Received: 29 May 2023 | Revised: 19 October 2023 | Accepted: 15 November 2023

DOI: 10.1002/csr.2682

RESEARCH ARTICLE

Corporate Social Responsibility and Environmental Management

WILEY

The integration of environmental, social and governance criteria in portfolio optimization: An empirical analysis

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Abstract

The increasing interest of investors in environmental, social, and governance (ESG) issues has prompted asset managers to develop new approaches to strategic asset allocation that can effectively integrate ESG factors into the optimization process. This study reviews the main techniques of the most recent ESG-efficient portfolio optimization models. Furthermore, this study conducts an empirical investigation to identify the impact of ESG constraints on mean–variance efficient allocations, and extends existing approaches by incorporating a downside risk framework. Our findings reveal that social and combined ESG ratings mitigate the negative skewness of portfolio returns, and that ESG rating, environmental rating, social rating, and combined ESG rating allow the sustainable investor to incur lower transaction costs.

KEYWORDS

asset management, ESG criteria, ESG rating, portfolio optimization, socially responsible investment, sustainable investment

JEL CLASSIFICATION

G11, G12, G23, M14

1 | INTRODUCTION

Investment decisions are increasingly based on three elements: return, risk, and sustainability (Amel-Zadeh & Serafeim, 2018). This study is focused on integrating the main effects of sustainability into portfolio construction. Financial returns and risk are insufficient to assess sustainability; therefore, an additional parameter should be considered: the environmental, social, and governance (ESG) criterion. In most models, ESG factors are represented by ESG ratings. Therefore, the main objective of this study is to identify the most suitable methodology for integrating ESG ratings into portfolio optimization.

This study focuses on the integration of sustainability issues in portfolio construction, that is, the allocation of financial resources through portfolio optimization, allowing the creation of products that fall under Article 8 or Article 9 of the EU Sustainable Finance Disclosure Regulation (SFDR).

The most practical way to incorporate sustainability criteria into investment choices is by applying positive or negative screening. However, this approach does not align with portfolio theory (Beal et al., 2005; Peylo, 2011). Therefore, the first step is to move from optimizations with two variables (mean–variance) to optimizations with three variables (mean–variance-ESG). Before proceeding, it is useful to point out that all the models we will analyze do not apply only to generic ESG ratings. They can be used in the same way with only one feature related to ESG issues, such as the pollution produced.

Therefore, we extend Markowitz (1952) portfolio model to include variables beyond the mean and standard deviation of returns. ESG ratings, or given characteristics of environmental or social issues, are criteria that can be used. The usefulness of this approach lies in overcoming the limitations of modern portfolio theory: investors are not always the same. They have different needs and objectives. However, traditional approaches do not capture the unique characteristics of different investors. The ability to use many variables allows for the construction of portfolios tailored to meet the needs of each investor.

Our main contributions to the existing literature are twofold. Our study extends the existing literature on the integration of ESG ratings into portfolio construction by considering downside deviation, that is, a measure of downside risk, which has been relatively neglected by both the academic and practitioners' community (Yang et al., 2023). Moreover, our analysis provides an empirical evaluation in the financial environment typical of European investors, in contrast to the existing studies, predominantly focused on the US markets.

2 | LITERATURE REVIEW

Different approaches have been proposed regarding the transition from an optimal mean–variance portfolio to portfolio optimization taking three variables into account: Steuer et al. (2005), Steuer et al. (2007), Hirschberger et al. (2013), Steuer et al. (2013), Utz et al. (2015), and Gasser et al. (2017).

Steuer et al. (2005) address multi-criteria portfolio optimization as a multi-objective mathematical problem. Steuer et al. (2007) evolve the suitable portfolio theory to develop an optimization model that includes not only return and risk but also other variables. Their work allows the transition to a general model with more than two variables. The addition of a third variable transforms the curve of the efficient frontier into a three-dimensional surface. Indeed, the traditional two-dimensional efficient frontier (a parabola if drawn without non-negativity constraints) can no longer be used to represent three variables on the same plane because return, risk, and a third variable can only be illustrated by a surface. Utz et al. (2015) focus on sustainability; they add a third variable related to ESG issues, as their goal is to increase the level of sustainability in a portfolio. However, these models have several limitations that prevent their widespread application. The main shortcomings lie primarily in two aspects. First, to understand these models, investors must be familiar with terms that they are not used to, such as ESG ratings. Second, the surface is difficult to interpret when non-experts make investment choices.

Pedersen et al. (2021) make it possible to overcome the problems present in three-criteria optimizations that lead to the formation of a surface. In this model, investors aim to maximize the Sharpe ratio of a portfolio at a given ESG rating level. Through this approach, it is possible to return to the two-dimensional efficient frontier, because the Sharpe ratio is the ratio of the expected return in excess of the risk-free rate to the standard deviation of the returns.

In this section, we map other sustainable optimization models presented in scientific literature. Different optimization models can be divided into macro categories.

The largest macro category concerns models that extend mean–variance optimization. Drut (2010) proposes maximizing the utility function used in mean–variance optimization by adding a constraint that requires achieving a minimum ESG rating. Baracchini and Addessi (2012) are among the first to add a third variable related to sustainability to an optimal mean–variance portfolio. Dorfleitner and Utz (Dorfleitner & Utz, 2012) propose a utility function based not only on portfolio returns but also on the so-called sustainability returns. Schmidt (2020) proposes minimizing the difference between volatility and ESG ratings under an expected return constraint. Shushi (2022) proposes the construction of ESG portfolios based on the average ESG score. García et al. (2019, 2022), moreover, propose the fuzzy value of global ESG as an additional objective function integrated into the Markowitz model.

The second category includes models that employ machine learning techniques. Such methodologies allow the prediction of various elements present in sustainable portfolio optimization. For example, we can mention the work conducted by Fish et al. (2019), where the ESG factor is applied to adjust expected returns with respect to ESG ratings for the hierarchical risk parity portfolio developed by De Prado (2016). This model allows the construction of highly diversified portfolios. The primary motivation is related to a structure that acts precisely in the application of intelligent diversification.

Several other approaches can also be considered. For example, Bender et al. (2020) add an emission-related constraint to portfolio optimization. Moreover, new models, approaches, and measures are emerging that allow the construction of portfolios that consider aspects related solely to rising temperatures or pollution production. For example, Mercereau and Merlin (2020) use temperature as the target variable instead of ESG ratings.

An area for further study concerns the relationship between ESG and asymmetric risk (downside risk) measures. Yang et al. (2023) point out that few studies in the literature explore this relationship in depth.

The scientific literature has identified three different connections between ESG factors and financial performance (Busch & Friede, 2018). First, sustainable investments can improve returns. The second possibility is that sustainable investments have no effect. The third possibility is that such investments decrease returns.

Broadstock et al. (2021) argue that high ESG values make it possible to lower risk during financial crises. According to this study, financial assets with high ESG values represent risk mitigation instruments. Engelhardt et al. (2021) reach the same conclusions regarding European equities, because companies with higher ESG values have higher cumulative abnormal returns and lower idiosyncratic volatility during a crisis. Thus, these stocks appear to be more resilient when uncertainty increases. Yang et al. (2023) also report similar results.

Lööf et al. (2022) confirm that the main effect related to ESG characteristics is risk mitigation; financial instruments with high ESG values allow them to reduce financial risk. They note that stocks with high ESG values have lower asymmetric risk, but also a lower potential for profit. According to Rubbaniy et al. (2022), while ESG stocks have a positive effect on risk, they cannot be classified as safe haven assets. Such stocks remain risky financial instruments and do not possess all the properties of a safe haven asset, at least not in every time frame. The scientific literature also documents that financial assets with high ESG values have a positive impact on systematic risk. Albuquerque et al. (2019) argue that implementing corporate social responsibility

(CSR) practices decreases companies' systematic risk. According to Ng and Rezaee (2020), stocks with higher ESG ratings have higher idiosyncratic risk compared to other stocks with the same systematic risk but lower ESG ratings. Therefore, according to this study, financial assets with high ESG ratings do not necessarily reduce risk.

3 | METHODOLOGY

The main objective of this empirical analysis is to understand whether a trade-off exists between a portfolio's risk-adjusted return and its level of sustainability. The key question is whether a sustainable investor will experience a reduction or an increase in portfolio risk-adjusted returns compared to a traditional investor.

To answer this question, we must estimate and compare the ESG-efficient frontiers of an investor who does not apply ESG information (traditional investor) and one who does (sustainable investor). To construct the two efficient frontiers, we assume that the two investors adopt two different methods for estimating expected returns.

Following the approach of Pedersen et al. (2021), the expected monthly returns for each stock are estimated by a traditional investor as follows:

$$E_t(r_{i,t+1}) = \mathrm{ERP}_{i,t} + \mathrm{bp}_{i,t}\,\mathrm{RP}_t \tag{1}$$

where $ERP_{i,t}$ is the equity risk premium (the difference between equity returns and the risk-free rate of return), $bp_{i,t}$ is the book-to-price ratio of each stock, and RP_t is the return premium of the portfolio constructed using the book-to-price ratio.

To construct this portfolio, Pedersen et al. (2021) allocate stocks into five sub-portfolios, ranging from the portfolio of stocks with the highest book-to-price ratio to the last portfolio containing stocks with the lowest book-to-price ratio. The assumption underlying this choice is that a traditional investor focuses on fundamental stock analysis, that is, on the evaluation of companies based upon their financial statement analysis. The book-to-price ratio is the most representative financial ratio, because it indicates how much the equity of a company is under- or over-priced by the market compared to its balance sheet. To estimate the return premium, Pedersen et al. (2021) construct a portfolio that is long on stocks with the highest book-to-price ratios and short on stocks with the lowest book-to-price ratios. Each asset is assigned the same weight; therefore, the portfolio is equally weighted and no optimization is applied in this stage of the analysis, which will be carried out only later. The book-to-price ratios for each stock and period are normalized by multiplying each value by the series mean and dividing it by the series standard deviation before being used to calculate the return premium.

Instead, the monthly returns of a sustainable investor are calculated as follows:

$$E_t(r_{i,t+1}) = \mathrm{ERP}_{i,t} + \mathrm{bp}_{i,t}\,\mathrm{RP}_{bp,t} + \mathrm{rating}_{i,t}\,\mathrm{RP}_{\mathrm{rating},t} \tag{2}$$

The first two addends are the same as those of traditional investors. In addition, the sustainable investor uses ESG information. To incorporate this information in estimating expected returns, Pedersen et al. (2021) include the addend $rating_{i,t}$, which is the normalized ESG rating or any other normalized sustainability-related rating for each stock, and $\mathrm{RP}_{rating,t}$, which is the return premium of the portfolio constructed with the ESG rating or a different sustainability rating. To estimate the return premium, the same method used to estimate the return premium with the book-to-price ratio is applied. This involves creating a portfolio long on stocks with the highest ratings and short on stocks with the lowest ratings.

To implement the construction of the efficient frontiers for traditional and sustainable investors, we have chosen to apply the methodology described to two different models. First, we evaluate the portfolio optimization problem proposed by Pedersen et al. (2021), that is, we maximize the Sharpe ratio for any given ESG rating. By calculating the various Sharpe ratios for each ESG rating, it is possible to construct the efficient frontiers.

Before proceeding, we need to explain the meaning of some symbols: $\mathbf{r} = (r_1, \ldots, r_n)'$ is the vector of returns in excess of the risk-free rate of stocks and $\mathbf{s} = (s_1, \ldots, s_n)'$ is the vector of ESG ratings of each stock. Pedersen et al. (2021) estimate the rating of a portfolio in the following way:

$$\overline{S} = \frac{\mathbf{w}'\mathbf{s}}{\mathbf{w}'\mathbf{1}} \tag{3}$$

where $\mathbf{w}$ is the vector of weights assigned to each asset in the portfolio after performing the optimization and $\mathbf{1}$ is a vector of ones.

This model considers three investors:

1. The unaware investor ignores ESG ratings and makes investment decisions based only on the means and standard deviations. Statistically, the unaware investor uses the expected return $E(\mathbf{r})$. Risk, on the other hand, is measured by the covariance matrix, that is, $\mathrm{var}(\mathbf{r})$;
2. The aware investor has preferences related to the mean-variance approach, but uses ESG ratings to adjust the estimation of return and risk. This investor also uses the expected returns and covariance matrix, but they are conditional on ESG ratings. Thus, we have $\mu = E(\mathbf{r}|\mathbf{s})$ and $\boldsymbol{\Sigma} = \mathrm{var}(\mathbf{r}|\mathbf{s})$.
3. The motivated investor uses ESG ratings to make investment choices and has a preference for high ESG values. Thus, portfolio optimization is based on return, risk, and sustainability. Return and risk can be summarized using the Sharpe ratio, whereas sustainability can be represented by ESG ratings.

The ESG efficient frontier, plotted in the Sharpe ratio-ESG rating plane, has a humped shape that is quite different from that of Markowitz. The reason lies in the tangency portfolio, which is the portfolio with the highest Sharpe ratio among all portfolios on the frontier. Consequently, the Sharpe ratio of the tangency portfolio and its ESG rating define the point of the maximum ordinate on the ESG efficient frontier. The hump shape of the ESG-efficient frontier depends on the fact that each portfolio corresponds to a given ESG rating but with a Sharpe ratio that is necessarily lower than that of the tangency portfolio.

In addition, when compared to the Markowitz efficient frontier, excluding financial assets without ESG ratings is necessary; consequently, fewer portfolios will be available for inclusion in the frontier. This reduction means that the maximum Sharpe ratio must be reduced because the available investible universe is smaller.

Individuals choose portfolios based on their personal preferences. The aware investor opts for the tangency portfolio; that is, he selects the portfolio with the highest Sharpe ratio, but also considers ESG information. The motivated investor chooses one of the portfolios located to the right of the tangency portfolio, that is, the portion of the efficient frontier with a higher ESG rating. The choice depends on the individual's preferences; the further to the right, the higher the investor's ESG preference. The unaware investor may choose portfolios below the efficient frontier. The main reason for this is the construction of a tangency portfolio without knowledge of information related to ESG values.

The optimal portfolio is a combination of four portfolios: of the risk-free asset, the tangency portfolio $\mathbf{\Sigma}^{-1}\boldsymbol{\mu}$, the minimum variance portfolio $\mathbf{\Sigma}^{-1}\mathbf{1}$, and the ESG tangency portfolio $\mathbf{\Sigma}^{-1}\mathbf{s}$. It is useful to examine the construction of the ESG-efficient frontier. Let us review the calculation of the Sharpe ratio in five steps.

1. The necessary inputs are the vector of ESG ratings $\mathbf{s} = (s_1, \ldots, s_n)$, the vector of asset weights $\mathbf{w} = (w_1, \ldots, w_n)$, the vector of excess returns over the risk-free rate of return $\mathbf{r} = (r_1, \ldots, r_n)$, and the variance of the portfolio, given an ESG rating level, $\mathbf{\Sigma} = \mathrm{var}(\mathbf{r}|\mathbf{s})$, that is, the covariance matrix.
2. The mean ESG rating is calculated as follows:

$$\bar{S} = \frac{\mathbf{w}'\mathbf{s}}{\mathbf{w}'\mathbf{1}} \tag{4}$$

3. A vector is calculated, where the mean ESG rating is subtracted from each ESG rating. Thus, we can determine whether each financial asset's ESG rating is higher or lower than the portfolio's mean ESG rating. When positive (negative) values are observed, the ESG rating of an individual financial instrument is higher (lower) than the mean ESG rating. Subsequently, the following vector is calculated:

$$\mathbf{S} = \left(s_1 - \bar{S}, s_2 - \bar{S}, \ldots, s_n - \bar{S}\right)' \tag{5}$$

4. The strength of preferences with respect to ESG issues π is calculated as follows:

$$\pi = -\frac{\mathbf{S}'\mathbf{\Sigma}^{-1}\boldsymbol{\mu}}{\mathbf{S}'\mathbf{\Sigma}^{-1}\mathbf{S}} \tag{6}$$

Pedersen et al. (2021) explain that π can be regarded as the strength of preferences toward ESG issues; by assigning a value of zero to π, the optimal portfolio obtained from (Pedersen et al., 2021) model becomes the traditional mean–variance optimal portfolio. Another reason is related to the fact that in the new optimal portfolio, the expected returns are adjusted with respect to $\mathbf{S}$. A positive π increases (decreases) the expected returns of financial instruments with an ESG rating higher (lower) than the mean rating and vice versa with a negative π.

5. The new Sharpe ratio can be calculated as follows:

$$SR_{ESG}\left(\bar{S}\right) = \sqrt{\boldsymbol{\mu}'\mathbf{\Sigma}^{-1}(\boldsymbol{\mu} + \pi\mathbf{S})} \tag{7}$$

After rewriting the Sharpe ratio, the construction of the ESG efficient frontier is also possible. This procedure is identical to that used to construct the traditional mean-variance efficient frontier. To construct a portfolio optimization model, it is necessary to solve the following utility maximization problem:

$$\max_{\mathbf{w}}\left(\alpha\mathbf{w}'\boldsymbol{\mu} - \gamma\frac{1}{2}\mathbf{w}'\mathbf{\Sigma}\mathbf{w} + f\mathbf{w}'\mathbf{s}\right) \tag{8}$$

where α, γ, and f represent investors' preferences with respect to expected return, variance, and ESG ratings, respectively. Through the formulation in Equation (8), the three investor preferences are explicitly expressed. The calculation of the third element (the ESG characteristics) is based on the multiplication the preference for ESG characteristics, the transposed vector of asset weights, and the vector of ESG characteristics for each financial instrument. The meaning is the same as that in the utility problem of Equation (8); however, this version is useful for the next steps. The solution to this problem is as follows:

$$\mathbf{w} = \frac{\alpha}{\gamma}\mathbf{\Sigma}^{-1}\boldsymbol{\mu} + \frac{f}{\gamma}\mathbf{\Sigma}^{-1}\mathbf{w}'\mathbf{s} + \frac{h}{\gamma}\mathbf{\Sigma}^{-1}\mathbf{1} \tag{9}$$

where h denotes the Lagrange multiplier. The starting point is that investors cannot identify their preferences optimally. Specifically, assigning numerical values to the three parameters employed to represent preferences is difficult. This makes it easier for investors to define the expected return, standard deviation, and ESG characteristics that a portfolio should achieve. Accordingly, it is possible to write an optimization problem for use with the new Sharpe ratio to construct an efficient ESG frontier. One option is to solve the following optimization problem:

$$\min \frac{1}{2}\mathbf{w}'\mathbf{\Sigma}\mathbf{w} \tag{10}$$

Subject to the constraints:

$$\mathbf{w}'\mathbf{1} = 1 \tag{11}$$

$$\mathbf{w}'\boldsymbol{\mu} = \mu_{target} \tag{12}$$

$$\mathbf{w}'\mathbf{s} = s_{target} \tag{13}$$

and the last constraint (13) can also be replaced by the following:

$$\frac{\mathbf{w}'\mathbf{s}}{\mathbf{w}'\mathbf{1}} = s_{target} \tag{14}$$

However, the proposed algorithm would produce the same results. At the same time, it is easier for an investor to identify a portfolio's mean ESG rating.

Another possibility is to maximize yield and thus:

$$\max \mathbf{w}'\boldsymbol{\mu} \tag{15}$$

Subject to the constraints:

$$\mathbf{w}'\mathbf{1} = 1 \tag{16}$$

$$\mathbf{w}'\boldsymbol{\Sigma}\mathbf{w} = \sigma^2{}_{target} \tag{17}$$

$$\frac{\mathbf{w}'\mathbf{s}}{\mathbf{w}'\mathbf{1}} = s_{target} \tag{18}$$

These optimizations help investors consider ESG ratings in their investment choices.

In contrast, the second model that we analyzed consists of an innovative approach that we developed from the one carried out by Pedersen et al. (2021). Our purpose is to fill the gap in scientific literature on the relationship between ESG ratings and asymmetric risk measures. Therefore, we apply the optimization of Pedersen et al. (2021); however, instead of variance, we employ the below-mean semivariance developed by Ballestero (2005) as the risk measure. The main advantage of this risk measure is that it uses an estimation technique similar to that used for the estimation of variance. Consequently, it can be perfectly integrated into the model proposed by Pedersen et al. (2021), without changing any additional features. Therefore, instead of maximizing the Sharpe ratio, we maximize the Sortino index for any given ESG rating. As is known, the Sortino index measures the excess return per unit of downside risk and not per unit of total risk, as the Sharpe ratio does.

In our analysis, consistent with operational practice, we impose the no short-selling constraint. In addition, we impose a diversification constraint to avoid obtaining portfolios that focus exclusively on one asset. Our optimizations identify the portfolio with the highest Sharpe ratio or Sortino index for any given ESG rating, that is, for any s_{target}. In other words, we construct two efficient frontiers: one in the Sharpe ratio-ESG rating plane and one in the Sortino index-ESG rating plane. Then, we take the portfolio with the highest Sharpe ratio and the portfolio with the highest Sortino index, which are the most efficient portfolios, on a purely financial point of view, in each of the two frontiers. An individual investor might choose a different portfolio, according to the preference towards the ESG issues, but our analysis is focused on the sole portfolios that can be identified following a purely objective, and not subjective, criterion.

For our analysis, the data sample was divided into two parts. The first 60 monthly observations were used for the in-sample analysis, whereas the last 60 observations were used for the out-of-sample study. The initial composition of portfolios, as of January 1, 2017, is derived by performing the sustainable portfolio optimization with the returns and risks estimated in sample. Then, a rebalancing of the portfolios is implemented every 6 months using the rolling window method, which allows subsequent optimizations to be performed to produce a six-monthly rebalancing of the composition of the portfolios and a true forward-looking simulation to be implemented. A time window of fixed length of 6 months was chosen, which contained a constant number of previous observations each time, in this case, equal to 60 months. With each optimization, we advanced the time window by 6 months, considering six new observations and excluding the six oldest observations. Finally, the monthly portfolio weights are updated based on the previous month's performance using a buy-and-hold logic. Once this process is performed for the entire available time series, which runs through December 31, 2021, the out-of-sample analysis can be conducted.

Once the out-of-sample analysis is performed, it is possible to compare the following statistics for each portfolio: ESG rating, Sharpe ratio, Sortino index, standard deviation, skewness, kurtosis, alpha, tracking error, information ratio, turnover, number of negative months, and maximum drawdown.

4 | DATA

The sample comprises a time series of returns from Euro Stoxx 50 index constituents. The rationale for selecting this benchmark depends on the following three factors:

1. Its components represent the most important continental European companies, as the Euro Stoxx 50 contains the top 50 blue chips of the Eurozone.
2. The Euro Stoxx 50 index has high liquidity, because its financial instruments represent the most traded listed European companies. In addition, the Euro Stoxx 50 index serves as the underlying for various investment products, such as ETFs, futures, structured products, and options, not only in Europe but also globally.
3. Given the present and future impact of the SFDR regulation on the entire European financial market, it is useful to analyze how to optimize a Euro Area equity portfolio according to the ESG criteria.

For each stock, we also employ a time series of the book-to-price ratio, which is necessary to estimate the expected values of each financial instrument. The benchmark used to estimate the relative performance measures is the Euro Stoxx 50 index, while the 1-month Euribor rate has been selected as a proxy for the risk-free rate.

We employ the time series of six different ESG ratings, provided by Refinitiv: ESG, environmental, social, governance, combined ESG and ESG controversies. Refinitiv has decided, in order to assign the ESG rating, to set a weight of 53.1% to the social rating, 28.7% to the governance rating, and 18.2% to the environmental rating. The combined ESG rating is calculated by Refinitiv considering the ESG rating and the ESG controversies rating. Each of these ratings can take values ranging from zero to 100, where zero always represents the worst result and 100 represents the highest, that is, the most sustainable rating.

For each time series, we downloaded 120 monthly observations from the Refinitv database from January 2012 to December 2021.

5 | RESULTS

For the out-of-sample analysis, we need to first resort to performance and statistical measures. We evaluate 12 different metrics: mean rating, Sharpe ratio, Sortino index, standard deviation, skewness, kurtosis, alpha, tracking error volatility, information ratio, turnover, negative months, and maximum drawdown.

In the tables presented in this section, the values in the columns indicate the means of the variables considered for all efficient portfolios generated. The adjective "traditional" indicates those portfolios constructed by sustainable portfolio optimization, but with the information held by a traditional investor. Thus, "traditional" means that portfolios were created using the model developed by Pedersen et al. (2021) or its modified version, proposed here, which is based on semivariance, but uses the expected returns of a traditional investor as input. Thus, it is defined traditional because this investor does not consider any information related to ESG issues when estimating expected returns. Instead, the term "sustainable" refers to a portfolio constructed using sustainable portfolio optimization but with information held by a sustainable investor. In this case, the sustainable investor also considers ESG rating information while estimating expected returns. Using two approaches to estimate expected returns, traditional and sustainable investors provide insights into how information related to ESG issues affect portfolio construction.

Moreover, the column "*t*-test" indicates that the statistical significance of the differences between the values in each pair of portfolios was tested. The tables show the results of the original Pedersen et al. (2021) model and of the same model modified with semivariance.

As Table 1 shows, the Sharpe ratios and Sortino indices of the portfolios constructed following the ESG rating are almost the same for both the variance and semivariance models. Specifically, with the use of the ESG rating, the traditional investor reaches higher levels of both the Sharpe ratio and Sortino index. We also note that the environmental rating leads to the same results for both the variance and semivariance models. The sustainable and traditional investors obtain the same risk-adjusted performance using the environmental rating. In Table 1, we observe that the model using semivariance yields a lower mean social rating for the sustainable investor than the model using variance. However, the sustainable investor obtained a higher mean social rating. We can also notice that by employing a governance rating, the models with variance and semivariance produce the same results. Moreover, the traditional investor obtains better results for the mean governance rating, Sharpe ratio, and Sortino index. Further, the semivariance model using the ESG combined rating succeeds in increasing the level of sustainability for both traditional and sustainable investors. However, the sustainable investor achieves higher sustainability values, whereas the Sharpe ratio and Sortino index are the same for both investors. The data presented in Table 1 conclude by indicating that, with the controversies rating, the traditional investor achieves the highest levels of Sharpe ratio, Sortino index, and sustainability. If we compare the risk-adjusted performance of all the portfolios constructed by taking into account the traditional and the sustainable information, we can notice a prevalence of the first one. This result can be justified by a higher predictive power of fundamental analysis if compared to the ESG ratings.

Table 2 exhibits an assessment of standard deviation, skewness, and kurtosis. These statistical moments are useful because they enable us to assess how returns are distributed, and therefore, to understand the risk profile of portfolios. Table 2 shows that using the ESG rating results in a higher standard deviation for the sustainable investor than for the traditional investor. We also observe that the traditional investor is subject to lower kurtosis and less negative skewness than the sustainable investor when using the environmental rating. Regarding the social rating, the sustainable investor's portfolio performs better than the traditional investor's portfolio in terms of skewness and kurtosis. However, this advantage is partially offset by the higher standard deviation. Table 2 also shows that the governance rating leads to the same conclusions as the environmental rating. The combined ESG rating produces a negative skew and lower standard deviation for the sustainable investor, pointing out a risk-reduction property of this rating. In contrast, the returns on the traditional investor's portfolio are subject to higher kurtosis. Finally, Table 2 shows that the use of the controversies rating does not benefit investors, both sustainable and traditional, in terms of risk reduction, if compared to the other ratings. The sustainable investor, on the other hand, is subject to a lower risk exposure compared to the traditional one, probably because a company with a better controversies rating is less subject to legal and reputational risks and, therefore, its returns are less dependent on extreme negative events. These findings confirm the results of Galletta and Mazzù (2022), which focus their analysis on a sample of banks and their ESG controversies ratings. A synthetic comparison of the traditional and sustainable portfolios, with regards to their risk profiles, does not highlight a predominant forecasting technique, if we consider all the three moments of returns distributions.

Now, we analyze three measures that are useful for evaluating the relative performance of portfolios: alpha, tracking error, and information ratio (Table 3). Table 3 shows that using the ESG rating, the model with semivariance increases the information ratio for the traditional investor. Thus, although the information ratio is the same for both investors in the model with variance, the model with semivariance allows the traditional investor's portfolio to achieve a higher information ratio. In the same table, we can observe that using the environmental rating, the traditional investor generates a portfolio with higher tracking error volatility, while the other measures are not statistically significant. Using the social rating, the traditional investor

TABLE 1 Mean rating, Sharpe ratio, and Sortino index.

Rating	Investor	Mean rating	t-test	Sharpe ratio	t-test	Sortino index	t-test
ESG	Pedersen et al. (2021) *portfolio*						
	Traditional	66.38		0.42	***	0.43	***
	Sustainable	66.36		0.39		0.40	
	Modified Pedersen et al. (2021) *portfolio with semivariance*						
	Traditional	66.38		0.42	***	0.43	***
	Sustainable	66.36		0.39		0.40	
Environment	Pedersen et al. (2021) *portfolio*						
	Traditional	64.57	***	0.43		0.44	
	Sustainable	64.51		0.43		0.44	
	Modified Pedersen et al. (2021) *portfolio with semivariance*						
	Traditional	64.57	***	0.43		0.44	
	Sustainable	64.51		0.43		0.44	
Social	Pedersen et al. (2021) *portfolio*						
	Traditional	73.86	***	0.49	***	0.50	***
	Sustainable	73.97		0.48		0.49	
	Modified Pedersen et al. (2021) *portfolio with semivariance*						
	Traditional	73.86	***	0.49	***	0.50	***
	Sustainable	73.96		0.48		0.49	
Governance	Pedersen et al. (2021) *portfolio*						
	Traditional	58.41	**	0.44	***	0.45	***
	Sustainable	58.35		0.43		0.44	
	Modified Pedersen et al. (2021) *portfolio with semivariance*						
	Traditional	58.41	**	0.44	***	0.45	***
	Sustainable	58.35		0.43		0.44	
ESG combined	Pedersen et al. (2021) *portfolio*						
	Traditional	61.27	***	0.41	**	0.42	**
	Sustainable	61.33		0.42		0.43	
	Modified Pedersen et al. (2021) *portfolio with semivariance*						
	Traditional	61.29	***	0.41	**	0.42	**
	Sustainable	61.34		0.42		0.43	
Controversies	Pedersen et al. (2021) *portfolio*						
	Traditional	53.84	***	0.37	***	0.38	***
	Sustainable	52.86		0.36		0.37	
	Modified Pedersen et al. (2021) *portfolio with semivariance*						
	Traditional	53.86	***	0.37	***	0.38	***
	Sustainable	52.89		0.36		0.37	

Note: ***, **, and * represent statistical significance levels of 1%, 5%, and 10%, respectively. Authors' calculations based on Refinitiv data.

manages to obtain a higher alpha, albeit with a significance of only 10%. The use of the governance rating with the semivariance model achieves a higher alpha for both investors. However, for both the semivariance and variance models, the traditional investor reaches a higher alpha, but at the expense of a higher tracking error volatility than the sustainable investor. The ESG combined rating allows the sustainable investor to achieve a higher information ratio and alpha than the traditional investor. The ESG controversies rating allow the sustainable investor to reach a higher alpha and the model with semivariance allows the sustainable investor to obtain a higher alpha than the same sustainable investor who, however, uses the model with variance. In summary, the traditional investor benefits from higher relative performances if compared to the sustainable investor, except in the portfolios based upon the ESG combined and controversies

TABLE 2 Standard deviation, skewness, and kurtosis.

Rating	Investor	Std. dev.	*t*-test	Skewness	*t*-test	Kurtosis	*t*-test
ESG	Pedersen et al. (2021) *portfolio*						
	Traditional	6.04%	***	−0.80		4.69	
	Sustainable	6.13%		−0.78		4.65	
	Modified Pedersen et al. (2021) *portfolio with semivariance*						
	Traditional	6.04%	***	−0.80		4.69	
	Sustainable	6.13%		−0.78		4.64	
Environment	Pedersen et al. (2021) *portfolio*						
	Traditional	6.24%		−0.43	***	3.73	***
	Sustainable	6.24%		−0.48		3.89	
	Modified Pedersen et al. (2021) *portfolio with semivariance*						
	Traditional	6.24%		−0.43	***	3.73	***
	Sustainable	6.24%		−0.48		3.89	
Social	Pedersen et al. (2021) *portfolio*						
	Traditional	5.66%	***	−0.49	***	3.12	***
	Sustainable	5.70%		−0.44		3.00	
	Modified Pedersen et al. (2021) *portfolio with semivariance*						
	Traditional	5.66%	***	−0.49	***	3.13	***
	Sustainable	5.70%		−0.44		3.00	
Governance	Pedersen et al. (2021) *portfolio*						
	Traditional	5.65%		−0.64	***	3.84	***
	Sustainable	5.64%		−0.69		4.03	
	Modified Pedersen et al. (2021) *portfolio with semivariance*						
	Traditional	5.65%		−0.64	***	3.84	***
	Sustainable	5.64%		−0.69		4.03	
ESG combined	Pedersen et al. (2021) *portfolio*						
	Traditional	6.03%		−0.83	***	4.86	***
	Sustainable	6.01%		−0.78		4.67	
	Modified Pedersen et al. (2021) *portfolio with semivariance*						
	Traditional	6.03%		−0.83	***	4.86	***
	Sustainable	6.01%		−0.78		4.67	
Controversies	Pedersen et al. (2021) *portfolio*						
	Traditional	6.44%		−0.85	*	5.44	*
	Sustainable	6.48%		−0.81		5.20	
	Modified Pedersen et al. (2021) *portfolio with semivariance*						
	Traditional	6.44%		−0.85	*	5.35	*
	Sustainable	6.47%		−0.81		5.21	

Note: ***, **, and * represent statistical significance levels of 1%, 5%, and 10%, respectively. Authors' calculations based on Refinitiv data.

ratings. The results of Table 3 support the evidence presented in Table 2, that is, the relevance of the controversies rating in enhancing the financial profile of investments.

Table 4 provides the data for the analysis of the three retrospective measures: turnover, negative months, and maximum drawdown. They represent negative aspects for the investor because turnover – that is, the portfolio turnover rate – is directly proportional to transaction costs, whereas the other two are measures focused on incurred losses. Table 4 shows that using the ESG rating, the model with semivariance resulted in higher turnover for both investors compared to the model with variance. In addition, the sustainable investor using the ESG rating experiences much lower turnover than the traditional investor. Regarding the environmental rating, we note that the model with semivariance increases the turnover for both investors compared to the model with variance and reduces the maximum drawdown of the sustainable investor. The sustainable investor with the environmental rating has lower turnover than the traditional investor. However, the sustainable investor has a higher maximum

TABLE 3 Alpha, tracking error, and information ratio.

Rating	Investor	Alpha	*t*-test	Tracking error vol.	*t*-test	Information ratio	*t*-test
ESG	Pedersen et al. (2021) *portfolio*						
	Traditional	1.44%	**	4.28%	***	0.31	
	Sustainable	1.41%		4.32%		0.31	
	Modified Pedersen et al. (2021) *portfolio with semivariance*						
	Traditional	1.44%	**	4.28%	***	0.32	*
	Sustainable	1.41%		4.32%		0.31	
Environment	Pedersen et al. (2021) *portfolio*						
	Traditional	1.48%		4.13%	**	0.37	
	Sustainable	1.47%		4.12%		0.37	
	Modified Pedersen et al. (2021) *portfolio with semivariance*						
	Traditional	1.48%		4.13%	**	0.37	
	Sustainable	1.48%		4.12%		0.37	
Social	Pedersen et al. (2021) *portfolio*						
	Traditional	1.82%	*	4.40%	*	0.36	
	Sustainable	1.80%		4.42%		0.36	
	Modified Pedersen et al. (2021) *portfolio with semivariance*						
	Traditional	1.82%	*	4.40%	*	0.37	
	Sustainable	1.80%		4.42%		0.36	
Governance	Pedersen et al. (2021) *portfolio*						
	Traditional	1.34%	***	3.40%	*	0.38	
	Sustainable	1.32%		3.38%		0.38	
	Modified Pedersen et al. (2021) *portfolio with semivariance*						
	Traditional	1.35%	***	3.40%	*	0.38	
	Sustainable	1.33%		3.38%		0.38	
ESG combined	Pedersen et al. (2021) *portfolio*						
	Traditional	1.39%	***	4.31%	*	0.30	***
	Sustainable	1.42%		4.30%		0.31	
	Modified Pedersen et al. (2021) *portfolio with semivariance*						
	Traditional	1.39%	***	4.31%		0.30	***
	Sustainable	1.42%		4.31%		0.31	
Controversies	Pedersen et al. (2021) *portfolio*						
	Traditional	0.78%	**	4.34%		0.21	
	Sustainable	0.82%		4.34%		0.21	
	Modified Pedersen et al. (2021) *portfolio with semivariance*						
	Traditional	0.78%	**	4.34%		0.21	
	Sustainable	0.83%		4.34%		0.21	

Note: ***, **, and * represent statistical significance levels of 1%, 5%, and 10%, respectively. Authors' calculations based on Refinitiv data.

drawdown than the traditional investor. Table 4 also shows that using the social rating results in a higher turnover for the traditional investor and a lower maximum drawdown for the sustainable investor, whereas the model with semivariance increases the turnover for both investors. Using the governance rating, we see that the model with semivariance reduces the maximum drawdowns for both investors compared to the model with variance and that the sustainable investor has a worse maximum drawdown than the traditional investor. The model with semivariance using the combined ESG rating reduces the maximum drawdown for both investors, but simultaneously they experience an increase in turnover. It can also be observed that the traditional investor is subject to worse turnover and maximum drawdown than the sustainable investor. By employing the ESG controversies rating, the model with semivariance increases the turnover of both investors compared to the model with variance. In addition, the model with semivariance increases the negative months for the

TABLE 4 Turnover, negative months, and maximum drawdown.

Rating	Investor	Turnover	*t*-test	Negative months	*t*-test	Max. Drawdown	*t*-test
ESG	Pedersen et al. (2021) *portfolio*						
	Traditional	11.43%	**	20.19		−19.62%	
	Sustainable	11.10%		20.62		−19.73%	
	Modified Pedersen et al. (2021) *portfolio with semivariance*						
	Traditional	11.47%	**	20.37		−19.62%	
	Sustainable	11.12%		20.62		−19.72%	
Environment	Pedersen et al. (2021) *portfolio*						
	Traditional	10.52%	**	20.50		−17.19%	***
	Sustainable	10.46%		20.62		−17.67%	
	Modified Pedersen et al. (2021) *portfolio with semivariance*						
	Traditional	10.55%	**	20.62		−17.19%	***
	Sustainable	10.49%		20.69		−17.66%	
Social	Pedersen et al. (2021) *portfolio*						
	Traditional	11.80%	***	20.06		−14.13%	***
	Sustainable	11.38%		20.00		−13.68%	
	Modified Pedersen et al. (2021) *portfolio with semivariance*						
	Traditional	11.82%	***	19.87		−14.13%	***
	Sustainable	11.41%		19.87		−13.68%	
Governance	Pedersen et al. (2021) *portfolio*						
	Traditional	13.07%		20.25		−16.52%	***
	Sustainable	13.02%		20.19		−17.01%	
	Modified Pedersen et al. (2021) *portfolio with semivariance*						
	Traditional	13.16%		20.19		−16.47%	***
	Sustainable	13.12%		20.12		−16.96%	
ESG combined	Pedersen et al. (2021) *portfolio*						
	Traditional	12.45%	***	20.00		−19.85%	***
	Sustainable	12.16%		20.19		−19.43%	
	Modified Pedersen et al. (2021) *portfolio with semivariance*						
	Traditional	12.50%	***	20.06		−19.84%	***
	Sustainable	12.22%		20.12		−19.42%	
Controversies	Pedersen et al. (2021) *portfolio*						
	Traditional	13.48%	***	22.81	**	−23.35%	
	Sustainable	14.11%		23.37		−23.14%	
	Modified Pedersen et al. (2021) *portfolio with semivariance*						
	Traditional	13.53%	***	22.87	*	−23.34%	
	Sustainable	14.15%		23.31		−23.14%	

Note: ***, **, and * represent statistical significance levels of 1%, 5%, and 10%, respectively. Authors' calculations based on Refinitiv data.

traditional investor and decreases them for the sustainable investor. Negative months are also more frequent for the sustainable investor. In conclusion, the portfolios of the sustainable investor dominate the portfolios of the traditional investors in terms of turnover reduction. This result relies on the stability of ratings if compared to financial ratios. Consequently, portfolios constructed focusing on sustainability are less subject to rebalancing than traditional ones. The number of negative months and the maximum drawdown, instead, do not show a clear dominance of a set of portfolios.

6 | CONCLUSIONS

In conclusion, according to the results of our empirical analysis, investors who intend to allocate their financial resources sustainably should focus on the following aspects.

Social and combined ESG ratings allow the sustainable investor to reduce the negative skewness of portfolio returns. This is an important risk management property for investors. By contrast, the ESG controversies rating allows the sustainable investor to generate a higher alpha for portfolios. Moreover, as this rating increases, and thus as the level of sustainability increases, portfolio alpha increases. This means that the information related to this rating allow investors to generate extra returns.

ESG, environmental, social, and combined ESG ratings allow the sustainable investor to experience lower turnover than the traditional investor. This translates into lower transaction costs. Moreover, the social rating and the combined ESG rating allow the sustainable investor to suffer lower maximum drawdowns than the traditional investor.

The model with semivariance, presented here for the first time, yielded superior results compared with the model with variance. This mainly affected the reduction in the maximum drawdown. However, this approach also has disadvantages. The model with semivariance tends to increase portfolio turnover. This means higher costs to be borne by the investor, so it must be checked whether the improvements made by the model are canceled out by an increase in costs. However, one must also consider that the series used in this analysis were only slightly non-normal. Therefore, in the presence of markedly non-normal series, the model based on the minimization of semivariance could increase portfolio performance; thus, higher costs from turnover could be clearly outweighed by superior risk-adjusted performance.

Our study has provided an empirical analysis of the integration of sustainability ratings into the portfolio construction process, not only in the traditional mean–variance framework, but also in the mean-downside risk environment. This study has evaluated also the performances and risks of portfolios constructed by traditional and sustainable investors, highlighting the limited usefulness of sustainability information as a tool of risk-adjusted performance enhancement, but also its ability to mitigate transaction costs, thanks to the reduction of portfolio turnover.

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How to cite this article: Abate, G., Basile, I., & Ferrari, P. (2024). The integration of environmental, social and governance criteria in portfolio optimization: An empirical analysis. *Corporate Social Responsibility and Environmental Management*, *31*(3), 2054–2065. https://doi.org/10.1002/csr.2682