just one also limits returns while increasing risk, where the MVO significantly helps.

This thesis demonstrates that the fund's optimal portfolio can reduce the risk by achieving a high return, all aligned with sustainability. The consideration of a broad range of funds, left aside the observation of their respective costs, entry or exit fees, under or overperformance of the benchmark, fund's managers' experience and fund's specific objectives. However, this had a motive, which was to interpret the portfolio from a systemic perspective in order to find the return and risk that best represent the European sustainable fund category. The customization comes into play when adapting the fund to different types of risk tolerance. In this sense, more proportion will be invested in the portfolio when being a more aggressive investor. A more conservative investor will invest a higher proportion in the risk-free asset.

The outcome of future research, apart from the above mentioned, could be whether it is possible to lower the risk to obtain the return found in this thesis or a higher one through fixed income funds or other types of assets. In addition to further research on the interrelationship of funds with European standards and whether the strategies remain as correlated in the years to come. Moreover, the consideration of funds with low management fees in this research may be viewed as a limitation, in which further research can introduce funds with higher management fees into the analysis to corroborate the alignment to high correlations.

This thesis has found the portfolio that balances risk and return in the context of sustainable investment, affirming that long-term investment in the field European sustainable funds is the focal aspect, not only due to the implication of sustainability, but also to the large-growth/blend approach of the funds. The portfolio and its characteristics, as well as the process of developing the thesis, can be used by individual investors, either to invest in it or to create new portfolios that improve the risk-adjusted return. It is clear that fund managers must work to find assets that primarily contribute to differentiate themselves from other funds, as well as policymakers must be vigilant and work together to ensure that regulations do not obstruct the diversification of funds.

References

Abate, G., Basile, I., & Ferrari, P. (2021). The level of sustainability and mutual fund performance in Europe: An empirical analysis using ESG ratings. *Corporate Social Responsibility and Environmental Management, 28*(5), 1446-1455. doi:10.1002/csr.2175

ABN AMRO Investment Solutions. (2021). *ABN AMRO Solutions Prospectus.*

ABN AMRO Investment Solutions. (2023). *ABN AMRO Parnassus US ESG Equities.*

ALFI. (2022). *Hitting the road to a greener future.* Retrieved from Luxembourg Sustainable Finance Initiative: https://lsfi.lu/fr/european-sustainable-investment-funds-study-2022-hitting-the-road-to-a-greener-future/

Association Investment Management Consultants. (2005). The Journal of Investment Consulting. *Insights from a Pioneer in Portfolio Theory and Practice: A Talk with Nobel Laureate William F. Sharpe, PhD*.

Belghitar, Y., Clark, E., & Deshmukh, N. (2017). Importance of the fund management company in the performance of socially responsible mutual funds. *The Journal of Financial Research, XL*(3), 349-367.

Bioy, H., Stuart, E., Boyadzhiev, D., Pettit, A., & Alladi, A. (2021, February 3). *European Sustainable Funds Landscape: 2020 in Review.* Retrieved from Morningstar: https://www.morningstar.com/en-uk/lp/sustainable-funds-landscape

Bodie, Z., Kane, A., & Marcus, A. J. (2012). *Investments* (9th ed.). McGraw-Hill/Irwin.

Boffo, R., & Patalano, R. (2020). *ESG Investing: Practices, Progress and Challenges.* OECD Paris. Retrieved from http://www.oecd.org/finance/ESG-Investing-Practices-Progress-and-Challenges.pdf

Bogle, J. (2010). *Common Sense on Mutual Funds* (10th ed.). Canada: John Wiley & Sons, Inc.

Cantillo, A. (2013). Survey of Literature on Portfolio Theory. *University of Missouri Kansas City*.

CFA Institute. (2023). *ESG Investing and Analysis*. Retrieved September 27, 2023, from https://www.cfainstitute.org/en/rpc-overview/esg-

investing#:~:text=ESG%20stands%20for%20Environmental%2C%20Social,material%20risks%20and%20growth%20opportunities.

CFA Institute. (2023). *Introduction to Alternative Investments*. Retrieved September 22, 2023, from https://www.cfainstitute.org/en/membership/professional-development/refresher-readings

Cooperators. (2023). *Can you successfully time the market?* Retrieved September 28, 2023, from https://www.cooperators.ca/en/resource-centre/plan-ahead/risk-tolerance

Corporate Finance Institute. (2023). *Management Fees*. Retrieved October 6, 2023, from https://corporatefinanceinstitute.com/resources/wealth-management/management-fees/

Council, E. (2023, July 31). *European Green Deal*. Retrieved from https://www.consilium.europa.eu

D Carbon. (2020). *Principles for Responsible Investment (PRI)*. Retrieved September 24, 2023, from https://dcarboneg.com/financial-institutions-consulting/principles-for-responsible-investment-pri/

Davison, L., McNally, F., & North, C. (2023, February 18). ESG: EU Regulatory Change and Its Implications. *Harward Law School Forum on Coporate Governance*. Retrieved from https://corpgov.law.harvard.edu/2023/02/18/esg-eu-regulatory-change-and-its-implications/

DPAM Degroof Petercam Asset Management. (2022). *DPAM Equities L Prospectus.*

Durango G., M., & Delgado V., L. (2017, November 27). Methodological design for structuring investment portfolios according to the risk profile. *Clío América, 11*(22), pp. 177-187. doi:10.21676/23897848.2439

Durán-Santomil, P., Otero-González, L., Correia-Domingues, R., & Reboredo, J. (2019, May 24). Does Sustainability Score Impact Mutual Fund Performance? *MDPI, 11(10)*(2972). doi:10.3390/su11102972

EFAMA. (2022, December). *Asset Management in Europe.* Retrieved from https://www.efama.org/newsroom/news/efama-asset-management-report-2022

European Banking Authority. (2022). The role of banking in transitioning to a

sustatinable economy., (pp. 1-7). Paris.

European Commission. (2023). *EU taxonomy for sustainable activities*. Retrieved September 26, 2023, from https://finance.ec.europa.eu/sustainable-finance/tools-and-standards/eu-taxonomy-sustainable-activities_en

Fabozzi, F. J., Gupta, F., & Markowitz, H. M. (2002). The Legacy of Modern Portfolio Theory. (Fall, Ed.) *The Journal of Investing, 11 (3)*, 7-22.

Financial Times. (2023, November 01). *DPAM L Equities - US SRI MSCI Index F*. Retrieved from https://markets.ft.com/data/funds/tearsheet/summary?s=LU1494415901:EUR

Kunthara, S. (2022, July 14). The Market Minute: Why Are Tech Companies Being Hit So Hard By The Downturn? *Crunchbase News*. Retrieved from https://news.crunchbase.com/layoffs/tech-companies-downturn/

LPL Financial. (2023). *Investor Profile Questionnaire*. Retrieved September 22, 2023, from https://www.lpl.com/

Markowitz, H. (1952). Portfolio Selection. *The Journal of Finance, 7, No. 1*, 77-91.

Microsoft. (2023). *Define and solve a problem by using Solver*. Retrieved October 20, 2023, from https://support.microsoft.com/en-gb/office/define-and-solve-a-problem-by-using-solver-5d1a388f-079d-43ac-a7eb-f63e45925040

Morgan Stanley. (2023, February). *Despite Market Challenges, Demand for Sustainable Funds Remains Strong.* Retrieved from https://www.morganstanley.com/ideas/sustainable-funds-performance-demand

Morningstar. (2011). *Morningstar Stock Sector Structure.* Retrieved from https://www.morningstar.com/content/dam/marketing/apac/au/pdfs/Legal/StockSectorStructure_Factsheet.pdf

Morningstar. (2021, November 8). *Morningstar Sustainability Rating.* Retrieved from Morningstar: https://www.morningstar.com/content/dam/marketing/shared/research/methodology/744156_Morningstar_Sustainability_Rating_for_Funds_Methodology.pdf

Morningstar. (2023, July 27). *SFDR Article 8 and Article 9 Funds: Q2 2023 in Review.* Retrieved from https://www.morningstar.com/en-uk/lp/sfdr-article8-article9

MSCI. (2023, July 18). *Funds and the State of European Sustainable Finance*. Retrieved from https://www.msci.com/www/research-report/funds-and-the-state-of-european/03949903501

NAO Sustainable Asset Management. (2023). *Protea Fund NAO Responsible Europe*. Retrieved November 02, 2023, from https://www.nao-sam.com/protea-fund-nao-sustainable-europe/

NAO Sustainable Asset Management. (2023). *PROTEA FUND NAO RESPONSIBLE EUROPE.*

OECD. (2014). *Germany keeping the edge: Competitiveness for inclusive growth.* Paris. Retrieved from https://www.oecd.org/germany/Better-policies-germany.pdf

Perold, A. (2004). The Capital Asset Pricing Model. *Journal of Economic Perspectives, 18*(3), 3-24.

Phipps, M. (28 de January de 2022). *Correlated and Non-Correlated Assets*. Recuperado el 20 de September de 2023, de The balance money: https://www.thebalancemoney.com/what-is-asset-correlation-2894312

POMS. (2009). Harry M. Markowitz. *Production and Operations Management, 18*(2), x-xii.

Prall, K. (2021). ESG Ratings: Navigating Through the Haze. *CFA Institute*. Retrieved from https://blogs.cfainstitute.org/investor/2021/08/10/esg-ratings-navigating-through-the-haze/

Principal Asset Management Berhad. (2023). *Investor Profiles*. Retrieved September 22, 2023, from https://www.principal.com.my/en/what-type-investor-are-you-these-7-easy-questions-may-tell-you

Protea. (2023). *Protea Fund Prospectus.*

PwC. (2021, October). *The state of ESG disclosure in Asset & Wealth Management - From fund issuer to end investor.* Retrieved from PwC: https://www.pwc.de/en/finanzdienstleistungen/sustainable-funds-in-the-ascendant.html

RIA in a Box. (2019, July 23). *2019 RIA Industry Study*. Retrieved from https://www.riainabox.com/resources/2019-ria-industry-study-total-

average-fee-is-117

Roszkowski, M. J., Davey, G., & Grable, J. E. (2005). Insights from Psychology and Psychometrics on Measuring Risk Tolerance. *Journal of Financial Planning*, 66-77.

SEC. (2016, December). *Mutual Funds and ETFs: A Guide for Investors.* Retrieved from https://www.sec.gov/investor/pubs/sec-guide-to-mutual-funds.pdf

Siegel, J. J. (1994). *STOCKS for the LONG RUN* (Fifth ed.). Mc Graw Hill Education.

Statista. (2023, September 27). *Total assets under management (AUM) of sustainable funds worldwide from 2010 to 2022, by region*. Retrieved October 2, 2023, from https://www.statista.com/statistics/1319691/sustainable-funds-aum-global-allocation/

Sustainalytics. (2023). *Morningstar Sustainability Rating for Funds*. Retrieved September 28, 2023, from https://www.sustainalytics.com/investor-solutions/analytic-reporting-solutions/morningstar-sustainability-rating-for-funds

Talogy Inc. (2023). *Past behavior is the best predictor of future behavior*. Retrieved October 17, 2023, from https://www.talogy.com/en/blog/past-behavior-is-the-best-predictor-of-future-behavior/#:~:text=The%20key%20here%20is%20that,on%2Dthe%2Djob%20performance.

Tayan, B. (2023). ESG Ratings: A Compass without Direction. *Harvard Law School Forum on Corporate Governance*. Retrieved from https://corpgov.law.harvard.edu/

The Upwork Team. (2022, March 28). *Systematic vs. Unsystematic Risk: The Key Differences*. Retrieved September 21, 2023, from Upwork: https://www.upwork.com/resources/systematic-vs-unsystematic-risk#:~:text=Avoidability%3A%20Systematic%20risks%20can't,financial%20and%20business%2Dspecific%20risks.

Titman, S., Keown, A., & Martin, J. (2018). *Financial Management: Principles & Applications* (13 ed.).

Tobin, J. (1958). Liquidity Preference as Behavior Towards Risk. In *The Review*

of Economic Studies (Vol. 25, pp. 65-86).

Trading Economics. (2023). *Germany 10 Year Bund Government Bond Yield*. Retrieved October 10, 2023, from https://tradingeconomics.com/germany/government-bond-yield

United Nations. (2021). The rise of the sustainable fund market and its role in financing sustainable development. *United Nations Conference on Trade and Development*.

United Nations Global Compact. (2022). *EU Regulation on sustainability-related disclosures in the financial services sector.* Retrieved from https://www.unpri.org/policy/eu-regulation-on-sustainability-related-disclosures-in-the-financial-services-sector/8645.article

United Nations Global Compact. (2023). *Principles for Responsible Investment*. Retrieved September 24, 2023, from https://www.unpri.org/

Yahoo Finance. (2023). *AAF-Parnassus US ESG Eqs C€*. Retrieved October 30, 2023, from https://finance.yahoo.com/quote/0P00019M2H.F?p=0P00019M2H.F&guccounter=1

Yue, X.-G., Han, Y., Teresiene, D., Merkyte, J., & Liu, W. (2020, September 29). Sustainable Funds' Performance Evaluation. *MDPI*. Retrieved from https://doi.org/10.3390/su12198034

Zaimovic, A., Omanovic, A., & Arnaut-Berilo, A. (2021). How Many Stocks Are Sufficient for Equity Portfolio Diversification? A Review of the Literature. *Risk and FInancial Management, 14*(11). doi:10.3390/jrfm14110551

Zumente, I., & Bistrova, J. (2021, May 6). ESG Importance for Long-Term Shareholder Value Creation: Literature vs. Practice. *Journal of Open Innovation*, https://doi.org/10.3390/joitmc7020127.

Appendix

Appendix 1: Risk profile questionnaire

Time Horizon

QUESTION 1

What is your age?

Your score

56 and over 1
46-55 2
36-45 3
20-35 4

QUESTION 2

What is your primary financial goal?

Wealth preservation 1
Retirement planning 2
Wealth accumulation 3

QUESTION 3

What is the time frame for you to achieve your financial goals?

0-5 years 1
5-10 years 2
10 years or longer 3

Time Horizon Total _____

Financial Goals

QUESTION 4

Which of the following best describes your financial goals?

Preserving principal and earning a moderate amount of current income 1
Generating a high amount of current income 2
Generating some current income and growing assets over an extended time frame 3
Growing assets substantially over an extended time frame 4

QUESTION 5

How do you expect your standard of living five years from now to compare to your standard of living today?

Less than it is today 1
The same as it is today 2
Somewhat higher than it is today 3
Substantially greater than it is today 4

QUESTION 6

Five years from today, you expect your portfolio value to be:

Portfolio value is not my primary concern; I am more concerned with current income 1
The same as or slightly more than it is today 2
Greater than it is today 3
Substantially greater than it is today 4

QUESTION 7

Generating current income from your portfolio is:

A primary concern (only if you are about to retire) 1
Not important 2

QUESTION 8

With the income generated from your portfolio, you plan to:

Use it for living expenses 1
Use some and reinvest some 2
Reinvest all income 3

Financial Goals Total _____

Risk Tolerance

Your score

QUESTION 9

You have just received a large amount of money. How would you invest it?

I would invest in something that offered moderate current income and was very conservative 1
I would invest in something that offered high current income with a moderate amount of risk 2
I would invest in something that offered high total return (current income plus capital appreciation) with a moderately high amount of risk 3
I would invest in something that offered substantial capital appreciation even though it has a high amount of risk 4

QUESTION 10

Which of the following statements would best describe your reaction if the value of your portfolio were to suddenly decline by 15%?

I would be very concerned because I cannot accept fluctuations in the value of my portfolio 1
If the amount of income I receive was unaffected, it would not bother me 2
Although I invest for long-term growth, even a temporary decline would concern me 3
Because I invest for long-term growth, I would accept temporary fluctuations due to market influences 4

QUESTION 11

Which of the following investments would you feel most comfortable owning?

Certificates of deposit 1
U.S. Government securities 2
Blue-chip stocks 3
Stocks of new growth companies 4

QUESTION 12

Which of the following investments would you least like to own?

Stocks of new growth companies 1
Blue-chip stocks 2
U.S. Government securities 3
Certificates of deposit 4

QUESTION 13

Which of the following investments do you feel are the most ideal for your portfolio?

Certificates of deposit 1
U.S. Government securities 2
Blue-chip stocks 3
Stocks of new growth companies 4

QUESTION 14

How optimistic are you about the long-term prospects for the economy?

Very pessimistic 1
Unsure 2
Somewhat optimistic 3
Very optimistic 4

QUESTION 15

Which of the following best describes your attitude about investments outside the U.S.?

Unsure 1
I believe the U.S. economy and foreign markets are interdependent 2
I believe overseas markets provide attractive investment opportunities 3

Risk Tolerance Total _____

Investor Scorecard

Time Horizon Total		x 1 =	
Financial Goals Total		x 2 =	
Risk Tolerance Total		x 3 =	
The total for each section is multiplied by a number that represents the overall importance of that section when determining your investment objectives.		TOTAL SCORE	

Match your total score with one of the investment objectives listed below. If your score is near the top or bottom of an Adjusted Total Range, you may want to examine the next or previous objective to determine which represents your needs more accurately.

Adjusted Total Range	Investment Objective
34-57	Income with Capital Preservation
58-83	Income with Moderate Growth
84-99	Growth with Income
100-114	Growth
115-125	Aggressive Growth

The investment objectives shown are for illustrative purposes only. Your investment objective is based on many factors including your financial situation, tolerance for risk, time horizon and other financial needs. Consult your financial advisor if you have any questions.

Income with Capital Preservation	Income with Moderate Growth	Growth with Income	Growth	Aggressive Growth
INCREASING RISK, VOLATILITY AND RETURN EXPECTATIONS				
▪ Need for capital preservation and current income ▪ No focus on growth ▪ Lowest tolerance for risk ▪ Shortest investment horizon	▪ Need for current income ▪ Moderate focus on growth ▪ Low tolerance for risk ▪ Short/intermediate investment horizon	▪ Equal focus on growth and current income ▪ Moderate tolerance for risk ▪ Intermediate investment horizon	▪ Little need for current income ▪ Focus on growth ▪ High tolerance for risk ▪ Intermediate/long investment horizon	▪ No need for current income ▪ Focus on aggressive growth ▪ Highest tolerance for risk ▪ Long investment horizon

Source: LPL Financial

Appendix 2: Categories Morningstar

Category List

Category Group	Category Name	Page
Equity	Africa Equity	5
	Asia Equity	5
	Asia ex-Japan Equity	5
	Australia & New Zealand Equity	5
	Canadian Equity Large Cap	5
	Canadian Equity Mid/Small Cap	5
	Communications Sector Equity	5
	Consumer Goods & Services Sector Equity	6
	Energy Sector Equity	6
	Europe Emerging Markets Equity	6
	Europe Equity Large Cap	6
	Europe Equity Mid/Small Cap	6
	Financials Sector Equity	6
	Global Emerging Markets Equity	6
	Global Equity Large Cap	6
	Global Equity Mid/Small Cap	7
	Greater China Equity	7
	Healthcare Sector Equity	7
	India Equity	7
	Industrials Sector Equity	7
	Infrastructure Sector Equity	7
	Japan Equity	7
	Korea Equity	7
	Latin America Equity	8
	Malaysia Equity	8
	Mexico Equity	8
	Natural Resources Sector Equity	8
	Precious Metals Sector Equity	8
	Real Estate Sector Equity	8
	Technology Sector Equity	8
	Thailand Equity	8
	UK Equity Large-Cap	9
	UK Equity Mid/Small Cap	9
	US Equity Large-Cap Blend	9
	US Equity Large-Cap Growth	9
	US Equity Large-Cap Value	9
	US Equity Mid-Cap	9

Category Group	Category Name	Page
Money Market	Africa Money Market	18
	Asia Money Market	18
	Australia & New Zealand Money Market	18
	Canada Money Market	18
	Euro Money Market	18
	Japan Money Market	18
	Latin America Money Market	18
	Mexico Money Market	18
	Sterling Money Market	18
	Thailand Money Market	18
	US Money Market	19
	Money Market Miscellaneous	19
Property	Property – Direct	20
Miscellaneous	Capital Protected	21
	Guaranteed	21
	Miscellaneous	21

Source: Morningstar.

Appendix 3: Sector classification Morningstar

Cyclical Super Sector
Sectors that roll up into the Cyclical Super Sector are highly sensitive to business cycle peaks and troughs.

Basic Materials
Companies that manufacture chemicals, building materials, and paper products. This sector also includes companies engaged in commodities exploration and processing. Companies in this sector include BHP Billiton and Rio Tinto, and Nufarm.

Consumer Cyclical
This sector includes retail stores, auto and auto parts manufacturers, companies engaged in residential construction, lodging facilities, restaurants, and entertainment companies. Companies in this sector include Hyundai Motor Company, McDonald's, and News Corporation.

Financial Services
Companies that provide financial services, including banks, savings and loans, asset management companies, credit services, investment brokerage firms, and insurance companies. Companies in this sector include Allianz, Commonwealth Bank, and IOOF.

Real Estate
This sector includes mortgage companies, property management companies, and REITs. Companies in this sector include Westfield Retail Trust, Vornado Realty Trust, and Simon Property Group, Inc.

Defensive Super Sector
Sectors that roll up into the Defensive Super Sector are anticyclical stocks.

Consumer Defensive
Companies engaged in the manufacturing of food, beverages, household and personal products, packaging, or tobacco. Also includes companies that provide services such as education & training services. Companies in this sector include Woolworths, Procter & Gamble, and Coca Cola.

Health Care
This sector includes biotechnology, pharmaceuticals, research services, home health care, hospitals, long-term care facilities, and medical equipment and supplies. Companies in this sector include Johnson & Johnson and Pfizer Inc.

Utilities
Electric, gas, and water utilities. Companies in this sector include AGL, APA Group and Envestra.

Sensitive Super Sector
Sectors that roll up into the Sensitive Super Sector have moderate correlations with business cycles.

Communication Services
Companies that provide communication services using fixed-line networks or those that provide wireless access and services. This sector also includes companies that provide Internet services such as access, navigation and Internet related software and services. Companies in this sector include Telstra, Vodafone and iiNET.

Energy
Companies that produce or refine oil and gas, oil field services and equipment companies, and pipeline operators. This sector also includes companies engaged in the mining of coal. Companies in this sector include Origin Energy, Caltex and Woodside.

Industrials
Companies that manufacture machinery, hand-held tools, and industrial products. This sector also includes aerospace and defense firms as well as companies engaged in transportation and logistic services. Companies in this sector include General Electric Company and Boeing.

Technology
Companies engaged in the design, development, and support of computer operating systems and applications. This sector also includes companies that provide computer technology consulting services. Also includes companies engaged in the manufacturing of computer equipment, data storage products, networking products, semiconductors, and components. Companies in this sector include Apple, Google, and Microsoft.

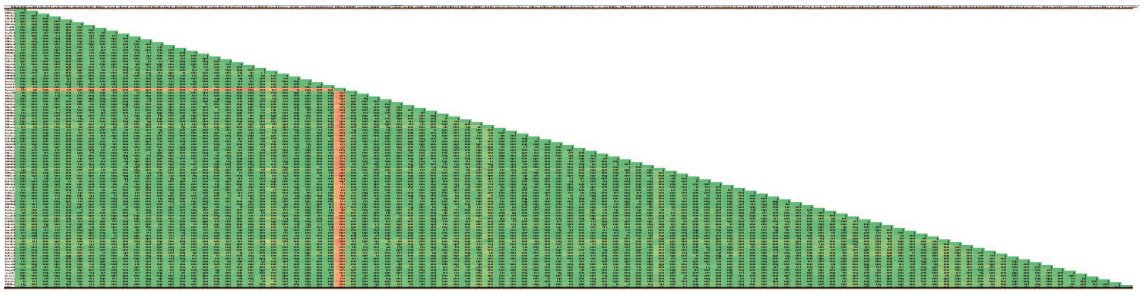
Source: Morningstar (2011).

Appendix 4: Funds' characteristics

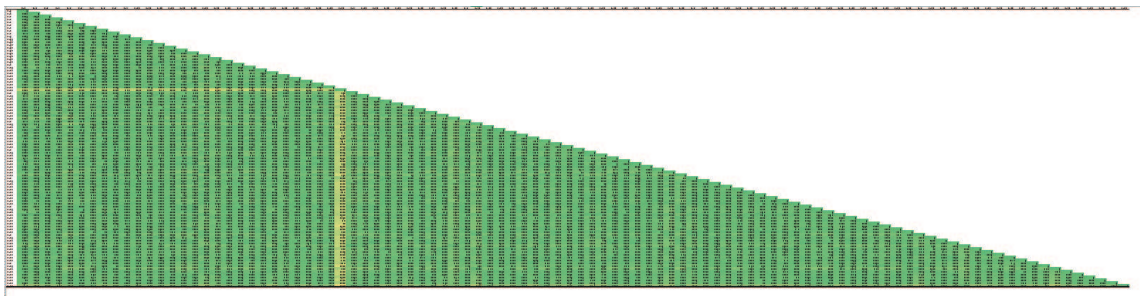
	AAF	DPAM	Protea
Inception date	19/01/2017	29/09/2016	04/12/2018
Legal status	UCITS - SICAV	UCITS - SICAV	UCITS - SICAV
Currency	EUR	EUR	EUR
Domicile	Luxembourg	Luxembourg	Luxembourg
SFDR	Article 8	Article 8	Article 8
Benchmark	MSCI US	MSCI USA SRI Index	EUROSTOXX50
Fund size	2.179.581.725	483.700.315	56.772.794
Share class size	307.956.010	120.578.756	24.725.055
Entry charge	-	Max. 1%	-
Exit charge	-	0,10%	-
Management fee	0,85%	0,30%	0,55%
Ongoing charge	-	0,40%	0,97%
Performance fee	-	-	-
Min. Initial investment	5.000	25.000	-

Appendix 5: Correlations by year

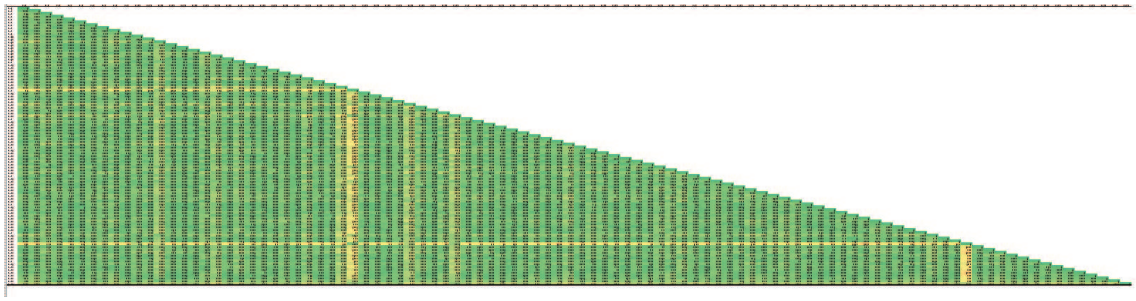
Jun 18 – Jun 19



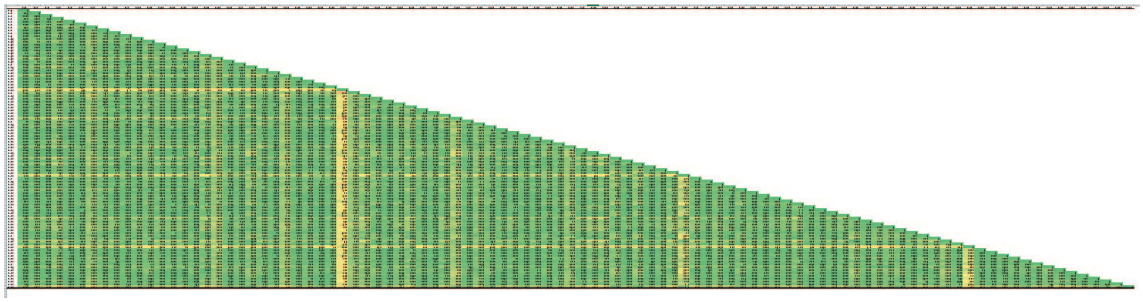
Jun 19 - Jun 20



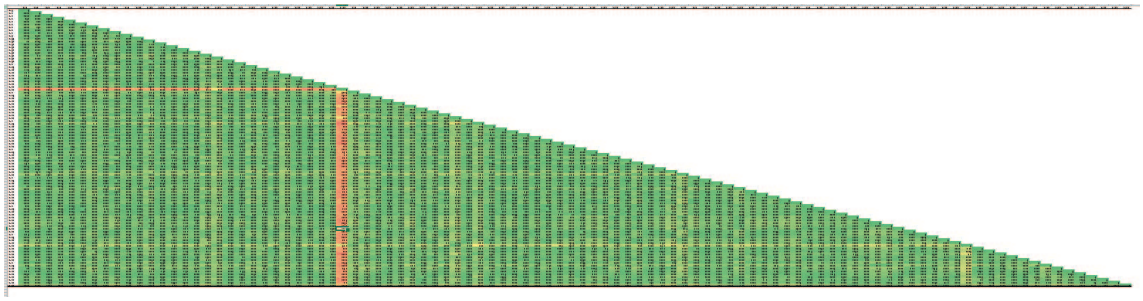
Jun 20 - Jun 21



Jun 21 - Jun 22



Jun 22 - Jun 23



Appendix 6: Table containing all points in the final graph (related to Table 10)

	Min variance											Optimal			
Mean	0,0149	0,0300	0,0400	0,0500	0,0600	0,0700	0,0800	0,0900	0,1000	0,1100	0,1200	0,1314	0,1380	0,1400	0,1448
Std	0,0652	0,0671	0,0714	0,0774	0,0847	0,0933	0,1028	0,1130	0,1238	0,1350	0,1465	0,1600	0,1685	0,1713	0,1786
Slope = sharpe ratio	0,2293	0,4473	0,5605	0,6463	0,7083	0,7505	0,7783	0,7963	0,8077	0,8149	0,8192	0,8217	0,8192	0,8173	0,8108
AAF-Parnassus US ESG Eqs C€	0,0000	0,0000	0,1036	0,2291	0,2714	0,2593	0,2472	0,2351	0,2230	0,2109	0,1988	0,1530	0,0000	0,0000	0,0000
Bantleon Equities Pacific ESG Leaders 1	0,0696	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Carmignac Pf L-S Eurp Eqs F EUR Acc	0,7619	0,6936	0,6344	0,5805	0,5215	0,4473	0,3730	0,2987	0,2244	0,1501	0,0758	0,0000	0,0000	0,0000	0,0000
DPAM L Equities US SRI MSCI Index F	0,0000	0,0000	0,0000	0,0000	0,0534	0,1296	0,2059	0,2822	0,3585	0,4347	0,5110	0,6338	0,8580	0,8999	1,0000
DWS Invest ESG Emerg Mkts Top Div FC	0,0440	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Fidelity Sust Glb Eq Inc I-ACC-EUR	0,0802	0,2055	0,1734	0,0633	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Natixis LCR Actions Euro ESG I	0,0241	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
PRIME VALUES A	0,0201	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Protea Nao Responsible Europe Sd Cl	0,0000	0,0354	0,0886	0,1271	0,1537	0,1639	0,1740	0,1841	0,1942	0,2043	0,2144	0,2132	0,1420	0,1001	0,0000
RobecoSAM Global SDG Equities S EUR Acc	0,0000	0,0656	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
CAL	0,0536	0,0551	0,0586	0,0636	0,0696	0,0766	0,0845	0,0929	0,1017	0,1109	0,1204	0,1314	0,1384	0,1407	0,1467

Declaration of authorship

Herewith I declare that I prepared this thesis independently on my own and without the use of any aids except those specified, that I used only the specified sources and that any direct or indirect quotes taken over from other authors are indicated as such. The work has not been submitted to any other examination board in the same or similar form.

December 7, 2023

Date Agustina Paula Rutenberg