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# What is the impact of an ESG filter on portfolio performance?

# Evidence for various investment strategies.

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# Executive Summary

Initiated by religious movements a few decades ago, sustainable finance is now a key concern for most financial institutions and any investors. It is now widely admitted that investors, in contrast with the standard Markowitz theory, do not only care about risk and return. Non-financial criteria such as environmental issues or ethics strongly impact their investment decisions. In this work, we analyze the influence of filtering out stocks failing to display high ESG score on the performance of popular portfolio strategies including equally weighted, minimum-variance, tangent and asset-risk parity portfolios. We find that, when no significance test is computed, the portfolios that perform the best are the portfolios following the minimum variance strategy combined with a consideration of ESG scores without any threshold. Whereas, when a significance test is calculated the link between ESG score and its impact on diversification strategy is invalid. This suggests that there is no evidence of a relationship between ESG scores and financial performance.

*“Earth provides enough to satisfy every man’s needs, but not every man’s greed”*

Gandhi

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## Abbreviations

AO: Asset Owner

ARESE: Agence de Rating Environnemental et Social des Entreprises

AuM: Assets under Management

BIC: Best-in-Class

CSR: Corporate Social Responsibility

ERC: Equal Risk Contribution

ESG: Environmental, Social and Governance

EU: European Union

EW: Equal Weight

EWP: Equally Weighted Portfolio

GHG: Greenhouse Gas

GIIN: Global Impact Investing Network

GMVP: Global Minimum-Variance Portfolio

MPT: Modern Portfolio Theory

MRC: Marginal Risk Contribution

MWD: Maximum Worst Drawdown

PB: Performance Budgeting

RB: Risk Budgeting

RDS: Royal Dutch Shell

RPP: Risk-Parity Portfolio

RRC: Relative Risk Contribution

SCM: Sample Covariance Matrix

SD: Standard Deviation

SF: Sustainable Finance

SFDR: Sustainable Finance Disclosure Regulation

SR: Sharpe-ratio

SRI: Sustainable and Responsible Investment

VaR: Value at Risk

WB: Weight Budgeting

WCED: World Commission on Environment and Development

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# Chapitre 1 Introduction

Sustainable development and finance are two words that might, at first sight, seem not linked. But the two terms are essential to the functioning of the current system. On the one hand, sustainable development is an approach that leads to results without harming future generations (United Nations, 1987). On the other hand, finance enters in any subject: from politics to agriculture. Finance's main objective is to manage money with constraints on risk and return but not specifically to quantify the impact on future generations. The importance of combining these two concepts is in line with the demand of investors, as their utility is no longer exclusively related to their personal interest, rather investors care more and more on the impact of their investments (either social, environmental or governance impact). Also, companies are responsible for their external impacts and the investors share more and more their opinions on their investments. From the side of policy makers (e.g., EU Action Plan or Sustainable Finance Disclosure Regulation) an increasing support makes the path to sustainable finance easier to access. A research from Arabesque and Oxford University has found that 80% of the studies reviewed provide evidence of a positive association of various ESG measures with stock price performance (Clark, Feiner, & Viehs, 2015). The question to be asked is: Does the integration of sustainable challenges in a portfolio, compromises its financial goals? In this thesis we will elaborate the link between sustainability and finance by analyzing the impact of environment, social and governance (ESG) factors on financial performance, through methodologies of ESG filtering and diversification strategies.

The interest of the research is to discover the effect of ESG filtering on classical diversified portfolios. Within this report we will first present a literature review containing 3 sections. The first section will approach the subject of Sustainable and Responsible Investments (SRI) where we will be explaining the history as well as the definitions and the ESG ratings that exist to date. In the second section we will present the different diversification strategies (equally weighted portfolio, minimum variance portfolio, tangent portfolio and risk parity portfolio). In the next section, Environment, Social and Governance (ESG) filters will be explained in order to understand the effect of ESG filters within financial computations. After the literature review, the next chapter is the empirical analysis. In this chapter, the different portfolios and their ESG filters will be referenced as well as the methodology used to assess the diversified portfolios. To conclude, an analysis of the portfolios affected by ESG filters is explained and analyzed. Finally, conclusions, limits and suggestions of future researches of the work will wrap up this report.

The results of this report have important implications as they are entering into the list of researches that aim at discovering the effect of extra-financial data on "classical" way of investing. Indeed, ESG criteria are extra-financial data that are more and more purchased by financial institutions, as the financial world continues to regulate investments. The main findings are that:

- The portfolio that performs the best, when no significance test is computed, is the portfolio following a minimum variance strategy combined with a consideration of ESG score without any threshold.
- When a significance test is computed on the results, these tests do not confirm a relation between ESG score and diversification strategy.

# Chapitre 2 Literature Review

## Section 2.1 Sustainable and Responsible Investments

In order to build our portfolio, the next sections will elaborate the sense and the role of Sustainable and Responsible Investments in the society over the years. The purpose of these 2 sections is to understand where SRI comes from, what are those investments and why do they exist.

### 2.1.1 History

The early stages of Socially Responsible Investment come from **religious movements** like Muslims (the respect of certain laws from the so called "Sharia" which leads believers to follow certain ethical path) and Quakers (a religious movement that appeared during the $17^{th}$ century) (Jess Liu, 2020). The convictions of these movements were numerous. A few examples of those convictions were the abolition of slavery and the weapon's sale, to the fight against alcohol consumption and the emergence of women's rights (Revelli, 2013).

During the 1920s, the first fund taking into account the ethic ideologies of those movements was developed: "**The Pioneer Fund**". This American fund was built on exclusion of specific stocks that were called the "sin stocks". The investment decision on such stocks were made on very specific sectors. Meaning that the sectors that were considered as immoral were banished from the fund (Revelli, 2013).

An important concept came forth in 1953, thanks to Howard R. Bowen's work on **Corporate Social Responsibility**: Social Responsibilities of a Businessman. The work enabled companies to focus not only on profit but also on their *economic responsibilities*.

In the 60s, during the Vietnam war, many actions against the financing of this war begun to rise. Some investors refused to finance this war; therefore, **ethic investments** gained more supporters.

The 70's were characterized by the first celebration of the Earth Day, showing the interest of some actors on the preservation of the Earth even though the evolutions and the international wars continued to emerge. Moreover, in 1971, "the first publicly available fund in the United

States to invest with issues of sustainability in mind" was launched: the **Pax Fund** (now the Pax Sustainable Allocation Fund) (Donovan, 2020). This is where we can observe the first links between sustainability and finance.

A very important progress was observed in the 80's. The concept of CSR evolved with Freeman's thesis involving the terms *shareholders* to *stakeholders* (Freeman, 1984). It was also in 1987, that the term "Sustainable Development" appeared for the first time in the Brundtland Report[1] (United Nations, 1987).

As time passes, the financial institutions were in the hurry of providing enough information to satisfy the growing demand of SRI. The Kyoto Protocol[2] has been a key catalyzer of the changes in favor of sustainability. One of the responses to the objectives of the Protocol was the emergence of **extra-financial rating agencies**. Less than a decade after the occurrence of traditional credit rating agencies, ARESE (Agence de Rating Environnemental et Social des Entreprises), the first *extra-financial* rating agency is created in 1997. ARESE is a French agency that has shown the rapid concern of Sustainable Investments in the European continent.

The end of the 20th century is characterized with the emergence of the **first sustainable index**, the Dow Jones Sustainability Index (DJSI), "the product of a landmark collaboration between S&P Dow Jones Indices and SAM (now RobecoSAM)" (S&P Dow Jones Indices, 2019).

The concept of Sustainable Finance (SF) grew very rapidly during the 20th century. We will see in the next section that the 21st century will be characterized by a series of regulations on SF.

In summary, we saw in this section that from a religious purpose to a financial index, the history of SRI has been in constant evolution since the 1920's. The shift of sustainable finance as an innovation into a mainstream way of investing will be described in the next section.

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[1] The Brundtland Report is a report published by the World Commission on Environment and Development (WCED). This report developed guiding principles for sustainable development, which is defined as the development of the present without impacting negatively future generations' needs (United Nations, 1987).

[2] The Kyoto Protocol has set targets in the United Nations Framework Convention on Climate Change with the aim to limit and reduce greenhouse gases (GHG) emissions by industrialized countries and economies in transition (UNFCCC). (United Nations Climate Change, 2021)

### 2.1.2 From innovation to mainstream

The 21st century is synonym of a variety of initiatives pushing to integrate sustainable investments in the financial analysis. In this section, we will be describing the initiatives and regulations that are promoting the use of SRI in the financial institutions and how this type of investment became mainstream.

In 2018, SRI represents 11 trillion euros of Assets under Management (Eurosif[3], 2018). With a rule of thumb, this number represents 14% of the total Assets under Management (AuM) worldwide. As the number of signatories of the Principles for Responsible Investment[4] has drastically increased from 2006 to 2020 (see **Figure 1**), hence the number of SRI AuM is bigger in 2020. This coalition is characterized by its 6 principles that require companies to be transparent about ESG factors (see appendix 2 for more details).

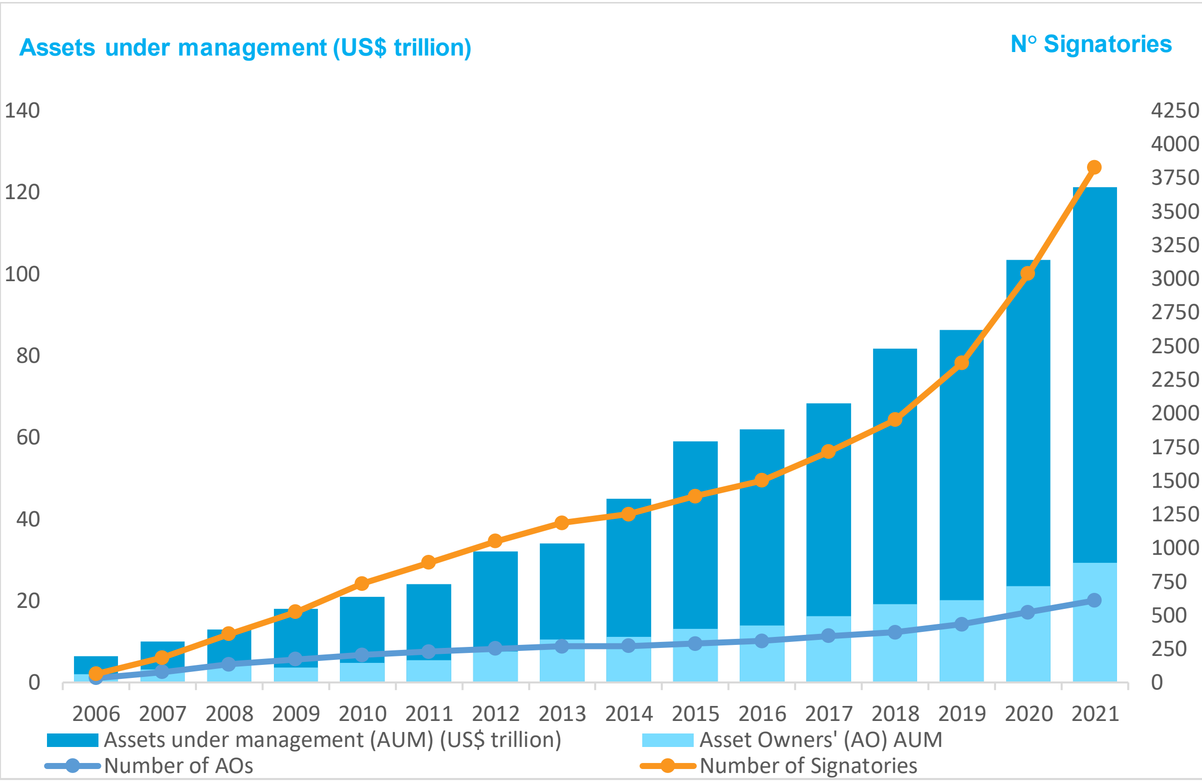



*Figure 1: PRI Growth 2006-2020 (PRI, 2021)*

[3] Eurosif is an organization that promotes extra-financial aspects to the European financial institutions. It is part of an international alliance called Global Sustainable Investment Alliance (Global Sustainable Investment Alliance, 2021).

[4] The Principles for Responsible Investment is a coalition that started in 2006 with only 63 participants, as of today the number is 3038 signatories (PRI, 2021).

Furthermore, a recent regulation related to SRI was issued in Europe: The Sustainable Finance Disclosure Regulation (SFDR). This regulation is a result of the European Union (EU) Action Plan elaborated at the Paris Agreement, named European Green Deal. It aims at reducing carbon emissions by 2030 and allows the EU to reach its net zero carbon emission objective by 2050. As a matter of fact, the EU Action Plan is covering all sectors with a number of regulations and/or directives (European Commission, 2017). SFDR strives to "reorient capital flows towards Sustainable investments, manage financial risks stemming from climate change and foster transparency and long-termism in financial and economic activity" (European Commission, 2018). Thanks to this European regulation financial advisers and market participants will need to disclose sustainability risks, adverse sustainability impacts and sustainability-related information (Mason Hayes & Curran, 2020).

*In fine*, the 21st century has seen an evolution regarding regulations surrounding SRI. In order to better understand the main subject of this thesis, the coming section will be introducing a definition of SRI as well as specific SRI strategies.

### 2.1.3 SRI definition and strategies

After a historical background of the evolution and recent innovation around SRI, a definition of this term can now be presented.

Generally, in the literature, SRI is referred as Social and Responsible Investing or as *Sustainable* and Responsible Investing. According to Eurosif (2018):

> *[Sustainable and Responsible Investment is] a long-term oriented investment approach which integrates ESG factors in the research, analysis and selection process of securities within an investment portfolio. It combines fundamental analysis and engagement with an evaluation of ESG factors in order to better capture long term returns for investors, and to benefit society by influencing the behavior of companies.*

The definition of the Global Sustainable Investment Alliance (2018) is giving a similar definition with an important similarity which is the integration of environmental, social and governance factors in the portfolio analysis (this term is explained in the next section 2.1.4 ).

As a matter of fact, **Figure 2** shows the different SRI strategies and the catch-all terminology that SRI summarizes.


***Figure 2 :*** *Styles of SRI strategies (Eurosif, 2018)*

According to a Harvard study, the most used SRI strategy within the sustainable finance industry is first the engagement and voting on sustainability matters, on the second place it is the *ESG integration factors in financial analysis* and negative screening comes in the third place (Amel-Zadeh & Serafeim, 2017).

Within the definition of Sustainable Responsible Investments, ESG factors keep appearing in the definition. To better understand SRI, we can complete this section with insights on the definition of ESG and a detailed explanation of the E, S and G factors.

### 2.1.4 Environment, Social and Governance Factors

ESG relates to 3 principal pillars: E for Environment, S for Social and G for Governance. In this section ESG factors will be described to complete SRI definition.

Let us start with the **Environmental (E) factor.** This factor considers waste management, reduction of greenhouse gas emissions and prevention of environmental risks. A well-known celebrity of the banking sector, Mark Carney, former governor of the Bank of England, stated in 2015: "Climate change is the Tragedy of the Horizon" (Carney, 2019). Indeed, to him and to other climate change actors, the environmental aspect is a very strong catalysis to change our ways of thinking. As stated earlier, environmental disclosures could help the financial industry to cope with the transition waited by the regulators.

**Social (S) factor** considers accident prevention, staff training, employees' rights, supply chain and social dialogue. According to a CFA institute study[5], social (S) factors and decisions of investment are linked. The profitability of companies could be negatively impacted through a bad management of its reputation and its relationship to workforce. Moreover, a study made by the Global Impact Investing Network has shown that investors, when they had to choose between social and environmental factors, would focus on social impact rather than environmental impact (GIIN, 2020).

The **Governance (G) factor** is another very important aspect. It takes into account the independence of the board of directors, the management structure and the presence of an audit committee. According to a J.P. Morgan study[6], higher returns are correlated to higher governance scores, compared to Environmental and Social scores. Moreover, Governance factor influences environmental related issues. For instance, the Diesel Gate could have been avoided if Volkswagen's governance was more monitored (e.g., Price, 2017). This example demonstrates that the governance factor helps to anticipate environmental issues.

The examples presented above for each of the factors are a non-exhaustive list of examples. A transversal comparison of the 3 factors was made by Amel-Zadeh & Serafeim's (2017) survey where they found that most investors consider that corporate governance issues are financially material to their investments, then environmental issues and social issues come at the end.

ESG and SRI are not anymore random fancy tools of the new era of finance. From the previous section, it is understood that the link between SRI and ESG is drawn by the combination of ESG factors to build SRI decisions. The understanding of those terms is necessary for the empirical study, where we will analyze a set of assets with the help of ESG factors, in order to

[5] Hayat, U., & Orsagh, M. (2015). Environmental, Social, and Governance Issues in Investing: A Guide for Investment Professionals. Codes, Standards, and Position Papers, 11, 1-43.
[6] J. P. Morgan (2018), ESG-Environment, Social & Governance Investing, CONFIDENTIAL. Confidential study received via an internship colleague.

determine ***to what extent does an SRI strategy affects the performance of diversified investment strategies.***

As the purpose of this thesis is to use ESG factors on an empirical framework, we will see in the next section, that the industry of finance has created an interesting tool to democratize these technical factors and quantify these ESG criteria for the financial sector.

### 2.1.5 ESG ratings

In this section we will develop the innovation that represents the **extra-financial rating agencies** or **ESG ratings agencies** mentioned in section 2.1.1.

As described earlier in this report, the first extra-financial rating agency appeared in the 1970's and was created by a company called ARESE. Since then, more than 100 ESG ratings agencies emerged (Amel-Zadeh & Serafeim, 2017). One of the data providers of these ratings, called Bloomberg (BBG), stated in 2019, that the number of customers using ESG data from their database has more than tripled over the past seven years.

Amel-Zadeh & Serafeim (2017) has raised the question: Why does financial industry use and search for ESG ratings?  The main conclusion of their work was that investors find that ESG data is relevant because of its link with financially material performances. By the same token, based on Bloomberg (2019), the ESG data is used to generate critical insights to compare risk and opportunities of the set analyzed.

In summary this means that E, S and G factors are now part of the global financial analysis. The conventional view of financial factors like P/E ratio, Price-to-book, Sharpe Ratio (SR) and Value at Risk (VaR) are now accompanied by E, S and G factors when analyzing investment decisions.

**Figure 3** represents the evolution of $1 invested in March 1993 in a portfolio of companies. What can be observed in this graph is the difference of the two lines, blue and orange, that differ by the weights allocated to companies better performing in ESG scores (blue) and the ones not performing so well (orange). The impressive conclusion from this graph is the final cumulated return of 10$ with the top ESG score strategy. Thanks to ESG ratings, a purely financial performance has been improved. Hence, an investor motivated uniquely by financial performance could consider, rationally, to integrate ESG scores or more broadly sustainable investing, as a style of investment. On **Figure 2**, we saw that one of the SRI strategies is to integrate ESG factors in the financial analysis, this is the exercise that has been done in the example above. In the same manner, the objective of this thesis will be an *elaboration of analyzing and comparing the performance of diversification strategies with a specific SRI strategy*.

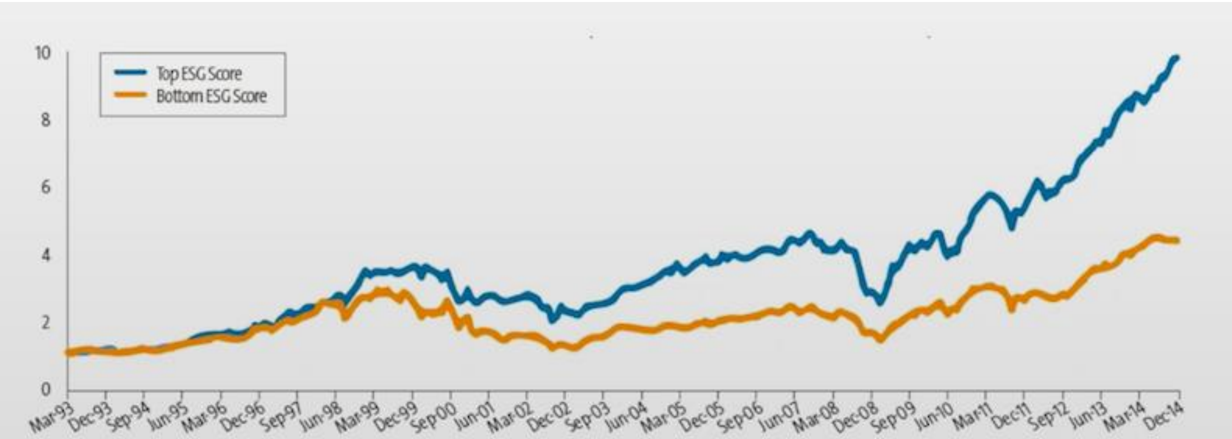



***Figure 3 :*** *Evolution of $1 invested from March 1993 to December 2014* – Reproduced from *"*Your Company's ESG Ratings: Understanding Sustainalytics Research Process*". (2019, October 30). [Video]. Sustainable Finance Solutions.* *https://www.sustainalytics.com/sustainable-finance/2019/04/26/webinar-understanding-esg-risk-ratings-2/*

As ESG data is becoming more available, many methodologies are now in place to build ESG data (Sahut & Pasquini-Descomps, 2015). The main ESG data players are MSCI, Sustainalytics, Thomson Reuters, Bloomberg, FTSE, Oekom Research, RepRisk, Inrate, RobecoSAM, and VigeoEIRIS (Bender, Bridges, He, Lester & Sun, 2018). **Table 1** presents some ESG rating agencies. It can be observed that the methodology differs from an agency to another.

| Rating Agencies | BBG | Sustainalytics | MSCI |
|---|---|---|---|
| **Description** | -Provides ratings of different data providers.<br>-Creates its unique ESG Data Disclosure score to determine the transparency of companies regarding ESG issues. | -Company reports.<br>-Peer-based comparison. | -Company assessment<br>-Industry and peer-based comparison.<br>-E, S and G risks and opportunities. |
| **Ratings** | -Bloomberg ESG Disclosure score: 0-100<br>-External data providers: Sustainalytics, MSCI and RobecoSAM, ISS, etc… | 0-100 (0 = lowest level of risk). | CCC to AAA. |
| **Key Metrics** | N/A. | 20 material ESG issues. | 37 key issues. |

***Table 1 :*** *Comparison of 3 data providers of ESG data*

Indeed, each data provider has developed its own methodology to build their ratings, which makes the ratings between providers different. As we can see in **Table 2**, MSCI World Index Universe constituents' correlation differs from an agency to another, which shows the ratings differences across ESG data suppliers.

| | **Sustainalytics** | **MSCI** | **RobecoSAM** | **BBG ESG** |
|---|---|---|---|---|
| **Sustainalytics** | 1 | 0.53 | 0.76 | 0.66 |
| **MSCI** | | 1 | 0.48 | 0.47 |
| **RobecoSAM** | | | 1 | 0.68 |
| **BBG ESG** | | | | 1 |

***Table 2 :*** *Cross Sectional ESG scores Are Different Across Providers* – Reproduced from "A blueprint for integrating ESG into equity portfolios", by J. Bender and al., 2018, *Journal of Investment Management*, 16(1), p. 4

Later in this thesis, we will choose a specific rating agency, in order to apply an SRI strategy on traditional diversified portfolios. Before starting the next section, it is important to emphasis an important limit of ESG ratings, as it is with these ratings that the quantitative analysis will be drawn. Indeed, ESG ratings are computed with the help of indicators that differ depending on the size of the firm (better ratings for larger firms), as well as the geographic location (better ratings for European firms) (Cook & al., 2016). Those biases do represent a problem regarding analysis of investors in general, but in the case of this thesis, the reader will be able to notice that these biases can be bypassed as the asset allocation chosen integrates only European companies and large cap firms.

Now that SRI strategies are clarified, the next section will address diversification strategies which is the second problematic of this thesis.

## Section 2.2 Diversification strategies

The purpose of this second section is to present different diversification strategies that will be used in the analysis part of this essay. In this section we discuss the properties of Markowitz modern portfolio, as well as the minimum variance and the tangent portfolio. We present also the equally weighted portfolio, as well as an introduction to shrinkage and we will conclude this part with the risk parity portfolio.

### Introduction

The aim of the following paragraphs is to show that diversification was not born yesterday with Markowitz. This is simply to understand that diversification methods were considered before the innovation of Modern Portfolio Theory.

Let us begin by the predecessors of Markowitz's risk-return relation. One of the first is Shakespeare when he made his comedian say:

> *[...] I thank my fortune for it,*
> *My ventures are not in one bottom trusted,*
> *Nor to one place; nor is my whole estate*
> *Upon the fortune of this present year (*Shakespeare, 1597)

Shakespeare explains that he is not worried about his fortune, because he diversifies it. On a similar matter, Bernoulli (1738) states, in one of his most known articles, St-Petersburg Paradox: "*It is advisable to divide goods which are exposed to some small danger into several portions rather than to risk them all together*". Indeed, Bernoulli defends the diversification concept to avoid risk (Rubinstein, 2002).

Above all, no theorization of this diversification was set to feed financial institutions. This is where MPT has its importance. This traditional portfolio selection problem will be explained in the next section.

### 2.2.1 Traditional portfolio selection problem

The traditional portfolio selection problem, also known as the Markowitz or the mean-variance framework, answers to the question: How should we invest our wealth? (Ruppert & Matteson, 2015). Before Markowitz, investors were answering to this question by using J.B. Williams' theory in "The theory of Investment Value". But this theory didn't consider risk and return, but only return. It is only in 1952, when two important works were published in the Journal of Finance: "Safety First and the Holding Assets" and "Portfolio selection" from A.D. Roy and H. Markowitz, respectively; that the idea of risk-return emerged.  It is important to note that even though those two works were quite similar, the one that was awarded a Nobel Price was Markowitz Modern Portfolio Theory. Indeed, the Nobel prized author based his findings on 3 principal assumptions: the investor is rational, he bases his selection process on maximizing the expected return and minimizing the risk (Markowitz, 1952; Markowitz, 1959). Besides, for each level of risk, there exists a portfolio of assets maximizing the expected return; reciprocally for each level of return, there exists a portfolio minimizing the risk that the investor is taking. These portfolios are called the efficient portfolios and the combination of these **efficient portfolios** forms the **mean-variance efficient frontier**. It is important to note that the portfolios above the efficient frontier are not feasible portfolios. Inversely, under this efficient frontier the portfolios are feasible, but they are not optimal diversified portfolios.

Let us start the explanation of the mean-variance portfolio selection problem with some basic concepts.

#### *2.2.1.1 Mean-variance portfolios*

Considering an optimizing investor, this investor is assumed to maximize the mean-variance objective function. It can be shown that the following function is the expected utility of the investor and is a quadratic utility

$$U(w) = \mathbb{E}[R_p] - \frac{\gamma}{2}\mathbb{V}[R_p] = \mu_p - \frac{\gamma}{2}\sigma_p^2 = \boldsymbol{M'w} - \frac{\gamma}{2}\boldsymbol{w'\Sigma w} \qquad (\mathbf{1})$$[7]

Where $R_p$ is the rate of return of portfolio $p$ and $\gamma$ is the coefficient of relative risk aversion, which is a measure showing the most appropriate risk for the investor. From equation (1) we can observe that $\boldsymbol{M'w}$ and $\boldsymbol{w'\Sigma w}$ are respectively the mean and variance of the rate of return of the portfolio. This portfolio selection problem theorized by Markowitz is often expressed in terms of risk returns trade-off, where the investor needs to choose a set of weights maximizing the utility function, through the following equivalent optimization program

$$\min_{w} \mathbb{V}[R_p] = w'\Sigma w \qquad (2)$$

Subject to

$$w'\mu \geq \mu^*$$
$$w'1 = \mathbf{1}$$

We use $\mu^*$ as the minimum acceptable portfolio return, 1 to define a *N*-dimensional vector of ones and **1** is a scalar of ones. Note that this second constraint ensures that all wealth is invested in the *N* risky assets. This objective function aims at minimizing risk for a minimum acceptable level of return. Equivalently, in the next formulation, we maximize the returns for a maximum acceptable level of risk ${\sigma_p^2}^*$,

$$\max_{w} \mathbb{E}[R_p] = w'\mu \qquad (3)$$

Subject to

$$w'\Sigma w \leq {\sigma_p^2}^*$$
$$w'1 = \mathbf{1}$$

All things considered, by solving the objective functions presented above, two important economic insights are provided by Markowitz' paradigm. First, it can be shown that a portfolio composed of correlated assets provides a preferred expected return-risk characteristic. This demonstrates the effect of ***diversification***. Second, this paradigm shows that, high expected returns can only be achieved by taking riskier portfolio allocations (Ait-Sahalia, Hansen & Hansen, 2009).

[7] $\mathbb{E}[X]$ and $\mathbb{V}[X]$ are, respectively, the expectation and the variance of the random variable $X$, and $\mu$ is the vector $N \times 1$ composed of individual expected returns: $\mu = (\mathbb{E}[\mathrm{R}_1], \dots, \mathbb{E}[\mathrm{R}_\mathrm{n}])'$.

It is important to notice that there are some issues to the mean-variance portfolio of Markowitz. One of the issues is that the approximation of the two moments of the distribution of the returns i.e., the expected returns and the variance-covariance matrix, are not exact (Meucci, 2005). Indeed, the two moments are unknow, which leads the utility function to estimation errors. As a consequence, the mean-variance portfolios are not well diversified portfolios in terms of portfolio weights (Green and Hollifield, 1992).

According to many authors like Merton (1980), Best & Grauer (1992) and Black & Litterman (1992), the mean is difficult to estimate and the impacts of this estimation on the portfolio are significant compared to the estimation of the covariance matrix. One way to reduce estimation errors is to consider only the Sample Covariance Matrix (SCM) with the minimum-variance portfolio optimization (Yang, Couillet, & McKay, 2015). On the efficient frontier, if we add the assumption that all assets have the same expected returns, we will fall on the same portfolio as the **MINV**[8] portfolio.

The solution of equation (1) gives the weights of the **MINV** portfolio, given by

$$w_{GMIN} = \frac{\Sigma^{-1}1}{1'\Sigma^{-1}1} \tag{4}$$

It has been proved by Jorion (1991) or Chopra & Ziemba (1993) that this solution has better out-of-sample results than any other mean-variance portfolios (Yang, Couillet & McKay, 2015). However, this strategy is known for its dramatic asset concentration (Maillard, Roncalli, & Teïletche, 2010).

Regarding the tangent portfolio (**TANG**), it is obtained by maximizing the Sharpe Ratio, introduced by William Sharpe (1994). This ratio is a measure of expected return per unit of risk

$$SR_p = \frac{\mu_p}{\sigma_p} \tag{5}$$

The **TANG** portfolio, like the **MINV**, is a portfolio that is on the efficient frontier of Markowitz and this portfolio is called tangent because it is the portfolio that passes through the origin and is tangent to the efficient frontier. The weights composing this portfolio are given by

---

[8] **MINV** refers to the minimum variance portfolio.

$$w^* = \frac{\boldsymbol{\Sigma}^{-1}\mu}{1'\boldsymbol{\Sigma}^{-1}\mu} \tag{6}$$

However, for both **TANG** and **MINV** portfolio, $\mu$ and $\boldsymbol{\Sigma}$ are not known. In the mean-variance paradigm, the optimization problem is solved thanks to sample estimators, which are parameters estimated from a sample data

$$\hat{\mu} = \frac{1}{T}\sum_{t=1}^{T} R_t \tag{7}$$

$$\widehat{\boldsymbol{\Sigma}} = \frac{1}{T-1}\sum_{t=1}^{T}(R_t - \hat{\mu})(R_t - \hat{\mu})' \tag{8}$$

Where, for $T$ asset return observations, $R_t \in \mathbb{R}^N$ is the returns of $N$ assets at time $t$. $\hat{\mu}$ and $\widehat{\boldsymbol{\Sigma}}$ are the sample estimators and are preferred because they are unbiased estimators. However, risk and return can be subject to large estimation errors[9]. Michaud (1989) calls this: "error maximization". According to the literature, in order to avoid this phenomenon, there exists a better way to estimate the sample covariance matrix. This is what will be explained in the next paragraph.

### Shrinkage of the sample covariance matrix and no-shortselling constraints

In this paragraph we will be explaining a term called the "shrinkage" and the purpose of using shrinkage in this thesis.

To avoid large estimation errors, Ledoit & Wolf (2003) applied to portfolio management a statistics concept called *shrinkage*. This principle consists of *shrinking* the sample covariance matrix towards a structured estimator. In other words, estimators of the sample covariance matrix have a quantity of positive (negative) errors. With the shrinkage effect, these estimates will have the tendency to be pulled downwards (upwards). This process is called "the *shrinkage* of the extremes towards the center" (Ledoit & Wolf, 2003). By doing so, the sample covariance matrix becomes a better estimator.

In more analytical words, the sample covariance matrix $\boldsymbol{\sigma}$, becomes $\boldsymbol{\delta F} + (\mathbf{1} - \boldsymbol{\delta})\boldsymbol{\sigma}$, where $\boldsymbol{F}$ is a highly structured estimator and $\boldsymbol{\delta}$ is referred to as the shrinkage constant[10] (it is framed between 0 and 1). By applying this formula for the sample covariance matrix, we find a

[9] Large estimation errors are built because the mean-variance optimization inevitably overweights (underweights) assets that have large (small) estimated returns, negative (positive) correlations and small (large) variances.
[10] The higher the shrinkage constant, the more the sample covariance matrix is shrunk to the target covariance matrix.

compromise between two extreme estimators. This new estimator performs better than the two extremes. Ledoit & Wolf (2003) compare this principle to a compromise of a bottle of Bordeaux and a steak. They explain that a client of a restaurant would prefer one bottle of Bordeaux accompanied by a steak, to either two bottles of Bordeaux (and no steak) or two steaks (and no Bordeaux).

According to Jagannathan and Ma (2003), restricting shortselling is implicitly applying a shrinkage to the sample covariance matrix. This is explained by the fact that, by using long-only constraints, estimation of the variance covariance matrix arriving at extreme values is less possible when adding a positivity constraint to the weights. We could expect from the results, when no-shortselling is applied, to obtain an estimation of the sample variance covariance matrix that performs as well as an estimation by shrinking the variance covariance matrix. Indeed, by using the constraint of no-shortselling the estimation errors decrease.

#### *2.2.1.2 Equally Weighted Portfolio*

For this part of the report, a naïve construction of a portfolio will be introduced. Indeed, the equally weighted portfolio is the naïve portfolio, and we will elaborate on that in the next paragraphs.

For Benartzi and Thaler (2001), Equally Weighted Portfolio (**EWP**) is an easy concept used by "unsophisticated" investors. The 1/N portfolio has a better optimization because of the absence of estimation errors (DeMiguel, Garlappi and Uppal, 2009a). This is also true for Duchin and Levy (2009) as long as the number of assets is low.

The **EWP**, unlike the **MVP** presented before, does not need any estimation neither of the mean nor of the covariance matrix. In this portfolio, the weights of the assets of the **EWP** are equal and depend on the number of assets *N*:

$$w_{EWP} = 1/N \tag{9}$$

The **EWP** is mostly used as a benchmark portfolio in order to compare with other investment strategies (Duchin and Levy, 2009; DeMiguel, Garlappi, Nogales & Uppal, 2009b; Fletcher, 2009; Jiang, Du & An, 2019).

Some limits of the **EWP** portfolio do exist. One of them is the constraint obliging the weights to be equal. According to Clarke, de Silva and Thorley (2002), due to the imposition of constraints, portfolio managers are led to underappreciated impact on performance. This means that constraints, like equal weights, could lead to decrease the value on performance.

Finally, the **EWP** or the naïve portfolio is the least concentrated portfolio in terms of weights; indeed, the **EWP** is well diversified in terms of weights but not in terms of risk, specifically, when some of the assets are riskier than others (Lassance, DeMiguel & Vrins, 2021). This is why we are moving to the *asset-risk-parity portfolio*, which is a portfolio well diversified in terms of *asset risk contributions*.

### 2.2.2 Risk-Parity Portfolio

In finance, there are three budgeting approaches used for asset allocation: the weight, the performance and the risk-parity budgeting (see **Figure 4**). In this section, we will be elaborating on the third one, the risk-parity budgeting method within asset allocation.

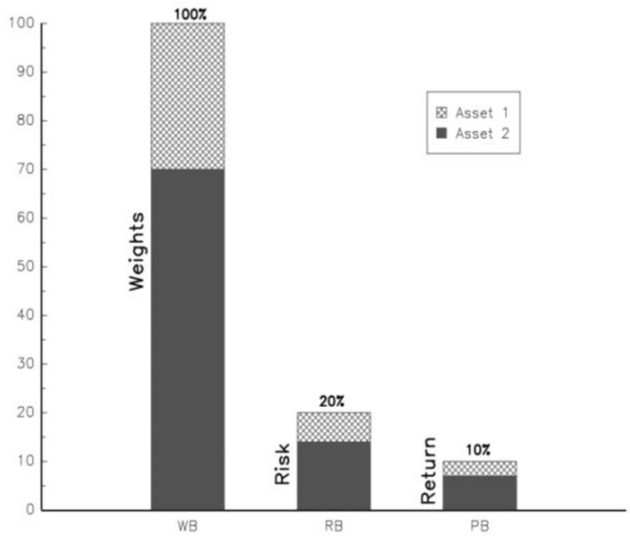



***Figure 4 :*** *Three budgeting methods - WB (Weight Budgeting), RB (Risk Budgeting), PB (Performance Budgeting) - with a 30/70 policy rule. For the weight budgeting, the weights are directly defined as 30% for asset 1 and 70% for asset 2. The RB approach with a target risk measure of 20%, therefore the risk budget of asset 1 and 2 are 6% and 14%, respectively. Regarding the PB method, with a target return of 10%, asset 1 has a weight of 3% and asset 2: 7%* – Reproduced from "*Introduction to risk parity and budgeting",* from Roncalli, T., 2016, p.72, Chapman and Hall/CRC

The Risk-Parity Portfolio (**RPP**) or the Equal Risk Contribution (ERC) is focused on the risk management. Consequently, the **RPP** took a rise on popularity after the financial crisis of 2008 (Roncalli, 2013). Pioneer of this asset allocation is Ray Dalio, in 1996, with the All-Weather

Portfolio (Bridgewater, 2012). The objective of the All-Weather Portfolio is to perform well in any situation.

There are two steps for a portfolio risk management:

- The first one is measuring the risk.
- The second one is the risk allocation (Litterman, 1996). In this step, we decompose the risk to a sum of risk contributions by assets (Roncalli, 2016). When allocating the assets to the **RPP**, no asset has a zero weight.

To have a better view on this risk management asset allocation, we will explain further the details of computation of a risk parity portfolio.

#### 2.2.2.1 Marginal Contribution and Total Risk Contribution

The volatility of a portfolio *p,* which has been introduced earlier, is given by

$$\sigma(w) = \sqrt{w'\Sigma w} \tag{10}$$

Following Euler's theorem[11], we can decompose the latter equation as follows[12]

$$\sigma(w) = \sum_{i=1}^{N} w_i \frac{\partial\sigma}{\partial w_i} = \sum_{i=1}^{N} w_i \frac{(\Sigma \mathrm{w})_i}{\sqrt{w'\Sigma w}} \tag{11}$$

The Marginal[13] Risk Contribution (MRC) of the i$^{th}$ asset to the total risk $\sigma(w)$ is defined as

$$\frac{\partial\sigma}{\partial w_i} = \frac{(\Sigma \mathrm{w})_i}{\sqrt{w'\Sigma w}} \tag{12}$$

The risk contribution from the i$^{th}$ asset to the total risk is defined as

$$\sigma_i(w) = w_i \frac{\partial\sigma}{\partial w_i} = w_i \frac{(\Sigma \mathrm{w})_i}{\sqrt{w'\Sigma w}} \tag{13}$$

From Euler's theorem it can be proved that the risk of the portfolio is the sum of the risk contribution, or that

$$\sigma(w) = \sum_{i=1}^{N} \sigma_i(w) \tag{14}$$

The risk parity portfolio is the portfolio in which the risk contribution of each asset is equal. In other words, the relative risk contribution (RRC), defined as the ratio of its risk contribution to the total portfolio risk $\sigma(w)$, should be equal for each asset

[11] A homogeneous function of degree 1 satisfies Euler Theorem and can be written as the product of the sum of the arguments of this function by their first partial derivative.

[12] Because the vectoral derivative is $\frac{\partial\sigma}{\partial w} = \frac{\Sigma \mathrm{w}}{\sqrt{w'\Sigma w}}$

[13] The term marginal is used because the MRC gives the change in volatility of the portfolio caused by a small increase in the weight of one component (Maillard & al., 2010).

$$RRC_i = \frac{\sigma_i(w)}{\sigma(w)} = \frac{w_i(\Sigma w)_i}{w'\Sigma w} \tag{15}$$

So that $\sum_{i=1}^{N} \frac{\sigma_i(w)}{\sigma(w)} = 1$

#### *2.2.2.2 RPP strategy*

Following Maillard & al. (2010) the risk parity portfolio is a risk-balanced portfolio such that the risk contribution is the same for all assets in the portfolio. They propose a quadratic programming algorithm to find this **RPP**.

$$\min_{w^*} \sum_{i=1}^{N} \sum_{j=1}^{N} \left(w_i(\Sigma \mathrm{w})_{\mathrm{i}} - w_j(\Sigma \mathrm{w})_j\right)^2 \tag{16}$$

Subject to

$$\sum_{i=1}^{N} w_i = 1 \text{ and } 0 \leq w \leq 1$$

Maillard & al. (2010) have found that the standard deviation of the **RPP** lays between the **EWP** and the minimum variance portfolio. Analytically, they have found that:

$$\sigma_{MINV} \leq \sigma_{RPP} \leq \sigma_{EWP} \tag{17}$$

It is important to specify that the risk parity strategy used in the empirical study of this thesis is the asset-risk-parity portfolio described below and not the factor-risk-parity portfolio, which ensures that each factor contributes equally to the total risk.

To summarize this second section, the principal characteristics of each asset allocation are presented in **Table 3** as well as a comparison of the out-of-sample results computed by past studies.

| | Minimum-variance Portfolio (MINV) | Tangency Portfolio (TANG) | Equally Weighted Portfolio (EWP) | Risk Parity Portfolio (RPP) |
|---|---|---|---|---|
| Summary | This portfolio of assets lies on the efficient frontier and is the portfolio with the lowest risk. | This portfolio also lies on the efficient frontier and is the portfolio that maximizes the Sharpe Ratio. | This portfolio is an equal combination of all the assets of the universe. | The **RPP** is a portfolio where the volatility of the assets is equally distributed. |
| Results | No estimation of the expected returns. Higher out-of-sample standard deviation than **EWP** and **RPP** portfolio (Maillard & al., 2010). Higher out-of-sample Sharpe Ratio than **TANG** portfolio (Jorion, 1991). | Lower out-of-sample Sharpe ratio than **MINV** portfolio (Jagannathan & Ma, 2003). | No estimation errors. Lower out-of-sample standard deviation than **MINV** and **RPP** portfolio (Maillard & al., 2010). | No estimation of the expected returns. Out-of-sample standard deviation between the **MINV** and the **EWP** (Maillard & al., 2010). |

***Table 3 :** Comparison of 4 strategies*

The portfolios studied, in the empirical analysis, are the asset allocation explained in this section: The Minimum Variance, the Tangent, the Equally Weighted and the Risk Parity portfolios. Additionally, the efficient frontier of Markowitz will help us understand the impact of the ESG filter on our set of portfolios. In the next section, we investigate these financial diversification strategies and their relationship with ESG ratings.

## Section 2.3 ESG filters impact on diversification strategies

As stated in the first section, the researches on ESG investing are not so recent. Indeed, beginning of 1970s, some researches were seeking a relation between ESG criteria and corporate financial performance (Friede, Busch & Bassen, 2015). The goal of this section is twofold. Firstly, we will understand the relation between ESG ratings and financial performance. Secondly, this section will present what the literature has already found on the integration of ESG ratings to diversification strategies.

### 2.3.1 ESG and diversification effect

We have explained earlier that the aim of the investor is to maximize its utility, by impacting this utility the performance of a portfolio could be in danger. In this section, we will be presenting what the previous financial theories of section 2.2 prove about the impact of ESG filters on the utility of the investor.

For Markowitz (1952) a screened universe (not specifically ESG screened but any screening that leads to a reduction of the scope of the initial universe) that is more diversified than a non-screened universe is not possible. In the same way, Rudd (1981) arrives at the "inescapable conclusion" that social responsibility criteria worsen investment risk. Additionally, an ESG-screened universe could increase risk, because of a loss of diversification (Verheyden, Eccles & Feiner, 2016). This loss of diversification is due to the exclusion of certain assets from the initial (non-screened) universe. Indeed, it has been proved (see **Figure 5**) that standard deviation of portfolio worsens with a decrease of number of stocks in a portfolio (Statman, 2004). It is important, here, to put an emphasis between the impact of standard deviation and the loss of diversification. Undoubtedly, when the number of a portfolio's assets decrease, diversification is impacted negatively, and this can be seen through an overall increase of standard deviation of the portfolios under the efficient frontier.

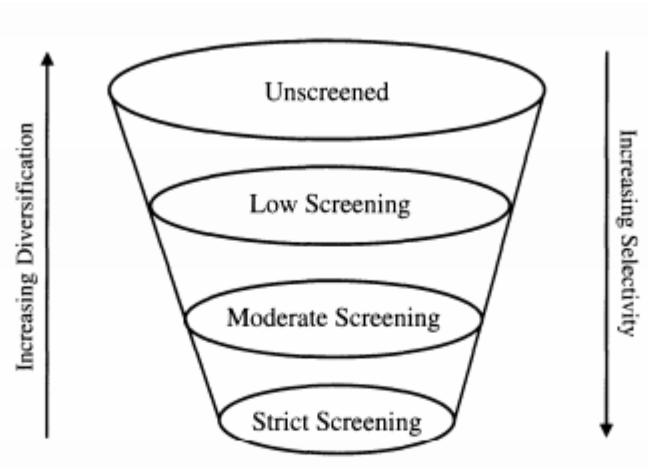



***Figure 5 :*** *The effects of social screening on the universe of stock choices – Reproduced from "Beyond dichotomy: The curvilinear relationship between social responsibility and financial performance",* from Barnett, M. L., & Salomon, R. M., 2006, p.1106, Strategic Management Journal

However, Hoepner (2010) argues that ESG criteria can also improve portfolio diversification through a reduction in the specific risk of the selected assets (see **Figure 13** in appendix 5).

Overall, ESG screened universe appears to worsen the utility of investors in general, but in some cases the specific risk could be decreased thanks to the ESG screens. In the next section, evidence of recent studies drawn on the question of the effect of ESG filters on the well-known Markowitz' efficient frontier will be presented. This section will help us understand a part of the intended results of this thesis.

### *ESG filter effect on the efficient frontier*

On the topic of efficient frontier portfolios, Qi and Li (2020) study the effect of ESG constraint on portfolio selection. In their study they were able to find that indeed, by imposing extreme ESG constraint the efficient frontier tends to move to the right of the risk return well known graph. Additionally, they focused their study on the weight space, where they found out that sustainable investment and conventional portfolio selection possess different portfolio weights. Similarly, another study from Pedersen, Fitzgibbons & Pomorski (2020) proposes a theory for building an ESG-efficient frontier, disclosing the highest SR for a certain level of ESG score (see **Figure 14** in appendix 6). They observe that the "hyperbola for a given ESG score clearly lies inside the standard hyperbola, because minimizing the variance among all portfolios must provide a result that is at least as small as minimizing over the subset with a given ESG score" (p.22). In other words, the results, driven by the ESG-efficient frontiers' authors, show that the efficient frontier derived from a set of assets respecting a certain ESG score, is with no doubt, a frontier inside the initial efficient frontier (see **Figure 15** in appendix 6).

On the same topic, another author having studied the diversification effect of a screened universe is Meucci (2005). He states that when adding new assets to the universe, the frontier goes toward the upper-left region and he adds that the effect is less pronounced when the number of assets analyzed is relatively low; we can presume that the inverse is true. This means that by reducing the number of assets from the initial universe, the frontier goes downwards the upper-left region. According to Meucci (2005), the frontier moves to the right of the risk-return trade-off.

Finally, authors studying the movement of the efficient frontier with ESG screening, all end up to the same conclusion, which is a movement of the ESG constrained efficient frontier to the right, characterized by a visible increase of the standard deviation compared to the non-constrained portfolios. It concretely means that the minimum variance and the tangent portfolios, as well as the portfolios lying below the efficient frontier, are supposed to move to the right of the risk-return trade-off graph.

Now that the question of the efficient frontier portfolio is answered, we can move to the literature's out-of-sample results.

### 2.3.2 ESG and financial performance

Some studies did show the outperformance of stock prices when using ESG criteria. Other studies show the opposite. Edmans (2011) shows that *intangible* information is hard to implement within the market pricing. This is called "managerial myopia theory" (Stein, 1988). In spite of this, other studies have integrated this intangible information within their analysis and the conclusions are balanced.

Some like David Diltz (1995), state that moral and ethical criteria don't hinder the performance of the portfolios. In the same idea, Bauer, Koedijk & Otten (2005) find no evidence that risk-adjusted returns of ethical funds are different from conventional funds, for the period 1990-2001. These statements are in opposition to the observations of **Figure 3**, where ESG integration enabled a financial outperformance. Here, we can observe divergent ideas, thus the results expected are not clear.

Others show that, even though negative screening does harm diversification, this screening provides higher performance (Auer, 2016). According to a research that analyzed more than 2000 empirical studies on ESG relation with Corporate Financial Performance, from 1970 to 2015, approximately 90% of them found a positive ESG relation (Friede, Busch & Bassen, 2015). On another register, Capelle-Blancard and Monjon (2014) suggest that "As of 2011, more than fifty academic papers have examined this issue [risk-adjusted performance and ESG criteria], all using similar methodology. They almost unanimously show that the financial performance of SRI funds does not differ significantly from their conventional peers" (p. 495). In their study, they find that the risk-adjusted return is reduced when using higher screening intensity. Whereas Bello (2005) analyses socially responsible funds and finds that those funds, characterized by some specific constraints, are not different from conventional funds in term of performance.

Those are the various findings on SRI strategies and their financial performance. Let us discover the studies on the performance of ESG stocks. Eccles, Ioannou & Serafeim (2014; 2012), tracked financial performance of 180 companies for 18 years and found that high sustainability companies outperform low sustainability companies, in terms of stock market and accounting performance. Moreover, a report delivered by Arabesque and the Oxford University, illustrates that 80% of the 41 researches influence the stock price performance positively, thanks to good sustainability performance (Clark, Feiner & Viehs, 2015). Regarding the cost of capital of large institutions, a study of 2006 found that there is a significant difference when sin stocks are excluded from the investments (Hong & Kacperczyk, 2009).

To conclude this section, the researches of this last literature review chapter, point at the effect of ESG filter on the efficient frontier, SRI strategies performance and ESG stocks performance. For some of these subjects the results are hard to anticipate. Concerning the diversification effect of ESG filters, the majority of the studies find a negative impact; most studies agree that ESG screening harms diversification. Thus, the effect of ESG filters on the efficient frontier is clear; the efficient frontier tends to be impacted negatively, because by reducing the universe, the efficient frontier always gives a smaller return for a same level of risk or inversely a higher risk for a same level of return. Finally, there is no converging answer regarding the potential impact of SRI strategies that perform the best in any case. On the topic of ESG stocks, the researches all agree that restricting some specific stocks improves the financial performance.

From these literature review, we can spot the question that could improve this existing literature. Indeed, the subject about the impact of SRI strategies on financial performance is a subject for which the literature has not yet converged to a clear idea. Hence, in addition to SRI strategy, the subjects about diversification and efficient frontier movement will be elaborated in the empirical analysis.

# Chapitre 3 Empirical Analysis

## Section 3.1 Methodology

The aim of this part is to describe the data used for our different portfolio strategies as well as the data used to filter assets of our portfolios, which will be the Sustainalytics ESG rating.

### 3.1.1 Dataset and portfolios

#### *3.1.1.1 Dataset for portfolio diversification*

The data used to build the diversified portfolios are assets retrieved from the EURO iSTOXX 80 Equal Weight (EW). The elements of this index are selected thanks to their largest free-float market capitalization of the EURO STOXX universe. Moreover, this index is Equally Weighted (STOXX, 2021). EURO iSTOXX 80 is composed of 80 assets (details of these assets can be found in appendix 1). Most of the assets are known companies such as Adidas, Hermes, BMW, Unilever, Total, BNP, ING and Ferrari. Whereas other lines of this index are less known companies for instance Wolters Kluwer, Prosus and Kering. Additionally, there is a big percentage of the companies that are French (FR), German (DE) and Dutch (NL). The other part of the lines are other countries of Europe such as Italy (IT), Spain (ES) and Finland (FI). The index is composed of 19 different sectors.

Furthermore, the choice of this index is motivated by EU's improvements regarding sustainable matters, like the EU Action Plan-Horizon 2020. One of the aims of this Action Plan encourages the European parties to reduce their impact regarding carbon emissions (see section 2.1.2). As all the assets are European owned companies, this avoids biases in our analysis because all the companies are at the same level of sustainable innovation and sensitivity.

The 80 assets composing the index will be used to build the portfolios. As a matter of fact, the financial data of the 80 assets, was extracted from Yahoo Finance, and more specifically daily "Adjusted Closing Price" for a period from 1st January 2014 to 31st December 2019 (see the distribution of the means of these returns in appendix 9 in **Figure 21**)

To summarize, the assets composing the EURO iSTOXX 80 EW will be used to build our portfolios. At this time the data is financial driven, whereas in the next paragraphs extra-financial data, used in the analysis, will be introduced.

### 3.1.1.2 Dataset for ESG Screening

Undoubtedly, the purpose of this work is to track the performances of different portfolio strategies. These portfolios depend on a considerable factor or criteria, the ESG score, which is explained hereafter.

The ESG score, as explained earlier, enables financial institutions to compare risk and opportunities, related to ESG, on the set analysed. In this report, the Sustainalytics' ESG scores will be the reference for ESG score for 2 main reasons. On the first hand, Sustainalytics' data is available on Yahoo Finance, which makes this data more interesting as it can be found by any investor, unlike other ESG data provider which reveals data uniquely on paid subscription accounts. On the second hand, Sustainalytics[14] is an independent ESG data provider. This reveals no conflict of interest between the rater and the company rated. An example of an ESG data provider, that is not an independent ESG rating institution, is the RobecoSAM asset management[15] company. This financial institution has a primary activity which is asset management, but it also offers ESG rating data.  This makes this rating non independent and less interesting in our case.

For the purpose of this thesis the ESG data, and more specifically, the Sustainalytics ESG rating is retrieved from Bloomberg database because of practicality regarding the coding part. This ESG score is given as an "overall percentile rank". Meaning that, each company obtains a total score according to Environment, Social and Governance criteria. This score is relative to its industry peers (**Figure 16** in appendix 7). Moreover, the best 1% of a certain industry will get a percentile of 99%, inversely the least 1% companies from the same industry will get 1% percentile (Bloomberg Terminal, 2021). In other words, the best performer, in terms of ESG criteria will get a score close to 100 and the worst ESG performer will get a score closer to 0. Also, it is possible to find in the data, 2 or more companies having a same score, but these companies won't be from the same set of industry[16].

The data was collected according to the availability of the ESG scores of the 80 assets analyzed. On the Bloomberg Terminal, the majority of the 80 assets issue ESG data since the 2nd February

[14] https://www.sustainalytics.com/
[15] About us overview. (2021). Retrieved 6 May 2021, from https://www.robeco.com/en/about-us/
[16] A detailed explanation of the computation of Sustainalytics ESG score can be found in appendix 3.

2015. In order to keep most of our assets within our analysis universe we kept a period from the 2nd February 2015 to the 31st December 2019, for the ESG scores (which is the out-of-sample period). The histogram on **Figure 6** represents the average returns of ESG scores (or percentiles) of our assets. The majority of the scores lie between 80 and 100 and some bad players have a score between 20 and 60.

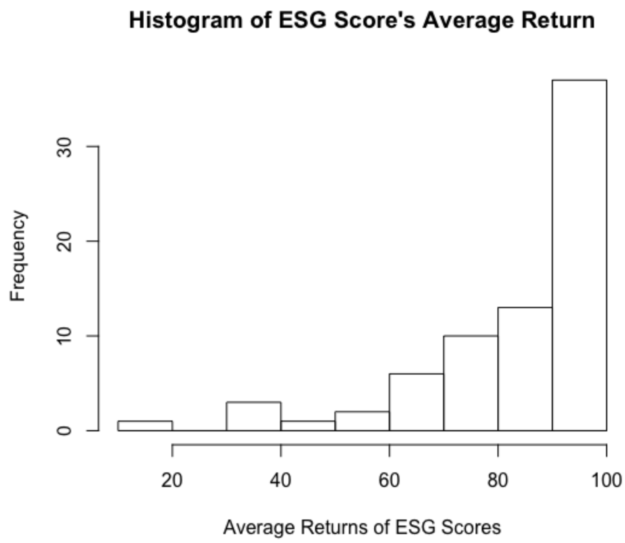



***Figure 6 :*** *Boxplot and histogram of average ESG Scores of our assets. The average ESG Score of each asset is the average of the ESG Scores of the period from 1st January 2015 to 31st January 2019.*

On **Table 4**, a summary of the number of assets composing our different universes is set. To clarify, the initial sample (80 assets) ends up with a sample of 76 assets, as for the whole sample period there is no available adjusted closing price for 4 companies - Adyen, Cellnex, Ferrari and Prosus. Besides, from the remaining 76 assets, there are 3 companies that have missing ESG data – Flutter, Linde and Teleperformance. This enables to draw a first ESG filter, excluding companies with no ESG data. From these 73 assets, we are able to put constraint on the available ESG data and follow the effect of the ESG filter.

| Sample Selection Process | # of companies |
|---|---|
| Initial Sample | 80 |
| Missing financial data | - 4 |
| **Sample of assets with financial data** | **76** |
| Missing ESG data | - 3 |
| **Sample of assets with financial data and ESG scores** | **73** |

***Table 4 :*** *Visual of our financial and extra-financial dataset*

Regarding the sample periods considered, the in-sample period is from 1st January 2014 to 31st December 2014, and the out-of-sample period is from the 1st January 2015 to 31st January 2019.

All things considered, the ESG screening used for the analysis, has not yet been presented. To compensate from the absence of explanation of the ESG screenings, the next section will be tackling the different universes considered.

### ESG Screening

We compare 3 different kind of ESG filters, as **Table 5** shows it:

| **SRI type** | **No.** | **ESG filter** | **Universe Name** | **# of assets** |
|---|---|---|---|---|
| **BIC[17] investment selection** | **A** | Exclude companies with no ESG data | First Screening | **73** |
| | **B** | Exclude companies with ESG score smaller than average[18] | Second Screening | **50** |
| | **C** | Keep SRI type No. A and increase/decrease the weight of the assets according to the ESG score[19] | Third Screening | **73** |

***Table 5 :*** *ESG Screening methodology summary*

A more detailed description of these screenings can be found in appendix 4. Now that the universes considered have been described, we can present the portfolios considered in our analysis.

### *3.1.1.2 Portfolios*

In this study we compare different strategy of diversified portfolios: the equally weighted, the global minimum, the tangent and the risk parity portfolio. Those portfolios are presented in **Table 6**, according to the type, their abbreviations and the reference section explained to compute these portfolios.

Each strategy is built with the 3 degrees of ESG filters. For each strategy, the degree of exclusion, thanks to ESG scores, is set. For example, for the **EWP** strategy, a first portfolio is set with no exclusion, whereas the 3 other portfolios using the **EWP** strategy are set with the 3

[17] BIC refers to Best-In-Class.
[18] The average ESG score of the 73 companies from 2015 to 2019 is 80.
[19] If the ESG score of asset "Adidas", as instance, is smaller than the average ESG score, the weight of Adidas is put to 0. Adidas's weight is rebalanced on other assets respecting the criteria.

types of ESG screening explained earlier. This is done for each diversification strategy (minimum variance, tangent, equal weights and risk parity).

| Strategy | No. | ESG filter | | | | Section |
|---|---|---|---|---|---|---|
| | | No screening | A | B | C | |
| **Equally weighted portfolio** | 1 | EWP | EWP (73) | EWP (50) | EWP (73)' | 2.2.1.2 |
| **Certainty-equivalent global minimum variance portfolio** | 2 | MINV | MINV (73) | MINV (50) | MINV (73)' | 2.2.1.1 |
| **Short-constrained global minimum variance portfolio** | 3 | SCMV | SCMV (73) | SCMV (50) | SCMV (73)' | |
| **Tangent portfolio** | 4 | TANG | TANG (73) | TANG (50) | TANG (73)' | |
| **Short-constrained tangent portfolio** | 5 | SCTAN | SCTAN (73) | SCTAN (50) | SCTAN (73)' | |
| **Risk Parity Portfolio** | 6 | RPP | RPP (73) | RPP (50) | RPP (73)' | 2.2.2 |

***Table 6 :*** *Illustration of the different strategies and the corresponding ESG filters and their abbreviations*

Finally, we are able to follow the performance of our portfolio with the financial and the extra-financial data described in the previous sections.

### 3.1.2 Performance evaluation

In this part we will introduce the performance evaluation sample as well as the methodology used to study the performance of the portfolios constructed.

To test the effectiveness of our approach, we proceed with the "rolling window" approach, proposed by DeMiguel & al. (2009a, 2009b), as the out-of-sample evaluation method. Firstly, we choose an estimation window $\tau$ to estimate the parameters we want to evaluate, where $\tau < T$ ($T$ is the total number of observations). In our case, the window $\tau = 252$ and $T = 1512$, which means that we have an estimation period of 1 year (2014) and a forecast horizon of 5 years (from January 2015 to December 2019). This small sample is due to the poor availability of ESG data. The results with different values of τ have the same intuition, hence we do not report them here. Secondly, the weights of the portfolio estimated for the period $\tau$ are used to compute the portfolio of the forecast horizon $T - \tau$. By doing so, we end up with $(N \times 1)$ dimensional weight vectors for each strategy, denoted $w^i$ which is the weight of the strategy $i$=1, 2, …, 6. In general, there is a third step, which is to repeat the first and second procedure until the end of the dataset. In our case, as the ESG data is a recent data, we only have one period of estimation $[t_0, \tau]$ and one period of forecast $]\tau, T]$. For all $t \in [t_0, T]$, the daily return between $t$ and $t\text{-}1$ of strategy $i$ is $r_t^i = w^{i\prime} r_t$, where $r_t^i \in \mathbb{R}^N$ is the vector of asset returns at time $t$ for strategy $i$. To summarize, the weights are estimated thanks to the estimation window and the returns are built thanks to the estimated weights. These estimations will build the performance measurements of our analysis. This methodology is interesting as stock return data within the estimation window is closer to stationary rather than on the whole sample (Lassance, Demiguel & Vrins, 2021). For each investment horizon, we assume that the transaction costs are negligible, as we keep a buy and hold strategy for the analysis. According to DeMiguel & al. (2009b), we consider the sample variance and the SR as performance measures.

$$\left(\hat{\sigma}^i\right)^2 = \frac{1}{T-\tau-1}\sum_{t=\tau}^{T-1}(w^{i\prime} r_t - \hat{\mu}^i)^2 \qquad (17)$$

$$\widehat{SR}^i = \frac{\hat{\mu}^i}{\hat{\sigma}^{i\prime}} \qquad (18)$$

$\left(\hat{\sigma}^i\right)^2$ is the variance of the returns of strategy $i$, in other words it is the dispersion of the returns around the mean. Where $\hat{\mu}^i$ is the mean of the returns of strategy $i$ and can be computed as follows $\hat{\mu}^i = \frac{1}{T-\tau}\sum_{t=\tau}^{T-1} w_t^{i\prime} r_t$.The Sharp Ratio is the trade-off between risk and return made by an investor while selecting a portfolio.

Additionally, we will be focusing on the Maximum Drawdown and the Value at Risk (VaR), to measure the maximum potential loss an investor could endorse and the worst expected loss over a given time, respectively.

## Section 3.2 Analysis of results

In this part we will be analyzing results of the methodology followed in section 3.1. We will first follow the impact of the 3 universes considered on the efficient frontier, in order to follow the movement of the efficient frontier when computing ESG criterion. After that, we will be demonstrating the performance evaluation and spot the best performer in the different universe of the portfolios constructed.

The question of the impact of the ESG filters on the portfolios is going to be answered in this part of the report. The results of the portfolio's performances and the ESG filters applied to those portfolios can be found in **Table 7**. The cumulative returns of all strategies are displayed in **Figure 10**.

### 3.2.1 In-sample analysis

Within this section, we will be observing the movement of the efficient frontier when applying ESG filters. From the literature review, we already have an intuition that the efficient frontier is supposed to move to the down-right of the risk-return tradeoff graph. This is due to the fact that by adding constraint to the investor's utility, the risk-return trade-off of the portfolios is inexorably affected.

From **Figure 7** and **Figure 8**, we can see that the ESG-filtered frontiers follow our intuition. The portfolios on the efficient frontiers with less assets are less diversified portfolios, hence the risk associated to these portfolios is impacted negatively (i.e., the portfolios with less assets in their universes are riskier than portfolios constituted of a bigger number of assets, see portfolios in **Figure 17**, **Figure 18** and **Figure 19** in appendix 9).

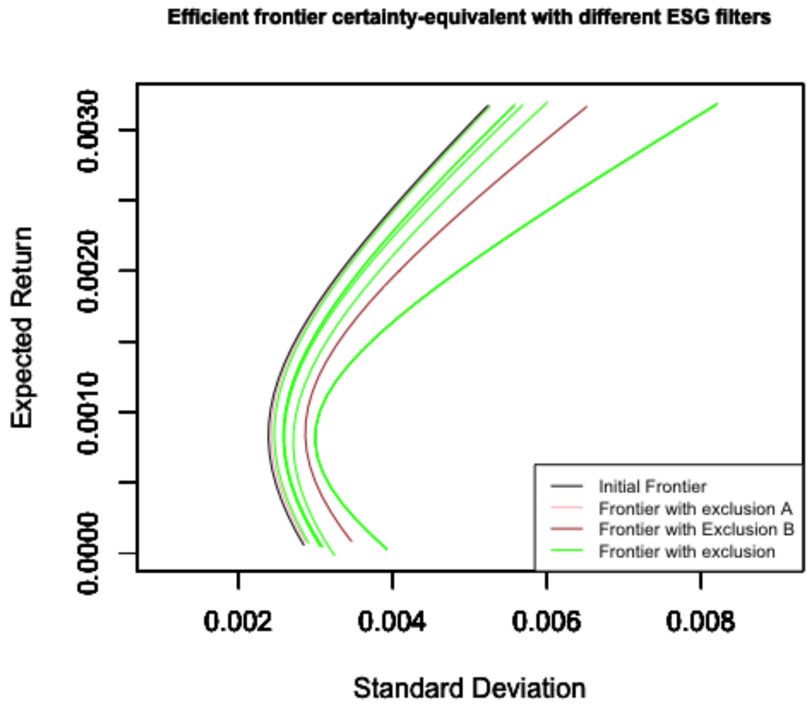



***Figure 7 :*** *Effect of ESG filters on the efficient frontier allowing short selling.*
*It can be observed from this risk-return trade-off that as assets are excluded from the investment universe, the efficient frontier worsens. In the sense that, by excluding assets, a same level of return generates a worst level of risk. This is in line with what the literature has already been able to demonstrate. Hence, ESG exclusion is not an exception to the rule stating that exclusion worsens diversification. Moreover, each green line represents a different degree of exclusion from excluding the assets that have an ESG score smaller than 10 (the green line that is in the extreme right) to the initial frontier. In other words, the more the green line is at the right, the more exclusion of assets on the initial universe is done.*

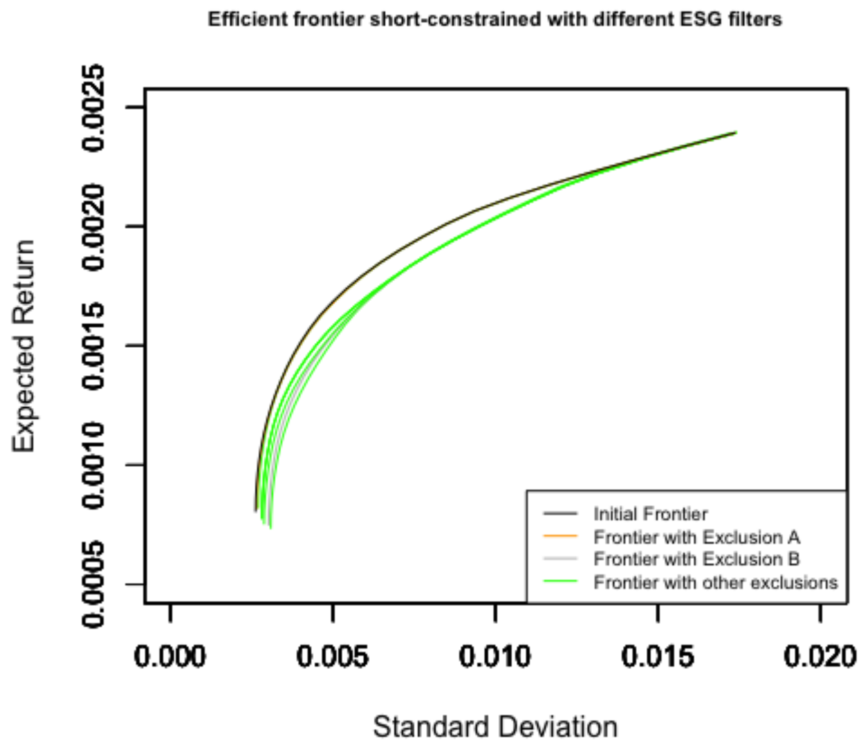



***Figure 8 :*** *Effect of ESG filters on the efficient frontier not allowing short selling.*
*A similar observation as* ***Figure*** *7 can be observed regarding the exclusion of assets. A certain point needs to be addressed within this graph, which is the point at the top right, where all frontiers seem to correlate. This point is in fact the investment of the asset "ORANGE SA" which seems to be the only asset with a positive weight within the optimization.*

Another observation can be made due to the shortselling constraint of the portfolios. Indeed, when restricting shortselling and when allowing the assets to be selled short, the efficient frontier is not the same. In other words, the portfolios composing the efficient frontier are different, in terms of risk-return tradeoff, when shortselling is allowed than when it is not allowed (see **Figure 9**). Firstly, it is different regarding the form of hyperbola of the efficient frontier. Secondly, when shortselling is allowed, the shrinkage of the variance covariance matrix does not result to better return for a same level of risk. Thirdly, when allowing shortselling the efficient frontier allows more return for a same level of risk compared to an efficient frontier that does not allow short selling.

From the literature review, we know that when shortselling is not allowed, the estimation of the variance covariance matrix should lead to similar results as if the variance covariance matrix was shrinked. This is the case for the blue line of **Figure 9**[20]. In the case of shortselling,

[20] In the appendix 9, more precisely in **Figure 20**, there is a zoomed version of this figure to see the details of the efficient frontiers.

the shrinked variance covariance matrix is not leading to an efficient frontier with a better risk-return tradeoff.

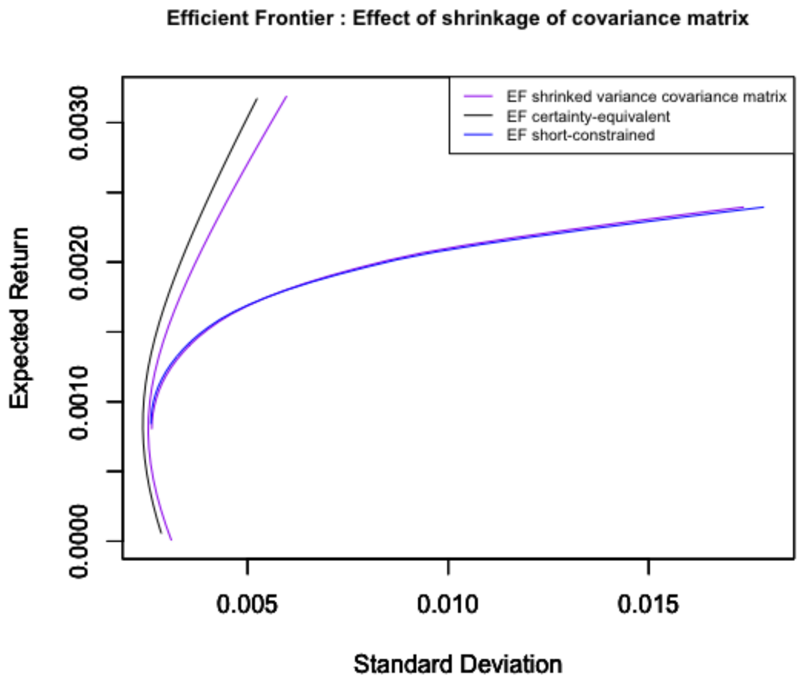



***Figure 9 :*** *This figure shows the effect of shrinkage of the variance covariance matrix on a certainty-equivalent efficient frontier and a short-constrained efficient frontier. We can observe that the short-constrained efficient frontier is overall generating more returns for a same level of risk or for a same level of return it is generating less risk. This is not the case for the black efficient frontier (certainty-equivalent) which is not generating greater results by shrinking the variance covariance matrix.*

Finally, the utility of the investor is challenged in the case of adding ESG filters to the initial universe. The investor has to be aware that by adding limiting constraints to his initial universe, this one is impacting his initial aim which is to maximize the expected return and minimize the risk of his investment.

### 3.2.2 Out-of-sample analysis

The out-of-sample results show different interesting results. We can quickly remind that the results of other analysis show different conclusions, between an outperformance and an underperformance of conventional or sustainable driven portfolios.

Several results can be deducted from the different portfolios created:

- The strategy that performs the best in absence of ESG screening, and when screening A and C are applied is the strategy **MINV**. In presence of ESG screening B the strategy that outperforms is **SCMV**. This is in line with the literature, indeed Jorion (1991) finds in his research that the minimum variance leads to the best performance compared to other mean-variance portfolios.

- Another observation can be made regarding the ESG screening that allows each strategy to perform the best.
    - The best screening for strategies **SCMV**, **SCTAN** and **RPP** are when no ESG screening is applied.
    - For strategy **MINV** the screening that allows the best performance is the screening A.
    - For strategy **TANG** the ESG Screening C leads to a better performance of this strategy.
    - **EWP** is an interesting strategy because we can see that both B and C screenings give the same performance, which is at the same time the 2 best screenings for this strategy (1/N).
- Inversely, the least performer portfolio, in terms of SR, is the tangent portfolio with the type B screening (second screening). This asset allocation (**TANG**) is for every kind of ESG screening, the least performer[21].
- An expected result can be observed regarding the standard deviation of the **EWP**, the **RPP** and the **MINV**. Indeed, for each screen the standard deviation of the **RPP** is bigger than **EWP** and smaller than **MINV** standard deviation. Maillard & al. (2010) on their work on RPP, found this same result.
- For a same constraint (ESG score bigger than 80) the results show that it is more interesting to erase the assets from the portfolio, rather than to keep those assets and redistribute them to assets respecting the constraints (i.e., the third ESG screening).
- The impact of the ESG screening on the investment strategies is different from a diversification strategy to another. In other words, the fact that the decrease of the performance is due to the screening, is not always true for the different strategies studied:
    - For strategies **EWP** and **TANG**, the more the assets are excluded the less the performance is impacted negatively.
    - Regarding strategies **SCMV**, **SCTAN** and **RPP** the ESG filter does truly impact negatively the performance of the portfolios created.
    - The **MINV** is a specific strategy where we cannot really observe a pattern regarding the impact of the ESG screening on the performance, as the

[21] See bold number on **Table 7**.

performance is greater when a first screening is applied (as said earlier) and then when no exclusion is applied and then when more exclusion is applied.

- The cumulative returns also show the outperformance of **MINV** with exclusion A, see figure below:

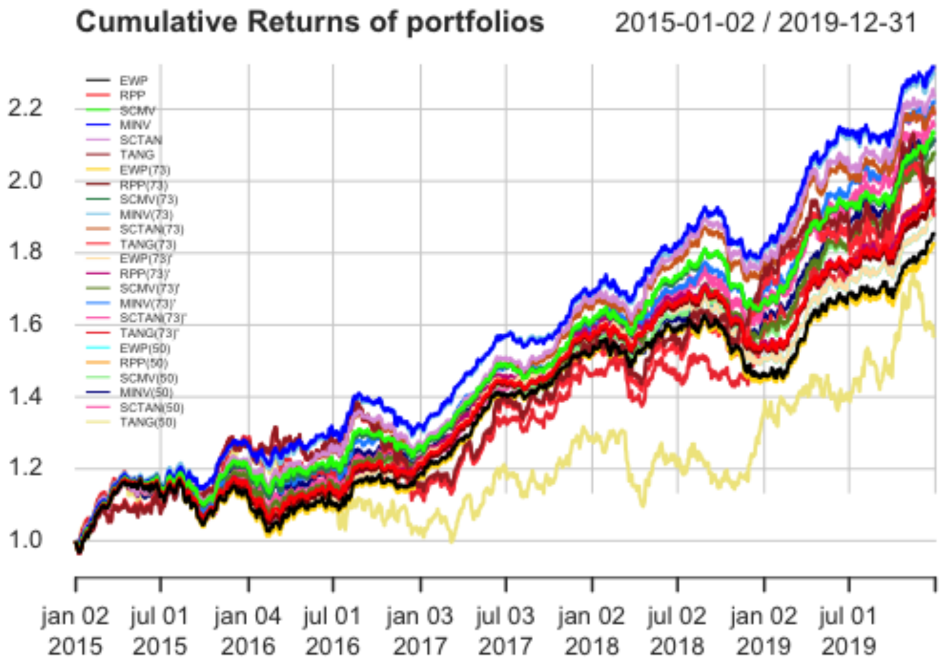



***Figure 10 :*** *Cumulative returns of all strategies with all ESG filters*

Overall, the best performer portfolio is the first screened certainty-equivalent minimum variance portfolio (bold number on **Table 7**). This strategy has been proved by Jorion (1991) and Chopra & Ziemba (1993) as being a best performer. The out-of-sample Sharpe Ratio of **MINV(73)** outperforms any other combination of assets. This portfolio is also accompanied by the smallest Maximum Worst Drawdown, as well as the smallest Value at Risk. This might be the decrease of systemic risk, illustrated in the literature, where a decrease of number of assets can be beneficial to the overall performance of the portfolio.

The certainty-equivalent minimum variance portfolios are in general outperforming other portfolios in terms of SR, for every screening, unless for the second screening (50 or type B) where in that case, it is the short constrained minimum variance that performs other strategic asset allocation. A conclusion of this result might be that the decrease of number of assets lead to better performance by shrinking the variance covariance matrix.

| No. | Portfolio | SD | SR | MWD | VaR |
|---|---|---|---|---|---|
| 1 | EWP | 0.00433 | 0.1153 | 0.1226 | -0.0069 |
| 1.A | EWP (73) | 0.00443 | 0.1100 | 0.1341 | -0.0071 |
| 1.B | EWP (50) | 0.00441 | 0.1195 | 0.1225 | -0.0069 |
| 1.C | EWP (73)′ | 0.00441 | 0.1195 | 0.1225 | -0.0069 |
| 2 | MINV | 0.00395 | 0.1712 | 0.0812 | -0.0059 |
| 3 | SCMV | 0.00372 | 0.1637 | 0.0940 | -0.0056 |
| 2.A | MINV (73) | **0.00389** | **0.1719** | **0.0789** | **-0.0059** |
| 3.A | SCMV (73) | 0.00374 | 0.1610 | 0.0958 | -0.0057 |
| 2.B | MINV (50) | 0.00418 | 0.1447 | 0.0870 | -0.0064 |
| 3.B | SCMV (50) | 0.00406 | 0.1453 | 0.0967 | -0.0062 |
| 2.C | MINV (73)′ | 0.00420 | 0.1532 | 0.0854 | -0.0064 |
| 3.C | SCMV (73)′ | 0.00410 | 0.1440 | 0.0998 | -0.0063 |
| 4 | TANG | 0.00700 | 0.0804 | 0.1803 | -0.0108 |
| 4.A | TANG (73) | 0.00710 | 0.0757 | 0.1874 | -0.0110 |
| 4.B | TANG (50) | **0.00923** | **0.0436** | **0.2204** | **-0.0145** |
| 4.C | TANG (73)′ | 0.00683 | 0.0811 | 0.1387 | -0.0107 |
| 5 | SCTAN | 0.00432 | 0.1502 | 0.0849 | -0.0064 |
| 5.A | SCTAN (73) | 0.00439 | 0.1439 | 0.0895 | -0.0066 |
| 5.B | SCTAN (50) | 0.00514 | 0.1236 | 0.1070 | -0.0078 |
| 5.C | SCTAN (73)′ | 0.00467 | 0.1331 | 0.1015 | -0.0071 |
| 6 | RPP | 0.00382 | 0.1435 | 0.1044 | -0.0059 |
| 6.A | RPP (73) | 0.00389 | 0.1383 | 0.1107 | -0.0061 |
| 6.B | RPP (50) | 0.00407 | 0.1371 | 0.1117 | -0.0063 |
| 6.C | RPP (73)′ | 0.00412 | 0.1351 | 0.1130 | -0.0064 |

***Table 7 :*** *Standard Deviation (SD), Sharpe Ratio, Maximum Worst Drawdown (MWD) and Value at Risk of the different strategies and ESG screenings*

To check whether the performances measures are statistically different, a significance test is required to conclude this last part of results. Indeed, the results need to illustrate the veracity of the findings and to be able to do that, a test of significance is needed. We compute different ANOVA tests (7 in total), on the different diversification strategies, as well as on the filters of these strategies with a confidence level of 5%.

- Test 1: ANOVA test on the diversification strategies (**EWP**, **MINV**, **SCMV**, **TANG**, **SCTAN**, **RPP**).
- Test 2: ANOVA test on the **EWP** and their filters (**EWP**, **EWP**(73), **EWP**(50), **EWP**(73)')
- Test 3: ANOVA test on the **MINV** and their filters (**MINV**, **MINV** (73), **MINV** (50), **MINV** (73)')

- Test 4: ANOVA test on the **SCMV** and their filters (**SCMV**, **SCMV** (73), **SCMV** (50), **SCMV** (73)')
- Test 5: ANOVA test on the **TANG** and their filters (**TANG**, **TANG** (73), **TANG** (50), **TANG** (73)')
- Test 6: ANOVA test on the **SCTAN** and their filters (**SCTAN**, **SCTAN** (73), **SCTAN** (50), **SCTAN** (73)')
- Test 7: ANOVA test on the **RPP** and their filters (**RPP**, **RPP** (73), **RPP** (50), **RPP** (73)')

For the 7 tests computed, no significant results are found. More precisely, the p-value found for the 7 tests is bigger than 5% (see appendix 10 for more details), which leads us to conclude that the hypotheses stating that "the returns' means of the strategies and the filters are equal" is not rejected. Finally, the results of the test cannot let us conclude that the results retrieved from the empirical analysis are significantly different.

# Chapitre 4 Conclusion

The last part of this report will be divided between conclusion, limits and suggestions for future works.

To summarize we have seen that in recent years, Socially Responsible Investments have both evolved and gained many followers. Becoming, from a religious belief fund, one of the mainstream topics in finance in the recent years.

The goal of this thesis was to analyze the impact of ESG filtering on the financial performances of a couple of popular investment strategies. This latter are diversification strategies, where 2 of them are strategies that fall on Markowitz' efficient frontier (minimum variance and tangent), with and without shortselling, the 1/N strategy and the asset risk parity strategy. These strategies were taken from their classical definitions and put into practice with certain constraint on the universe selected. It is also important to note that the methodology used within this thesis does not come from any other past methodology.

The main conclusion arises on the fact that ESG filters do lead to a better performance in some conditions. Those conditions are represented in this thesis by the financial strategy used. Indeed, the minimum variance strategy combined with a screening of the universe with the assets that have an ESG score but without putting a threshold is the performing strategy. Another conclusion was observed when comparing the 4 different strategies, the minimum variance portfolio strategy is the strategy that performs the best without taking into account the ESG filters and also when the ESG filters are taken into account. This is a striking result given that the minimum variance portfolio does not aim to deliver appealing returns but focuses on minimizing risk. However, it is in line with previous researches (e.g., Jorion (1991) or Chopra & Ziemba (1993)) who stress the remarkable performance of this, otherwise, very simple approach. One last conclusion is that there exists a compromise between the number of assets composing the portfolio and the ESG scores of those assets. The 3 assets erased from the screening that performs the best, appear to impact the performance of this strategy and an ESG filter in this case improves the different factors impacting the performance. Finally, a surprising result comes at the end of this report stating that the results found by the strategies studied are not statistically different from each other.

The conclusions of the report include some similarities with the theory. The theory is indeed stating that ESG filter does affect positively the financial performance of a portfolio. And the results found are stating that one of the portfolios with an ESG filter is the best performer. We can also conclude that the decreasing amount of asset is creating a lack of performance just like some authors, as Hoepner, state. Other conclusions from past analysis have been made as the fact that given large differences in the empirical results, some authors warn that there is no conclusive evidence regarding the relationship between ESG and financial performance of companies (Ioannou and Serafeim, 2011; Orlitzky, 2013). These last conclusions fit well with our findings stating that we cannot deduct that the relationship between ESG and financial performance leads to a significant difference.

## Section 4.1 Research limitations

Regarding the limits of this work, the report contains some limits that will be summarized in the next paragraphs. This work is trying to draw a link between sustainability and financial performance, but these two subjects gather many limits. A first limit is the difference between ESG score depending on the data provider. Indeed, this limit influences the conclusions of this thesis, as the results could have been different from an ESG data provider to another. This might be an overall limit of this thesis or any other thesis considering a specific ESG data provider rather than another. In addition, the average ESG score is taken through 4 consecutive years, but the ESG score changes each month, which means that a company that was not managing its ESG risk in 2015, could have done progress and would score better in year 2019, and this is something that is not taken into account in this thesis. Moreover, portfolio selection incorporates many different ways of selecting assets, which makes this choice of diversification strategy very small compared to the multiple possible ways of addressing portfolio selection. Nevertheless, the strategies used in this thesis are very popular and in general they have been performing quite well. Also, the assets that are considered in the analysis part have been chosen because the companies composing this index are European companies, the choice of this index could be changed to another index and the conclusions can lead to different results. Finally, the non-significance of the results found decreases veracity of the conclusions conducted.

## Section 4.2 Future suggestions

We end up this thesis by formulating some suggestions for future academic researches:

- The initial 80 stocks of the index selected could be replaced by any other bigger index, which leads the possibility of increasing the N number of assets and draw more general conclusions.
- As the ESG data providers do not lead to the same ESG scores, a possible evolution of this work would be to compare the results between different ESG data providers. Indeed, the results could differ, which makes this conclusion interesting in case the industry of finance finds that a regularization of the data collected could be improved.
- It could be interesting to apply the comparison of the ESG filter on an index that is sustainable and on a classical index.
- A possible suggestion for future researches is the possibility to detail the ESG score and the threshold considered into an E, S and G score. By this, it will be possible, depending on the preference of the investor, to choose one of the pillars of ESG score. In addition to this, the feasibility of this potential research is possible as the data on each of the pillars exists for any ESG score from any data provider.
- The dynamic approach that could have been made, by using a sliding window to help the re-optimization of the portfolio, has an impact on the performance analysis. The actual study has considered daily returns of one year in order to estimate the rest of the window. This could have been done differently by using a sliding window that would allow a more active strategy. Moreover, one more suggestion is the possibility to integrate a more active strategy by not using "pure buy-and-hold" strategy but rather by using a rebalancing strategy.

# Appendix

## Appendix 1:

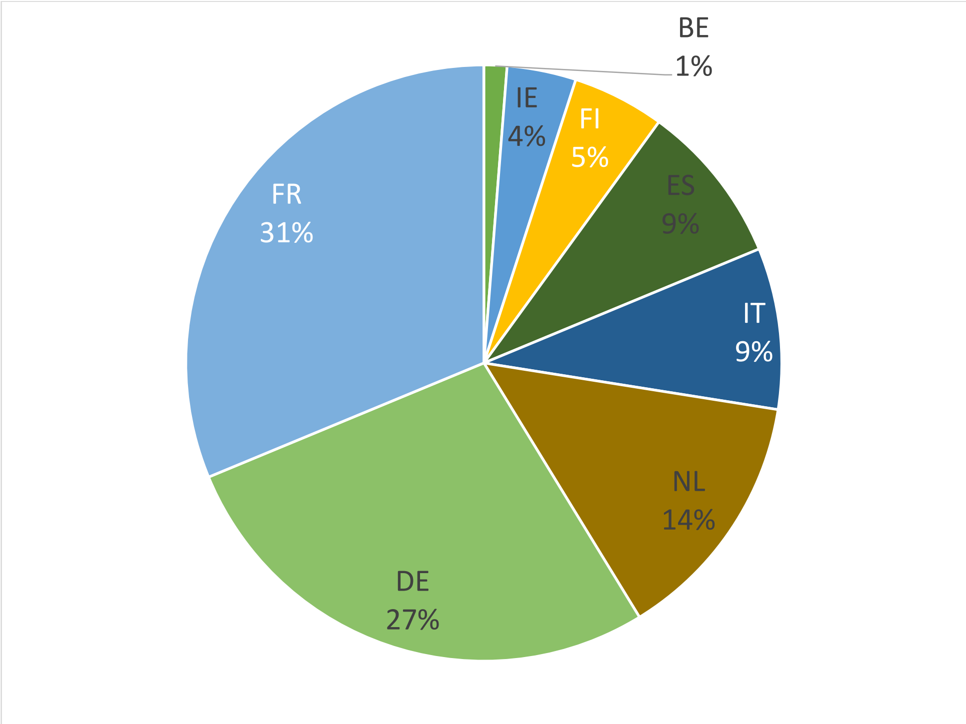



***Figure 11 :*** *Composition of EURO iSTOXX 80 EW per country*

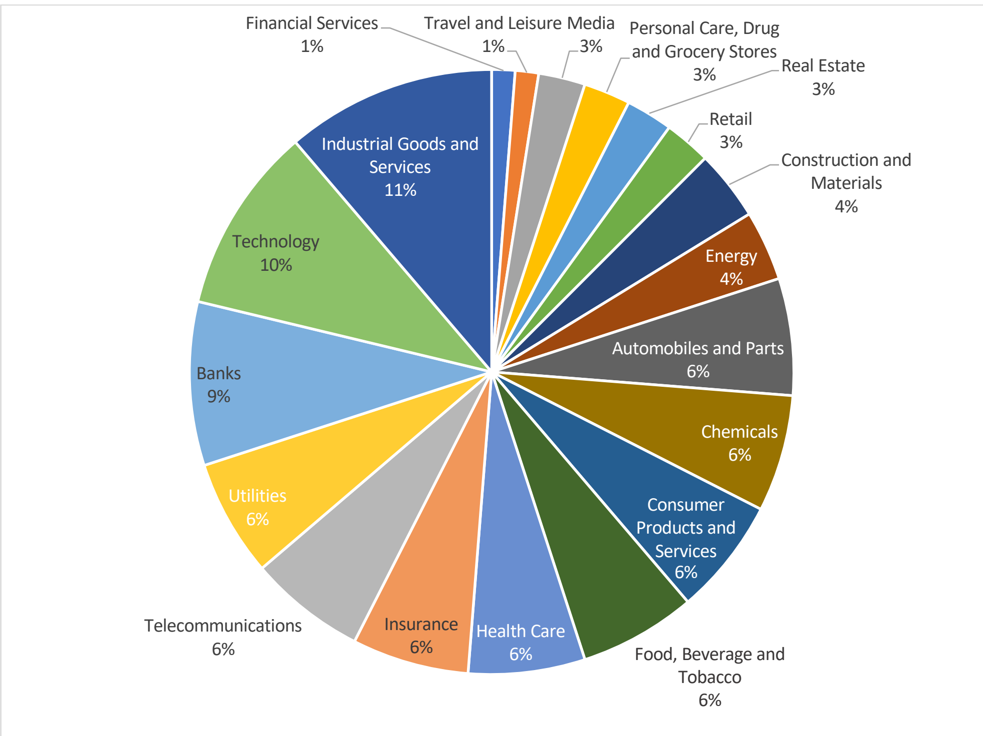



***Figure 12 :*** *Composition of EURO iSTOXX 80 per sector*

## Appendix 2:

The Principles for Responsible Investments are composed of 6 different principles:

- **Principle 1:** We will incorporate ESG issues into investment analysis and decision-making processes.
- **Principle 2:** We will be active owners and incorporate ESG issues into our ownership policies and practices.
- **Principle 3:** We will seek appropriate disclosure on ESG issues by the entities in which we invest.
- **Principle 4:** We will promote acceptance and implementation of the Principles within the investment industry.
- **Principle 5:** We will work together to enhance our effectiveness in implementing the Principles.
- **Principle 6:** We will each report on our activities and progress towards implementing the Principles (PRI, 2021).

## Appendix 3:

The ESG rating used in the analysis is from the data provider called Sustainalytics. This ESG score is accessible thanks to Bloomberg Terminals where Sustainalytics ESG ratings are retrieved as a percentile ranking. The Sustainalytics' ESG Risk Ratings are computed thanks to a multitude of indicators. The company's assigned an overall percentile rank thanks to environmental, social and governance total score and depending on its industry peers. The top 1% companies are awarded an ESG percentile rank of 99% and the bottom 1% have a percentile of 1%. In other words, the bigger is the ESG percentile rank the better the ESG score of the company and the less ESG risks are awarded to this company.

The Sustainalytics ESG Risk Rating of a company is measured by computing the exposure to industry-specific material ESG risks and the management of these risks. Sustainalytics identifies 5 categories of ESG risks from negligible to severe (Sustainalytics, 2021).

## Appendix 4:

### *Universe considered*

In order to study the impact of the ESG filter, the initial universe will be decreased of some assets not respecting some specific conditions, that will be described hereafter.

### SRI Type A

In this universe, we take into account ESG scores. In the sense that the assets selected in this universe, are the assets that are rated by Sustainalytics. For now, the level of rating is not taken into account in the construction of this universe. Hence, from the initial universe, we exclude Flutter, Linde and Teleperformance, that don't have any ESG data for the period that we are interested in. We will call this universe the *First Screening* or the *73 assets*.

### SRI Type B

This second universe is excluding companies according to their ESG ratings. In order, to keep the Best-in-class companies this universe will admit only companies that have an average ESG Score[22] bigger than 80. As Statman (1987) shows that a portfolio is well diversified when it is composed of more than 30 stocks, the *Second Screening* or the *50 assets* universe can still represent a well-diversified portfolio.

### SRI Type C

The third screening is a screening that is composed of the same number of assets as the "SRI Type A", but with the constraint of Best-in-class assets. In other words, the universe of this SRI Type is composed of the 73 assets of SRI Type A and when the optimization is applied the weight is allowed to be different from 0 if the ESG score of this asset is greater than 80.

## Appendix 5:

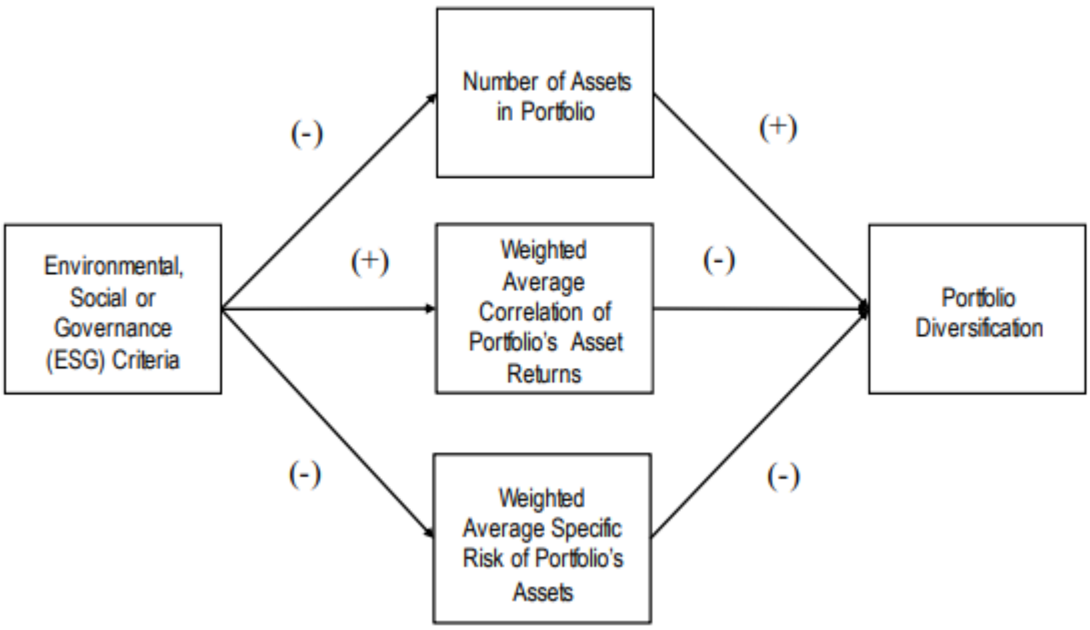



***Figure 13 :*** *A simple theory of the effect of ESG criteria on portfolio diversification – The figure shows how ESG criteria impacts portfolio diversification through the 3 factors (number of assets, correlation and specific risk)* - Reproduced from "Portfolio Diversification and Environmental, Social or Governance Criteria: Must Responsible Investments Really Be Poorly Diversified?*",* from Hoepner, A. G. F., 2010, SSRN Electronic Journal, p.11.

[22] The average ESG score is computed on the evaluation sample. Hence, it is an average computed on monthly data on the 5 years (from 2014 to 2019).

## Appendix 6:

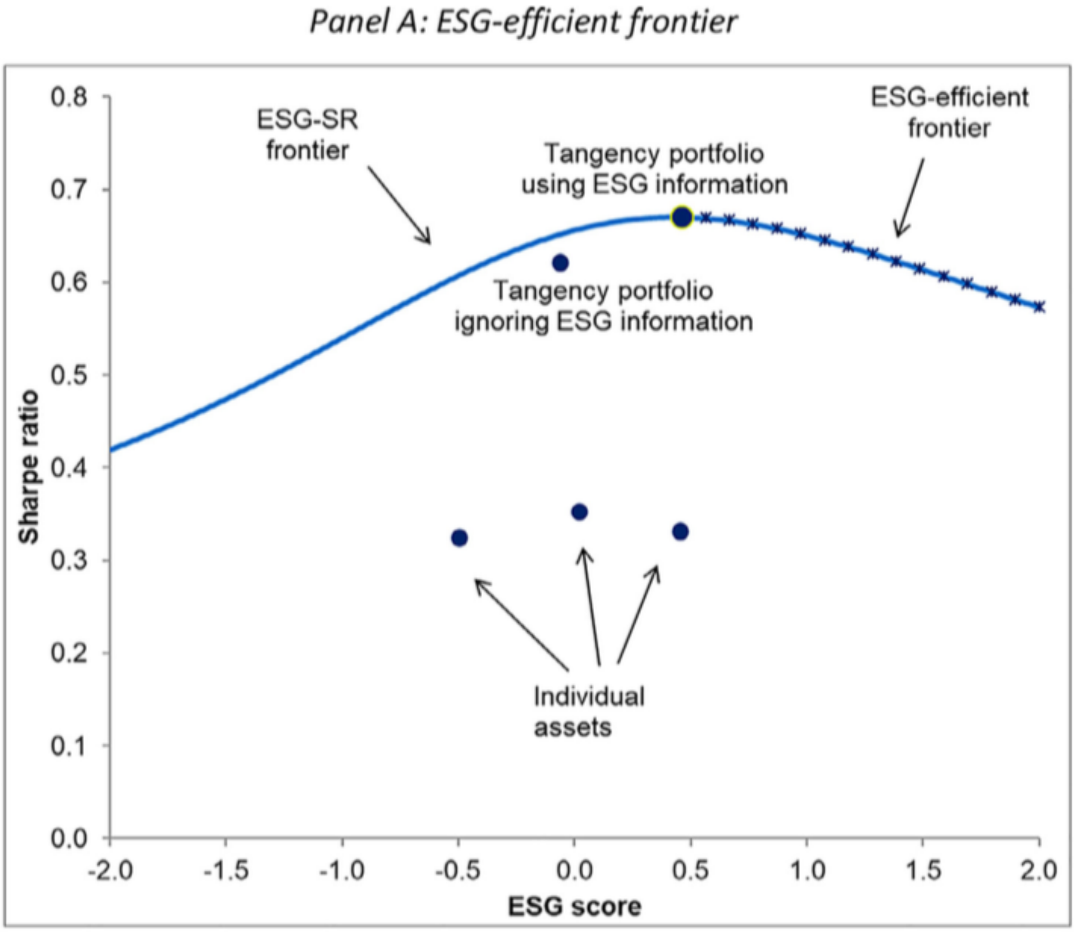



***Figure 14 :*** *This graph shows the ESG-SR frontier; that is, "the maximum Sharpe ratio (on the y-axis) that can be achieved for all portfolios with a given ESG score (on the x-axis). The peak of the ESG-SR frontier is the Sharpe ratio (SR) of the standard tangency portfolio. Investors who care about both SR and ESG should choose a frontier portfolio to the right of this portfolio, on the ESG-efficient frontier"* (Pedersen, Fitzgibbons & Pomorski, 2020) - *R*eproduced from "Responsible investing: The ESG-efficient frontier.", from Pedersen, L. H., Fitzgibbons, S., & Pomorski, L., 2020, *Journal of Financial Economics*, 1–51, p.3

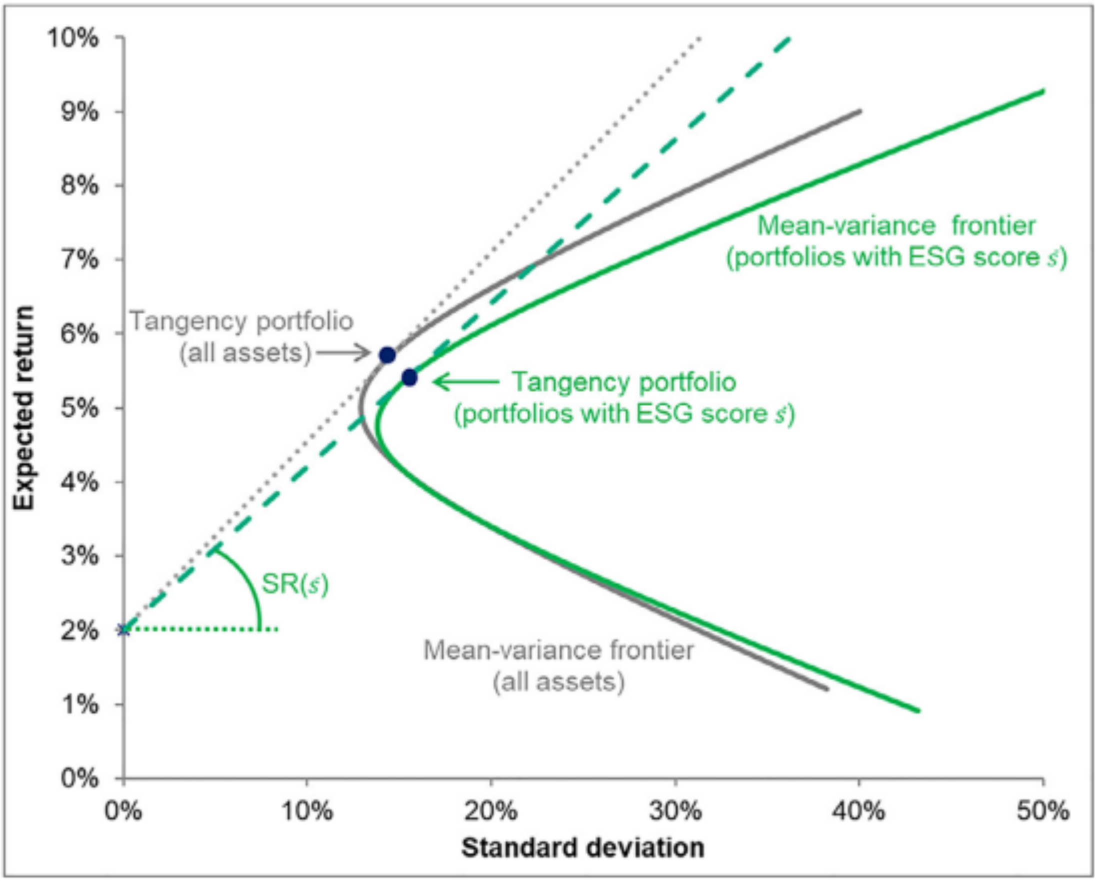
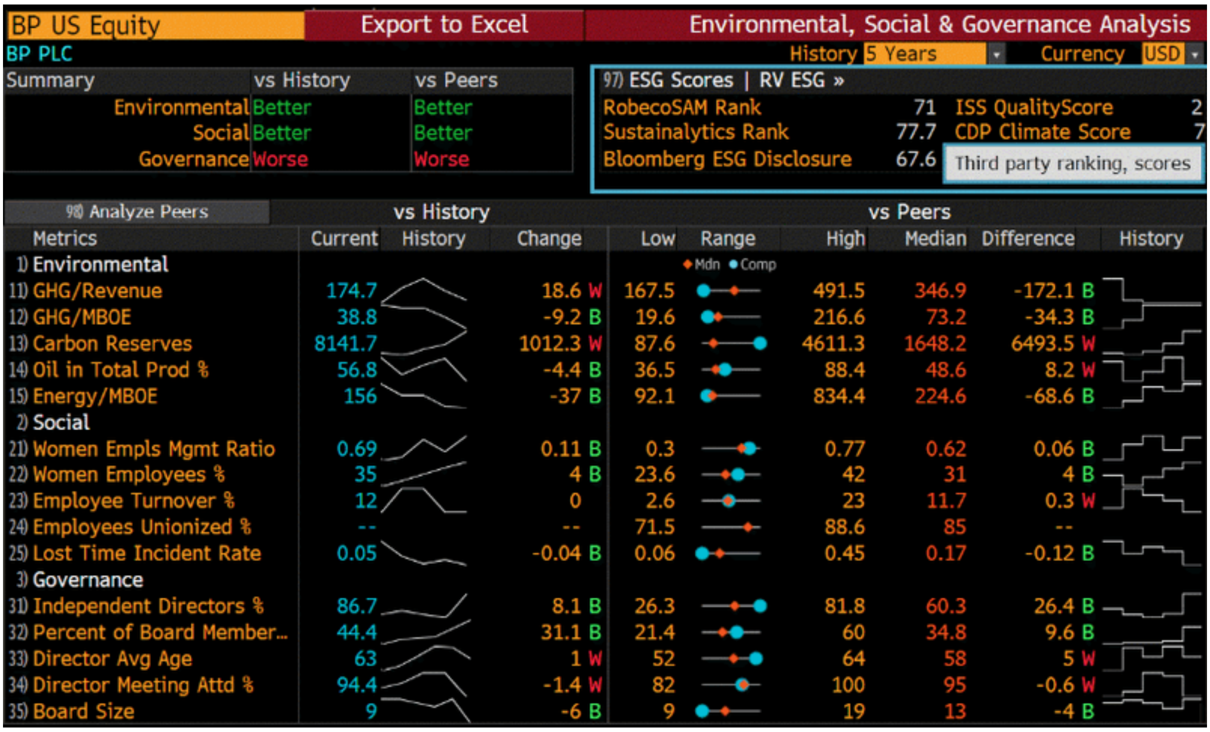



***Figure 15 :*** *This figure shows "the standard mean-variance frontier and the corresponding standard tangency portfolio (denoted "all assets"). The slope of the line from the risk-free rate to the tangency portfolio is the maximum SR. Panel B also shows the mean-variance frontier built exclusively for portfolios with a certain ESG score, $\bar{s}$. This frontier is a hyperbola that lies inside (i.e., to the right of) the standard hyperbola, and it has its own tangency portfolio with corresponding Sharpe ratio SR ($\bar{s}$)"* (Pedersen, Fitzgibbons & Pomorski, 2020) - *R*eproduced from "Responsible investing: The ESG-efficient frontier.", from Pedersen, L. H., Fitzgibbons, S., & Pomorski, L., 2020, *Journal of Financial Economics*, 1–51, p.3

## Appendix 7:



BP US Equity | Export to Excel | Environmental, Social & Governance Analysis

BP PLC | History 5 Years | Currency USD

| Summary | vs History | vs Peers |
|---|---|---|
| Environmental | Better | Better |
| Social | Better | Better |
| Governance | Worse | Worse |

97) ESG Scores | RV ESG »

| | | | |
|---|---|---|---|
| RobecoSAM Rank | 71 | ISS QualityScore | 2 |
| Sustainalytics Rank | 77.7 | CDP Climate Score | 7 |
| Bloomberg ESG Disclosure | 67.6 | Third party ranking, scores | |

98) Analyze Peers

| Metrics | Current (vs History) | History | Change | Low (vs Peers) | Range | High | Median | Difference | History |
|---|---|---|---|---|---|---|---|---|---|
| 1) Environmental | | | | | ◆Mdn ●Comp | | | | |
| 11) GHG/Revenue | 174.7 | | 18.6 W | 167.5 | | 491.5 | 346.9 | -172.1 B | |
| 12) GHG/MBOE | 38.8 | | -9.2 B | 19.6 | | 216.6 | 73.2 | -34.3 B | |
| 13) Carbon Reserves | 8141.7 | | 1012.3 W | 87.6 | | 4611.3 | 1648.2 | 6493.5 W | |
| 14) Oil in Total Prod % | 56.8 | | -4.4 B | 36.5 | | 88.4 | 48.6 | 8.2 W | |
| 15) Energy/MBOE | 156 | | -37 B | 92.1 | | 834.4 | 224.6 | -68.6 B | |
| 2) Social | | | | | | | | | |
| 21) Women Empls Mgmt Ratio | 0.69 | | 0.11 B | 0.3 | | 0.77 | 0.62 | 0.06 B | |
| 22) Women Employees % | 35 | | 4 B | 23.6 | | 42 | 31 | 4 B | |
| 23) Employee Turnover % | 12 | | 0 | 2.6 | | 23 | 11.7 | 0.3 W | |
| 24) Employees Unionized % | -- | | -- | 71.5 | | 88.6 | 85 | -- | |
| 25) Lost Time Incident Rate | 0.05 | | -0.04 B | 0.06 | | 0.45 | 0.17 | -0.12 B | |
| 3) Governance | | | | | | | | | |
| 31) Independent Directors % | 86.7 | | 8.1 B | 26.3 | | 81.8 | 60.3 | 26.4 B | |
| 32) Percent of Board Member... | 44.4 | | 31.1 B | 21.4 | | 60 | 34.8 | 9.6 B | |
| 33) Director Avg Age | 63 | | 1 W | 52 | | 64 | 58 | 5 W | |
| 34) Director Meeting Attd % | 94.4 | | -1.4 W | 82 | | 100 | 95 | -0.6 W | |
| 35) Board Size | 9 | | -6 B | 9 | | 19 | 13 | -4 B | |

***Figure 16 :*** *On this Bloomberg Terminal we can see the multiple metrics computed by Bloomberg, as well as ESG scores from other data providers (upper right) like Robecco SAM Rank, Sustainalytics Rank, etc...(Bloomberg, 2021).*

## Appendix 8:

| Eurosif | GSIA-equivalent | PRI-equivalent | EFAMA-equivalent |
|---|---|---|---|
| Exclusion of holdings from investment universe | Negative/ exclusionary screening | Negative/ exclusionary screening | Negative screening or Exclusion |
| Norms-based screening | Norms-based screening | Norms-based screening | Norms based approach (type of screening) |
| Best-in-Class investment selection | Positive/ best-in-class screening | Positive/ best-in-class screening | Best-in-Class policy (type of screening) |
| Sustainability themed investment | Sustainability-themed investing | Sustainability themed investing | Thematic investment (type of screening) |
| ESG integration | ESG integration | Integration of ESG issues | - |
| Engagement and voting on sustainability matters | Corporate engagement and shareholder action | Active ownership and engagement (three types):<br>Active ownership<br>Engagement<br>(Proxy) voting and shareholder resolutions | Engagement (voting) |
| Impact investing | Impact/community investing | - | - |

***Table 8 :*** *Sustainable Investment Strategies - Reproduced from* "European SRI Study 2018*",* from Eurosif, 2018, http://www.eurosif.org/wp-content/uploads/2018/11/European-SRI-2018-Study-LR.pdf

## Appendix 9:

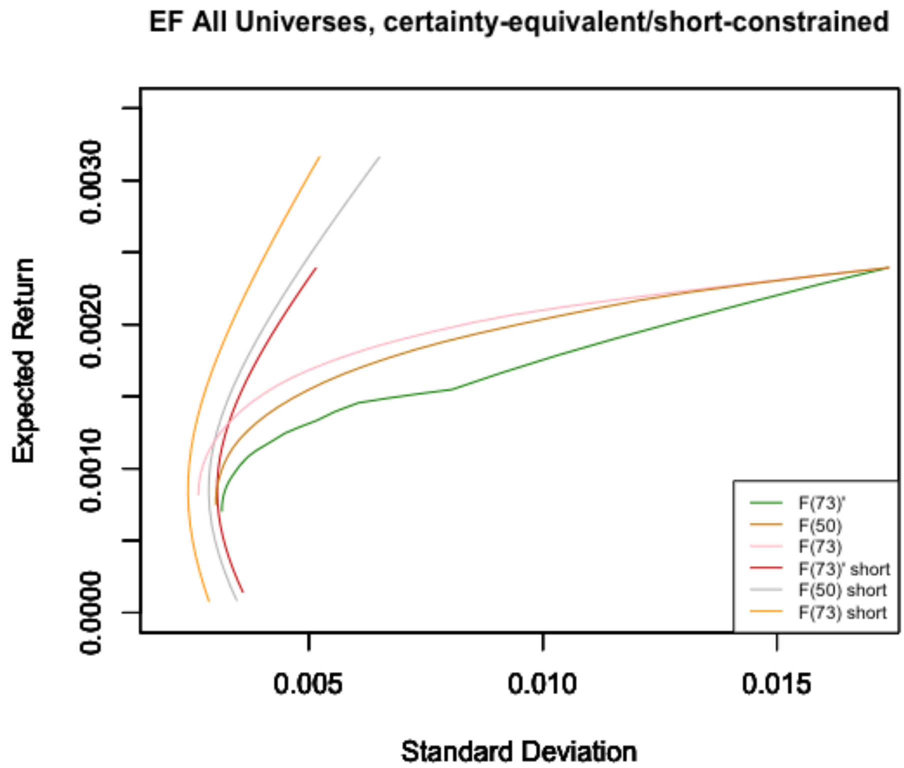



***Figure 17 :*** *Shift of the Efficient frontier when ESG filters are applied. When the number of assets decreases, an expected shift at the right of the initial frontier is seen (purple vs. brown). When the number of assets is fixed and the weights are rebalanced, a constraint on the weights leads to a higher perception of risk (green frontier).*

*Shift of the efficient frontier in an informative prior ESG setup. Everything else being equal, an increase in ESG constraint will lead more risk for a same level of return. Also, when using the same ESG constraint the rebalanced frontier (red) seems to be less attractive as it is the farthest from the initial frontier (blue). Hence the frontier even with decreased assets (grey) has a better risk return trade off than the rebalanced frontier.*

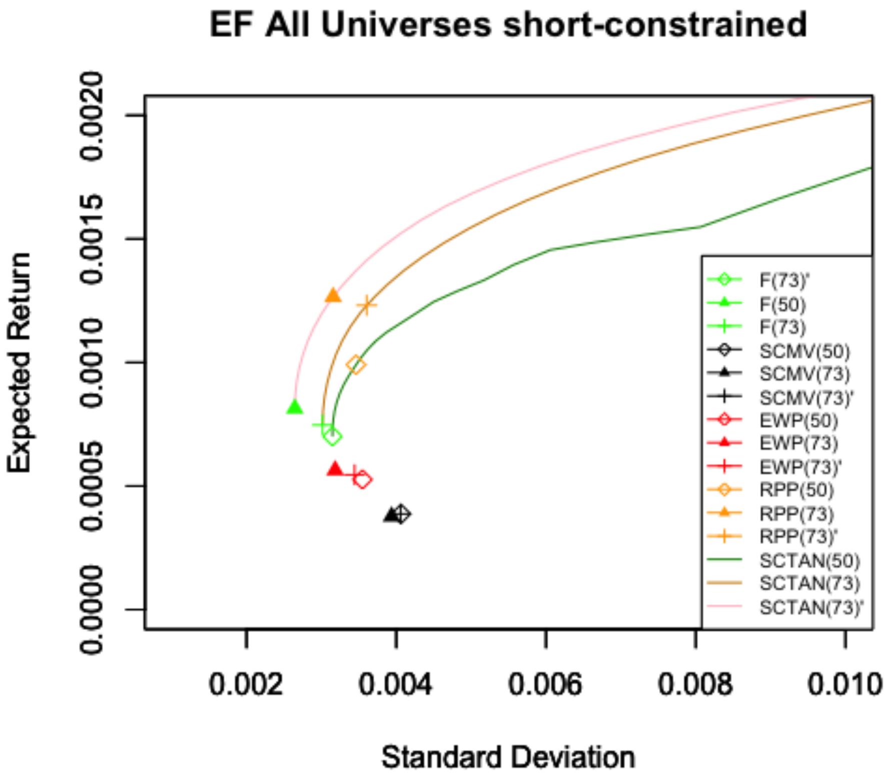



***Figure 18 :*** *This figure shows the different diversification strategies with the 3 SRI Types chosen for this report in a short-constrained universe.*

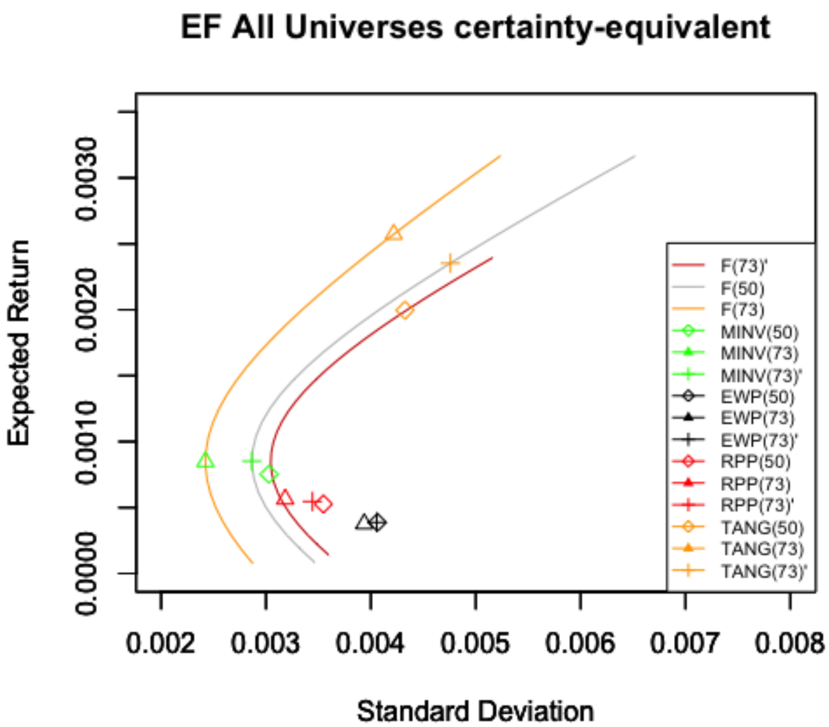



***Figure 19 :*** *This figure shows the different diversification strategies with the 3 SRI Types chosen for this report in a certainty-equivalent universe.*

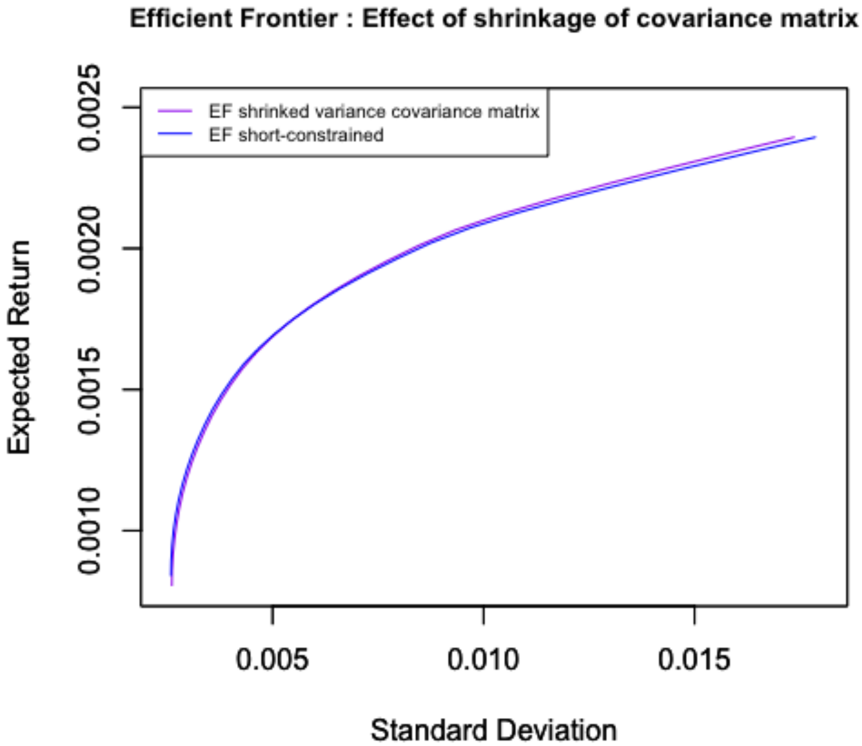



***Figure 20 :*** *Efficient Frontier with shrinked covariance matrix (purple) and efficient frontier with a variance covariance matrix as estimator of risk (blue). We can observe that the shrinked efficient frontier for bigger returns and risks enables greater returns for a same level of risk, compared to the blue curve. Inversely, for small level of risk-return, the non shrinked covariance efficient frontier enables better returns for a same level of risk. The universe considered here is the initial universe or the 76 assets. Note that a similar pattern occurs for the 2 other universes, hence, there is no need to illustrate a similar graph.*

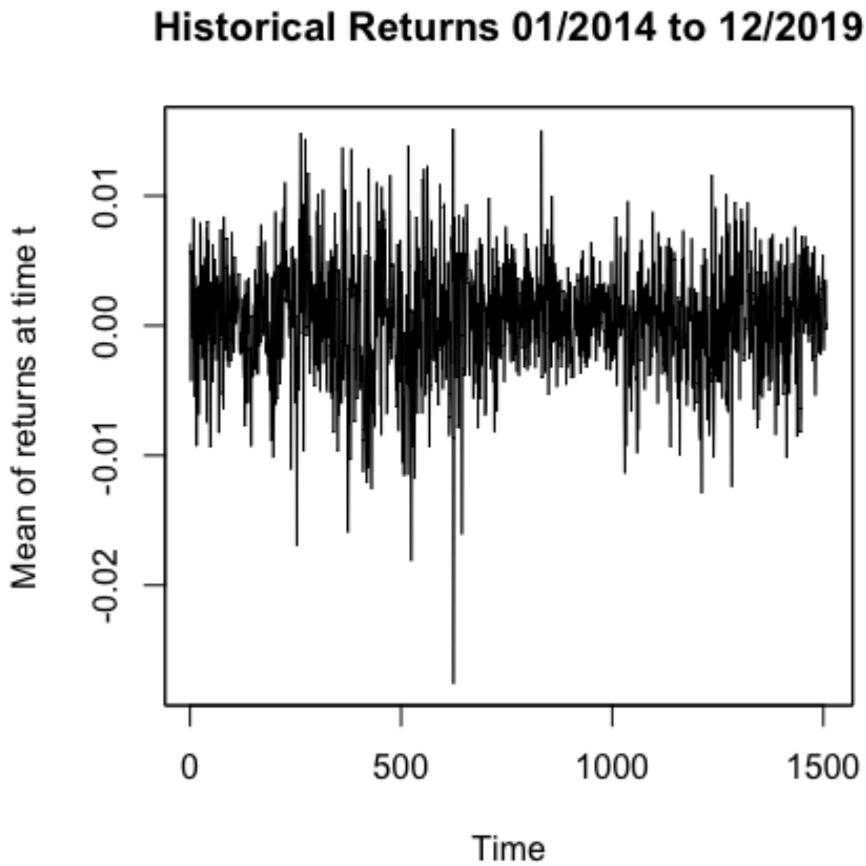



***Figure 21 :*** *Historical evolution of the mean of the daily returns, from January 2014 to December 2015. The shock around observation 500 corresponds to 24th January 2016 when the results of the Brexit were given.*

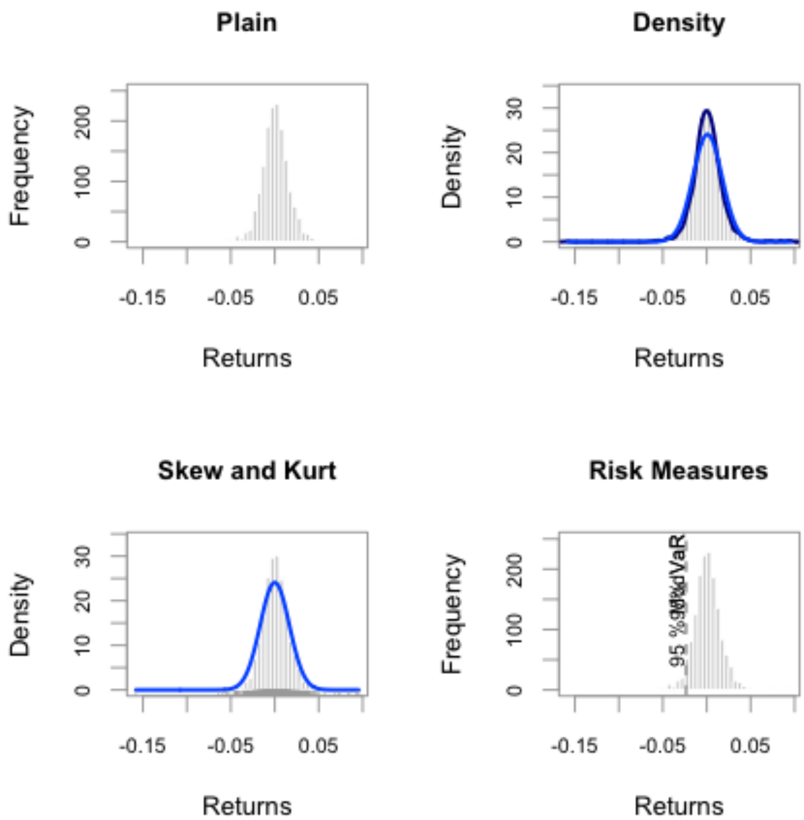



*Figure 22 : Histograms of the returns of the sample period. We can observe on the bottom right histogram the normal distribution as well as the density plot (dark blue). We can observe a left kurtosis.*

## Appendix 10 :

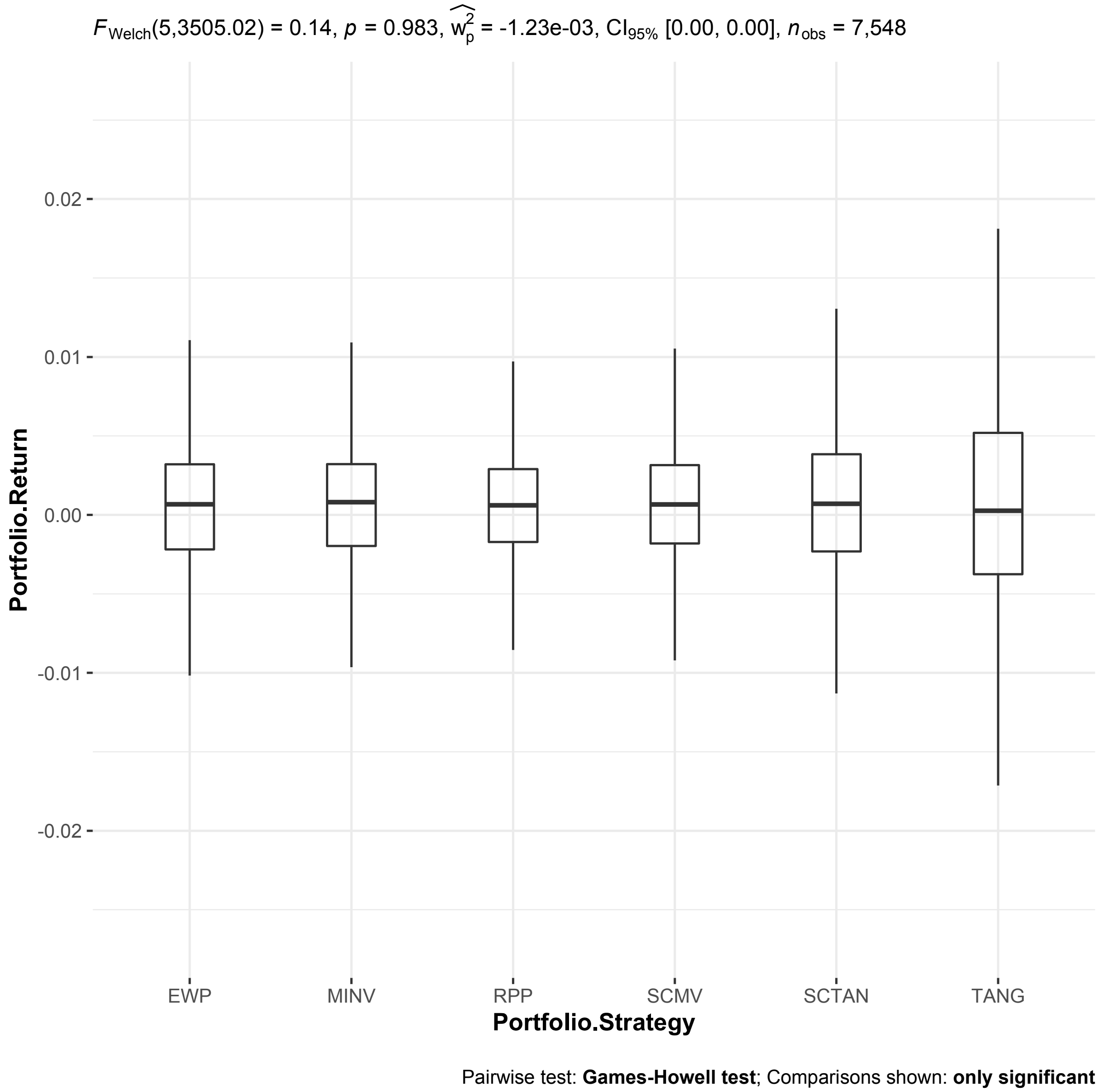



***Figure 23 :*** *Results of ANOVA test on different diversification strategies.*

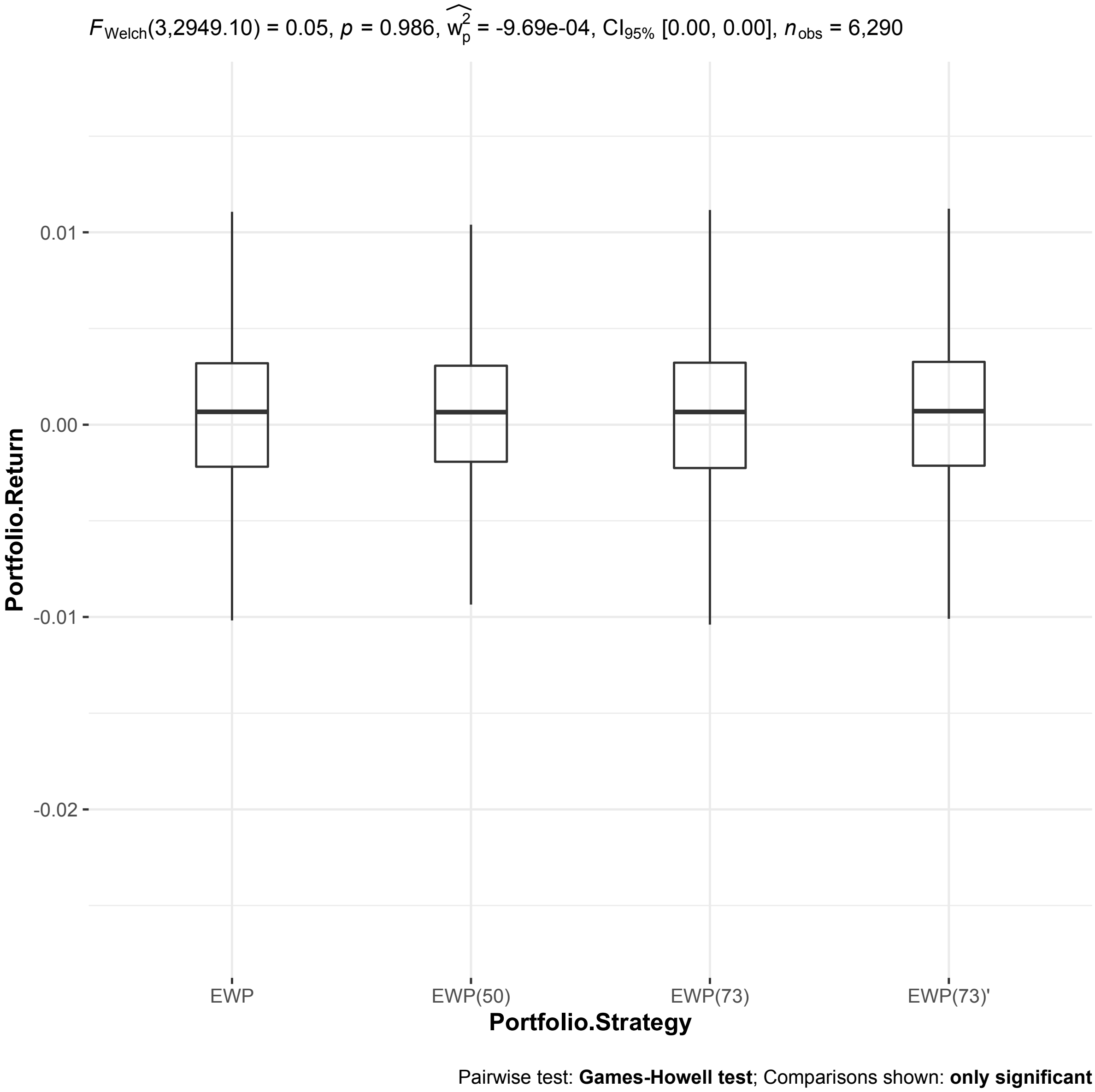



***Figure 24*** *: Results of ANOVA test on* ***EWP*** *portfolios with different filters.*

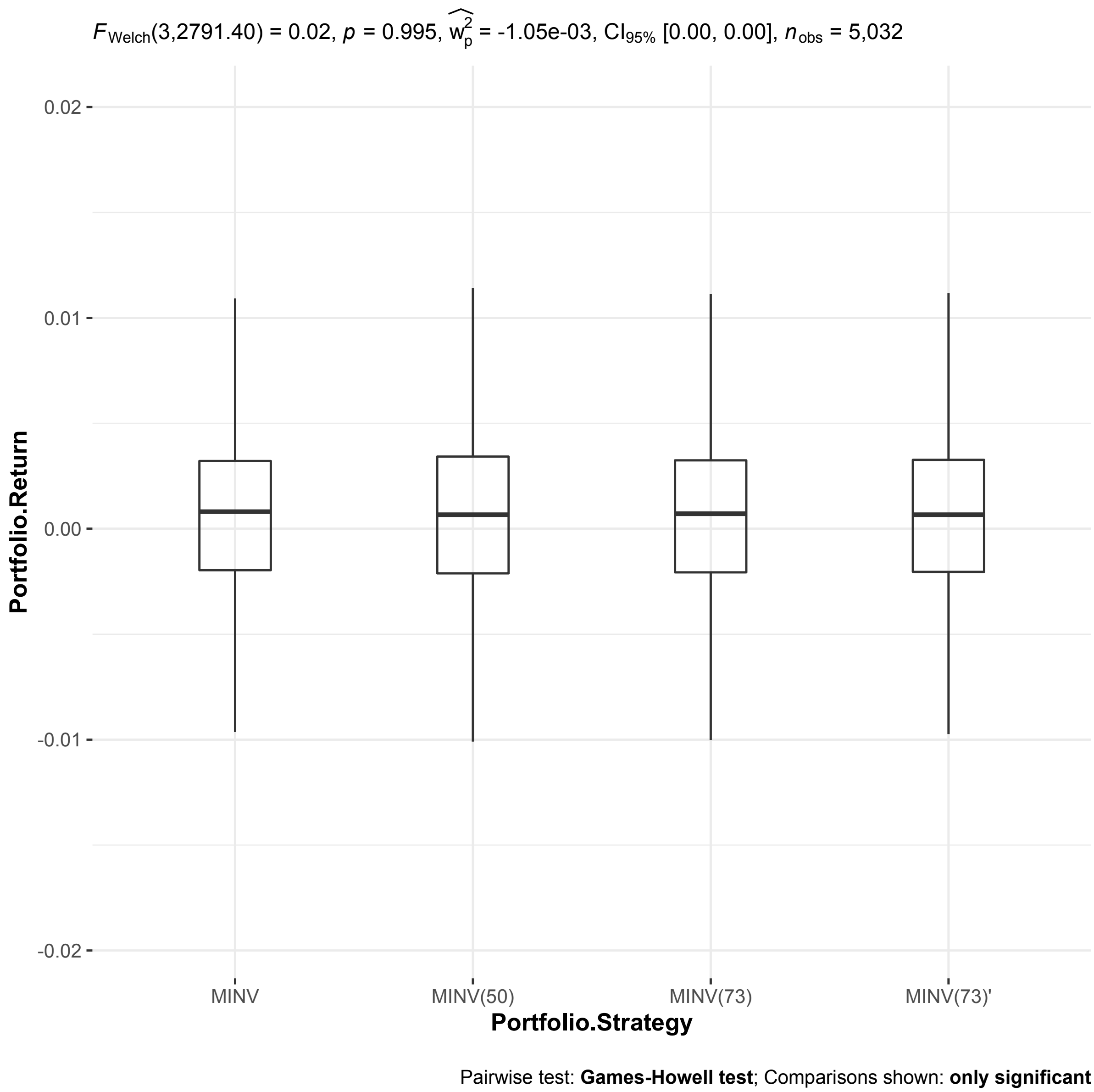



***Figure 25:*** *Results of ANOVA test on **MINV** portfolios with different filters.*

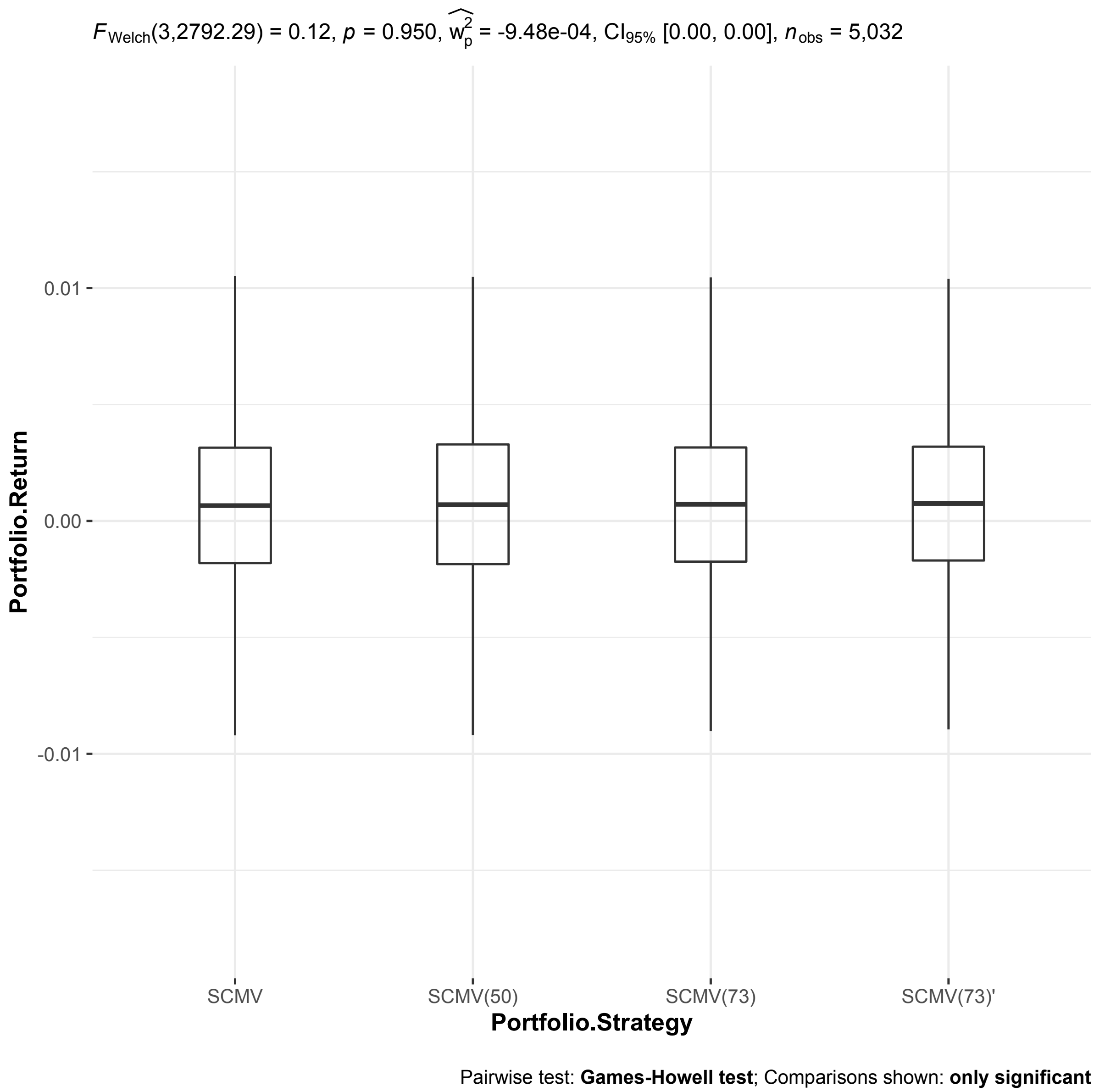



***Figure 26 :*** *Results of ANOVA test on* ***SCMV*** *portfolios with different filters.*

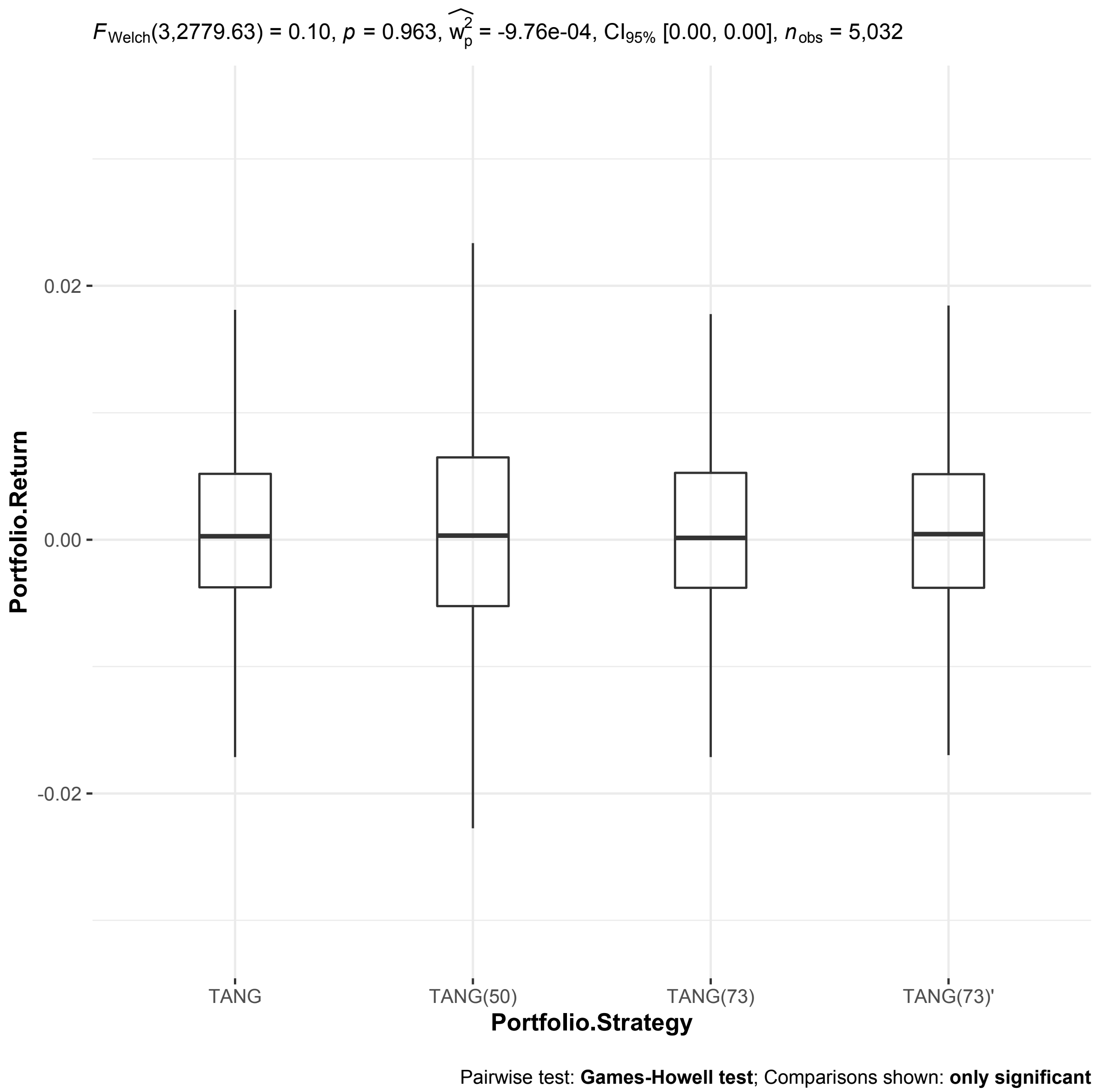



***Figure 27*** *: Results of ANOVA test on* ***TANG*** *portfolios with different filters.*

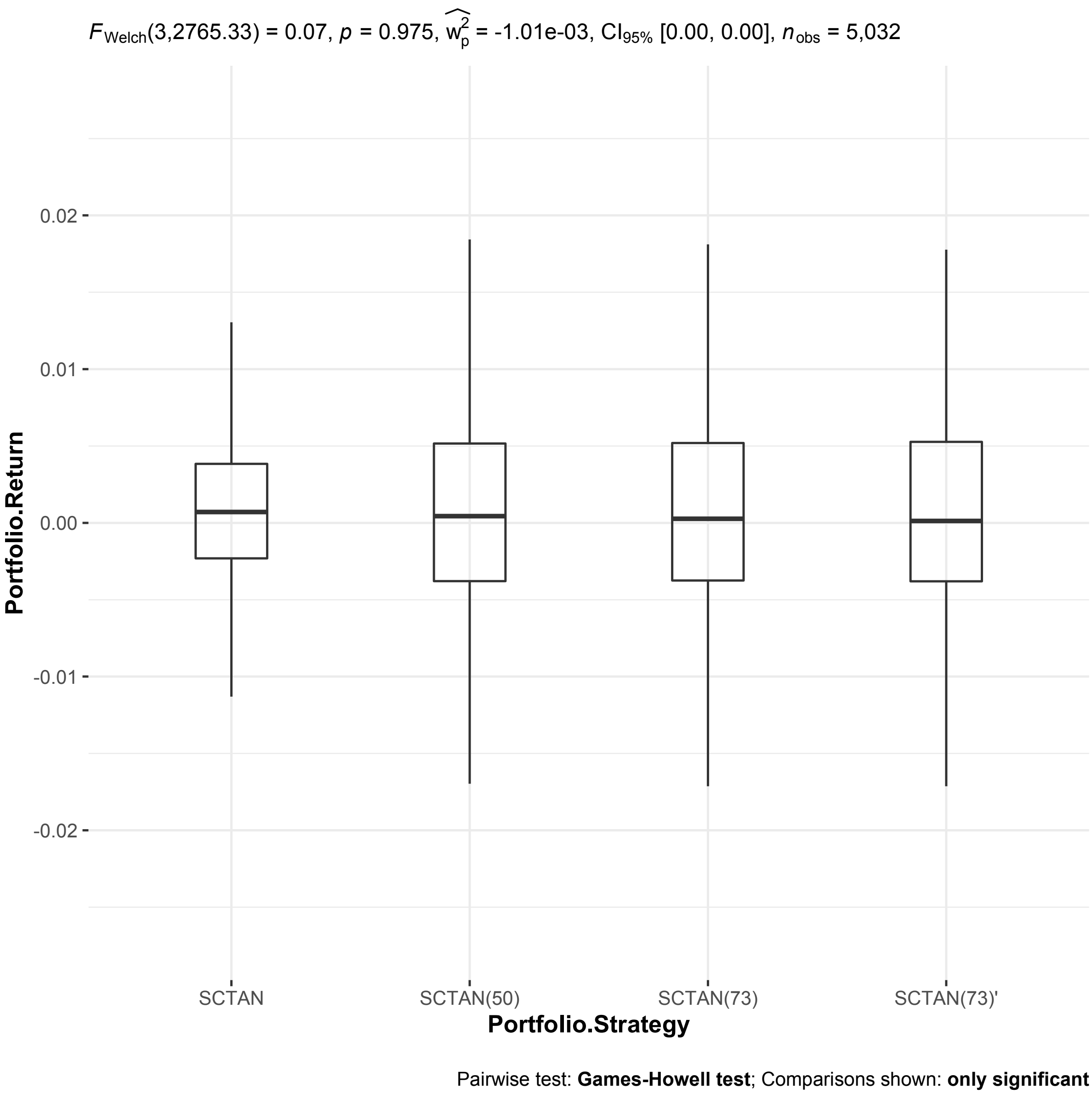



***Figure 28** : Results of ANOVA test on **SCTAN** portfolios with different filters.*

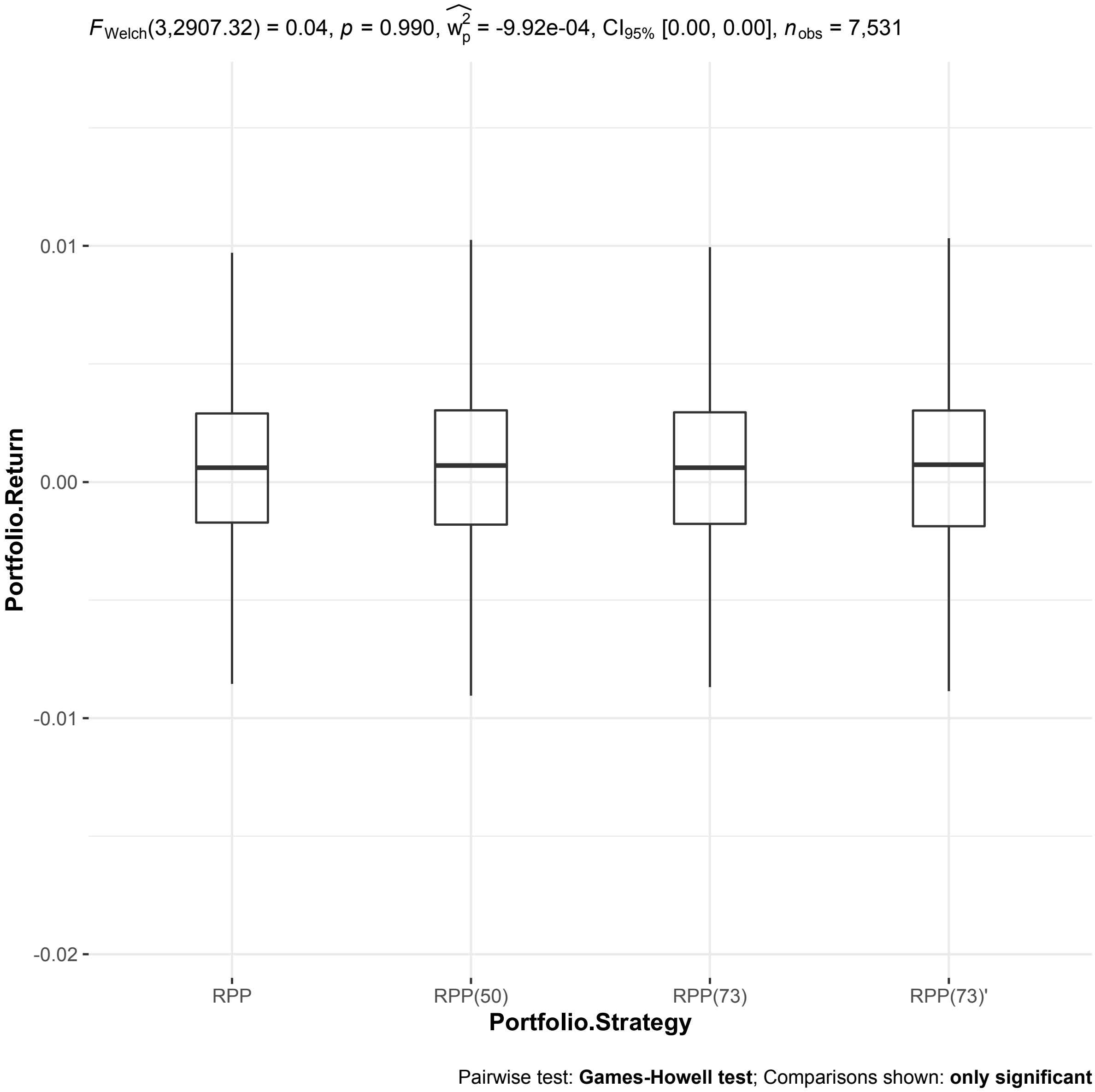



***Figure 29*** *: Results of ANOVA test on* ***RPP*** *portfolios with different filters.*

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