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Investing in the Sense of ESG

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Abstract. This paper examines the impact of ESG risks on the portfolio allocation and analyses the impact of these risks on the resulting profitability and riskiness of the portfolio. The analysis of ESG risks is rising in the modern dynamic economy and represents a tool for redirecting capital to sustainable economic activities. Using mean-variance analysis and applying an optimisation task, we searched for a reference optimal portfolio meeting the preferences of our intended investor. Markowitz's theory was extended for a risk-averse investor with a ESG risk preferences and a limited choice of underlying assets for the portfolio. The set of potential underlying assets of the portfolio consists of shares of publicly traded institutions in the European Economic Area, for which the RepRisk index (RRI) is available. The RepRisk index was chosen to evaluate companies' ESG performance. The ESG risk factor was considered when calculating the optimal mean-variance portfolio and the portfolio with the maximum Sharpe ratio for each value interval as determined by the RepRisk index. In the end, the paper examined the impact of the investor's ESG preferences on the selection of underlying assets for the portfolio compared with the reference portfolios and compared the resulting riskiness and profitability of the portfolios concerning the investor's ESG preferences with the reference portfolios. The paper showed that ESG risks are already included in the riskiness of assets. The increasing demands of the investor for a portfolio with lower exposure to ESG risks do not negatively impact the portfolio's performance.

Keywords: ESG risk, RepRisk, Socially responsible investing, Portfolio choice, ESG-Markowitz model

1 Introduction

Environmental, social, and governance (ESG) investment can be characterized as an investment that incorporates considerations of environmental, social, and governance factors. This approach represents a more refined method of portfolio management, where investors prioritize assets with strong ESG performance or favorable ESG scores. ESG factors are becoming a core component of routine portfolio management as wrote Hill (2020), (Melas *et al*. 2017), etc. Numerous financial institutions, including pension funds, investment funds, and insurance companies, etc. have adopted the United Nation Principles for Responsible Investment. Many of these organizations either establish dedicated ESG mandates or apply ESG criteria across their entire portfolio. In response, asset managers have adapted to this increasing demand by integrating ESG considerations into their strategies. This integration ranges from exclusionary screening to fully embedding ESG factors into security selection and portfolio construction processes.

ESG investing is gaining attention from investors for its potential to support sustainability and investment stability. That is why we decided to investigate this issue. We decided to use the well-known Markowitz model and show that it can also be used to incorporate ESG factors into the creation of an optimal portfolio.

Institutions can potentially mitigate ESG risks and should feel proactive and in control. The EBA (2020) defines ESG risks as any negative impact on a financial institution resulting from the current or future

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impacts of ESG factors on its counterparties. ESG risks are defined as the negative materialisation of ESG factors from a prudential point of view. These factors can thus affect the financial performance of institutions by manifesting themselves in financial or non-financial prudential risks, such as credit, market, operational, liquidity and financial risks. The materialisation of ESG factors depends on the short, medium and long term. The degree of impact of various ESG factors on financial institutions depends on the business activities of the financial institutions and the type of assets and liabilities held by these institutions. Financial institutions can feel proactive and in control of their risk management strategies by understanding and actively managing these factors.

Environmental risks are risks caused by the exposure of financial institutions to counterparties that can potentially be negatively affected by environmental factors, including factors resulting from climate change, factors resulting from other environmental degradation, such as air pollution by emissions, water pollution, drinking water shortages, land pollution and soil, biodiversity reduction and deforestation and other factors resulting from the transition to a circular economy. Transitional risks arise from the need for companies to adapt to climate and legislative changes. These are critical ESG factors and should be carefully considered in investment decision-making.

Social risks are risks arising from financial institutions' exposure to counterparties, which refer to the entities or individuals with whom the financial institution has a contractual relationship, that can potentially be negatively affected by social factors. Such social factors include, for example, inequality, health, inclusion, labour relations or investments in human capital and communities. The social risks of counterparties can also materialise through physical risks in the form of financial penalties, strikes, or lack of free and willing labour or through transitory risks resulting from the counterparty's growing costs for improving employee equality, inclusion, improving working conditions, improving the impact on society or costs associated with improving the counterparty's behaviour towards customers.

Management risks represent institutions' exposure to counterparties that management factors can negatively affect. There are many ways in which governance risks can materialise. Among these methods, we recommend a lack of code of conduct and lack of activity in combating money laundering and corruption, which can be sanctioned and penalised, thereby reducing the company's profit potential and increasing costs. Another of the ways is the loss of trust among investors, business partners and customers after the discovery of unfair practices in the management of the company. On the other hand, governance plays a fundamental role in ensuring that the counterparty's environmental and social risks are considered. Acknowledging the potential impact of climate and environmental change and related physical and transitory risks is a sign of good corporate governance. Conversely, neglecting the impact of ESG risks on the institution is also considered improper company management, which can create additional risks.

Hong and Kacperczyk (2009) discovered that social norms can significantly affect market investing. Environmental aspects are primarily concerned with climate change mitigation and adaptation to this change and environmental change in general. They consider the effects of environmental changes on entities and the impact of entities on the environment. If these influences are favourable, they represent opportunities; if they are unfavourable, we speak about risks. Social aspects can relate to inequality, inclusiveness, labour relations, investing in human capital and communities, or the entity's overall impact on society. Controlling factors, on the other hand, are responsible for integrating the consideration of social and environmental factors into the decision-making process.

Chen et al. (2021) introduced a framework to include ESG performance in portfolio optimisation. They used data envelopment analysis (DEA) to incorporate environmental, social, and governance factors. Their results show that traditional investment strategies should attain consistency in investments and social values. Another point of view introduced by Cerqueti et al. (2021) is to exploit the effect of portfolio diversification to reduce systemic risk.

Investors solve the problem of which assets to invest in because choosing suitable assets affects their future profits/losses for a certain level of risk (Fabozzi et al. 2002). Nowadays, the transition to more sustainable investor behaviour consists mainly of redirecting finances sustainably. For the sustainable

development of investment, it is appropriate to finance those activities of entities that consider financing also from the point of view of ensuring the consequences and impacts on the planet or future generations. This article highlights the possibilities of including ESG criteria in creating investment portfolios. We were motivated by Pedersen *et al*. (2021) and Prol *et al*. (2022) that it is possible to use Markowitz approach in the context creation portfolio and take into account ESG factors.

ESG criteria relate to environmental, social and governance standards. ESG factors are primarily intended to help private and institutional investors understand the relationship of entities to the opportunities and risks arising from these aspects. Organisations and investment products with an excellent ESG rating are gaining more and more prestige and a competitive advantage not only among investors. In addition, many ESG standards are subject to current and upcoming binding legislation. In our geographical area, these are binding regulations of the European Union. The application of ESG criteria has a significantly positive overall societal undertone with the aim of contributing to the sustainability of life on our planet. ESG investing is known as responsible investing or, in more proactive cases, impact investing. Investors are a crucial element in the transition to a sustainable economy, and the potential benefits of ESG criteria in investment decision-making should inspire optimism and hope for a more sustainable future.

Our paper aims to show investors the impact of ESG criteria on the profitability and riskiness of portfolios and to emphasise the importance of including ESG criteria and risks in investors' investment decision-making process.

2 Methodology

We consider institutions as critical players in the financial markets in financing the transition to a sustainable economy. Breitenlechner et al. (2022) pointed out the critical role of financial institutions as a propagation channel for uncertainty shocks. Due to their role and the nature of their activities, the impact of financial institutions on sustainability is much more important than that of other companies. Banks and other financial market participants are creators of financial products. They are mediators of monetary exchange, and at the same time, they are a source of funds for financing economic activities. It is expected that the pressure from investors will cause institutions to focus on supporting sustainable economic activities in terms of ESG criteria. The ESG information published by companies themselves cannot be considered sufficiently reliable, as their informative value is questionable. For this reason, we decided to use the RepRisk Index (RRI) (RepRisk, 2023).

RepRisk uses an "outside-in" approach. RepRisk analyses available information from public sources and stakeholders, deliberately excluding information reported by the companies through artificial intelligence algorithms. Institutions' exposure to counterparties is considered in the RepRisk index only in cases where the connection between the institution, the company and the event is demonstrable based on publicly available sources. The RepRisk Index (RRI) helps to capture the ESG risks of investment in companies and track the development of ESG risk over time. RRI takes values from zero to one hundred. The higher the value, the higher the company's risk exposure. RRI should be classified into the following classes: values from 0 to 25 mean low exposure to risks, values from 26 to 49 about medium risk exposure, and values from 50 to 59 about high exposure to risks. If the values of RRI belong to the interval from 60 to 74, then these values indicate a very high exposure to risks. Finally, values from 75 to 100 mean the companies' extremely high-risk exposure. RRI decreases over time. For the first 14 days after a significant risk event, the RRI remains constant. If no new events are detected, the RRI drops to zero within a maximum of 2 years. If the RRI is in the range of 25 – 100 and no severe events are detected, the RRI decreases by 25 points in two months until it reaches the value of 25. If the RRI falls below the threshold of 25 points and no severe events are detected, it decreases by 25 points over 18 months until it reaches 0. The RepRisk index also captures institutions' exposure to counterparties associated with events and thus transfers the adverse effects of counterparties to the banks that finance these counterparties. Institution's exposure to counterparties is considered in the RepRisk index only in cases where the connection between the bank, the company and the event is demonstrable based on publicly available sources.

In this paper, we will solve the investor's problem of choosing a portfolio of institution based on their evaluation by the RepRisk index and the investor's choices of weights in the portfolio in the sense of the Markowitz selection of the portfolios.
To create a portfolio, we considered a rational investor with a given risk aversion and preferred expected return. Let the investor want to invest the amount of 100,000 EUR and his investment decision is influenced by his risk aversion γ equals five. It follows that the invested amount at risk is 20,000 EUR. From the available underlying assets of the banks, we created a set of portfolios, the riskiness and expected return of which we calculated using the Markowitz M − V analysis. By solving the optimisation task of modern portfolio theory, we calculated the optimal portfolio that best corresponds to the investor's preferences. We calculated the reference portfolio with the maximum Sharpe ratio by solving another optimisation task.
Moreover, our investor decides to invest in the sense of the ESG criterion. The subsequent scenarios should describe investors' preferences according to RRI: investor prefers lower exposition to ESG, which means the maximal value of RRI for the portfolio is 25; investor prefers middle exposition to ESG: the maximal value of RRI for a portfolio is 49; investor accepts high ESG exposure: the maximum RRI value for the portfolio is 59; the investor accepts a very high exposure to ESG: the maximum RRI value for the portfolio is 74; the investor without ESG preferences or taking into account extremely high exposure to ESG risks, the maximum RRI value for the portfolio is 100. Based on the investor's different ESG preferences, we selected a portfolio that corresponded to them.
The Markowitz portfolio selection concerning ESG was solved by Pedersen *et al*. (2021).
Investor *M* takes a wealth of *W* and chooses a portfolio of risky assets with returns $r = (r_1, \dots, r_n)$ and $x = (x_1, \dots, x_n)^T$, where x_i is the fraction of capital invested in security *i*.
The investor's utility depends on her future wealth and the ESG characteristics of the portfolio. Given her portfolio choice, the investor's future wealth is

$$\widehat{W} = W(1 + x^T r)$$

The utility function of the ESG investor introduced by Pedersen *et al*. (2021) is

$$U = E(\widehat{W}\,|s) - \frac{\gamma}{2} Var(\widehat{W}\,|s) + Wf(\bar{s})$$

where γ is the absolute risk aversion of the investor.
$E(\widehat{W}\,|s)$ is expected wealth conditioned by the ESG information *s*.
$Var(\widehat{W}\,|s)$ is a variance of the wealth conditioned by the ESG information *s*.
$f: R \to R \cup \{-\infty\}$ is the ESG preference function. We assume that the ESG preference function depends on the average ESG score among the risky asset positions.
$\bar{s} = \frac{x^T.s}{x^T.1}$ is the weighted sum of ESG scores, scaled by the total position in risky assets. $\bar{s}$ is mean ESG score.
Our investors choose the best portfolio based on the level of risk given by standard deviation and a mean ESG score.
The second problem to be solved here is choosing the portfolio with the highest Sharpe Ratio for the given ESG score. We will solve the next optimisation problem.

$$max_{\bar{s}}(\, max_{\sigma}(SR(\bar{s})\sigma - \frac{\gamma}{2} Var(\widehat{W}\,|s) + Wf(\bar{s}),$$

where the optimal level of risk is given by $\sigma = SR(\bar{s})/\gamma$.
The maximum Sharpe ratio for given ESG score of $\bar{s}$ is obtained by optimization task

$$SR(\bar{s}) = \max \frac{x^T \mu}{\sqrt{x^T \Sigma x}}$$

with constrains: $x^T.1 = 1$ and $x^T.s = \bar{s}$.

3 Results

The paper analysed historical daily closing prices of selected European institutions from Orbis Europe's database within three years (March 2, 2020 - April 1, 2023). We have chosen an investment universe

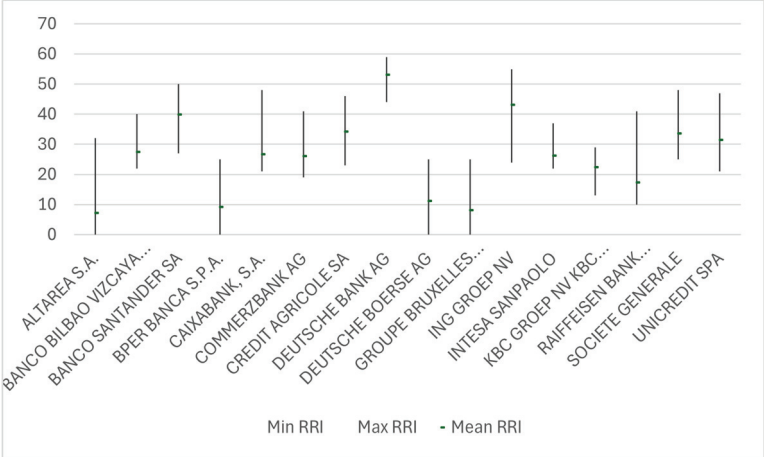
consisting of sixteen institutions. The inclusion condition was that they had all the necessary data available, i.e. daily closing prices and monthly RRI data. We converted monthly RRI data to daily frequency by assuming that the RRI value did not change throughout the month. Our sample consists of the following European institutions: Deutsche Boerse AG., Groupe Bruxelles, Lambert SA., ING Groep NV., Intesa Sanpaolo, KBC Groep NV/ KBC Groupe SA., Raiffeisen Bank International AG., Societe Generale, Unicredit SPA., Altarea SA., Banco Bilbao Vizcaya Argentaria SA., Banco Santander SA., Bper Banca S.P.A., Caixabank S.A., Commerzbank AG., Credit Agricole SA. a Deutsche Bank AG. We have used Wolfram Mathematica software 14.0 to obtain all our results.
The closing prices P_t was used to calculate logarithmic returns R_t by the formula

$$R_t = ln\frac{P_t}{P_{t-1}}.$$

Mean returns and volatility are annualised using 252 days convention.

The values of RRI are reported monthly. RRI data were collected from Orbis Europe's database. Figure *1* shows minimum, maximum and mean values of RRI during the analysed period for each financial institutions's. Mean RRI values showed that Altarea SA. achieves the lowest average exposure to ESG risks while Deutsche Bank AG achieves the highest ESG exposure.

Figure 1: The RR index's minimum, maximum, and mean values for selected institutions.



Source: own processing based on collected data

We take into account two approaches on how to create optimal portfolios. The first one represents an investor who preferes optimal portfolio created in the sense of Markowitz Mean – Variance (MV) analysis. The second one represents an investor preferring optimal portfolio created in the sense maximized Sharpe ratio. The Sharpe ratio is an indicator that compares the portfolio's expected return with its associated risk. A higher Sharpe ratio value means better reward of the investor for risk. We will enrich both approaches with the consideration that the investor will take into account the ESG behavior of the company expressed by the RepRisk Index (RRI).

The highest RRI value is 59 achieved by Deutsche bank AG. For this reason, we decide to monitor only the first three RRI intervals, i.e. low exposure, medium exposure and high exposure to ESG risks. We have prepared portfolios with ESG preferences that range from 0 – 25, 25 – 49, and 50 – 59. In this way, we examine two types of investors according to their ESG preferences.

We start with a Mean – Variance (MV) portfolio. We have found that investors should invest 65.96% of the amount of EUR 100,000 in the shares of Deutsche Boerse AG., 8.76% in the shares of Unicredit SPA., 14.78% in the shares of Caixabank S.A. and 10.50% to Commerzbank AG., if he wants to minimise the mean-variance utility function of the portfolio. The expected anualized return (EAR) of this portfolio is 10.20% of invested amounts, with a volatility equal to 24.89%. The resulting Sharpe ratio equals to 0.4098 (see Table 1). The portfolio consists of four assets only which is quite concentrated

albeit expected due to no constraints on maximum portfolio weights in the optimisation. This under-diversification of assets might have a potential impact on the riskiness of the portfolio, but this is out of scope of this paper.

Table 1: Optimal MV portfolio without ESG preferences

Banks	Weight	EAR	Volatility	Sharpe Ratio
DEUTSCHE BOERSE AG.	65.96%			
UNICREDIT SPA.	8.76%	10.20%	24.89%	0.4098
CAIXABANK, S.A.	14.78%			
COMMERZBANK AG.	10.50%			

Source: own processing based on collected data

The optimal portfolio represents our reference portfolio with minimum risk and maximal expected return, with which we compare portfolios compiled according to the investor's ESG preferences.
Now, we consider the following three scenarios: an investor wants to invest only in a portfolio of shares with low exposure to ESG risks or prefers investments in shares with medium exposure to ESG risks. Finally, we consider an investor who requires a portfolio of shares to have a high exposure to ESG risks. If we adjust the investor's preferences in such a way that the investor only considers investing in a portfolio with low exposure to ESG risks, or the investor focuses on portfolios characterised by medium exposure, or the investor searches only for portfolios with high exposure to ESG risks, we get the following results (see Table 2).

Table 2: Optimal MV portfolio with ESG preferences

RRI	Banks	Weight	EAR	Volatitily	SR	ERRI
0-25	DEUTSCHE BOERSE AG.	65.96%	10.20%	24.89%	0.4098	16.90
	UNICREDIT SPA.	8.76%				
	CAIXABANK, S.A.	14.78%				
	COMMERZBANK AG.	10.50%				
26-49	DEUTSCHE BOERSE AG.	49.05%	9.45%	26.86%	0.3520	26.
	ING GROEP NV	4.13%				
	UNICREDIT SPA.	12.51%				
	CAIXABANK, S.A.	13.13%				
	DEUTSCHE BANK AG.	21.17%				
50-59	DEUTSCHE BOERSE AG.	2.04%	9.11%	42.35%	0.2151	50.
	ING GROEP NV	21.86%				
	DEUTSCHE BANK AG.	76.09%				

Source: own processing based on collected data

Considering a low exposure to ESG risks, we get an optimal portfolio identical to the reference portfolio (see Table 1). In the case of medium exposure to ESG risks, the investor creates a portfolio of shares of all institutions and thus achieves a slighly lower expected anualized return of 9.45%, which is accompanied by a higher risk of the portfolio. Suppose the investor focuses only on portfolios with high exposure to ESG risks. In that case, the expected anualized return of his optimal portfolio will reach 9.11% of the invested amount. Still, at the same time, his portfolio will have the highest risk compared to the other two possibilities. Sharpe ratio reaches the maximum value in the case of choosing a portfolio with the lowest exposure. Table 2 reports how weigths of the shares the investor choose under different scenarios. It is evident that an investor will achieve a lower expected annual return by focusing on portfolios with higher ESG exposure. At the same time, he will create a riskier portfolio. When we focus

on Sharpe ratio values, the most efficient portfolio is again the one that takes into account institutions with lower RRI values. We can conclude that an investor will achieve the best results if he prefers institutions with low exposure to ESG risks. Interestingly, for a given universe of sixteen institutions, we obtained the same portfolio composition in the 0-25 RRI interval and the optimal MV portfolio without ESG preferences (see Table 1 and Table 2). This is due to the fact that expected RRI (ERRI) of the optimal MV portfolio with the strictest ESG preferences (RRI 0-25) is 16.90. From the result, we can deduce that the ESG constraint is a non-binding constraint and thus the two portfolios convolute. Again, as in the optimal MV portfolio, the concentration is high and can be a matter of further research.

We now consider an investor willing to invest in institutions with RRIs of 0-25, 0-49 and 0-59 and compare the results with the reference optimal MV portfolio presented in Table 1. In this way, we examine three types of investors according to their ESG preferences. The first investor prefers to invest in institutions with low exposure to ESG risks. The second investor is willing to invest in institutions with low or medium exposure to ESG risks and the third investor considers, along with the first two options, the option of investing in institutions with high exposure to ESG risks. The results showed that the selection of underlying institutions for the portfolio is the same in each interval and at the same time remains unchanged compared to the reference portfolio. It follows from the above that the portfolio with minimal risk and maximal expected return is already in the interval 0-25 and the investor's preferences for lower exposure to ESG risks do not negatively affect the minimal riskiness of the portfolio.
Now, we create a reference portfolio that considers the investor's risk aversion and maximises the Sharpe ratio for subsequent comparison. An investor without ESG preferences maximises Sharpe ratios if he invests 36.32% in shares of Deutsche Boerse AG., 17.70% in Unicredit SPA. and 45.98% in Commerzbank AG. The resulting portfolio achieves an expected annualized return (EAR) of 15.94%, and its risk expressed by volatility is equal to 33.74%. The resulting maximised Sharpe ratio is 0.4725 (see Table 3).

Table 3: Portfolio with maximum Sharpe ratio without ESG preferences

Banks	Weight	EAR	Volatility	SR
DEUTSCHE BOERSE AG.	36.32%	15.94%	33.74%	0.4725
UNICREDIT SPA.	17.70%			
COMMERZBANK AG.	45.98%			

Source: own processing based on collected data

Table 4: Portfolios with maximum Sharpe ratio and ESG preferences

RRI	Banks	Weight	EAR	Volatility	SR	ERRI
0 - 25	DEUTSCHE BOERSE AG.	36.32%	15.94%	33.74%	0.4725	21.65
	UNICREDIT SPA.	17.70%				
	COMMERZBANK AG.	45.98%				
26 - 49	DEUTSCHE BOERSE AG.	11.96%	19.18%	41.47%	0.4625	26
	UNICREDIT SPA.	32.36%				
	COMMERZBANK AG.	55.68%				
50 - 59	ING GROEP NV.	0.001%	9.87%	43.44%	0.2271	50
	UNICREDIT SPA.	14.01%				
	COMMERZBANK AG.	0.004%				
	DEUTSCHE BANK AG.	85.98%				

Source: own processing based on collected data

Let us again create portfolios that maximize the Sharpe ratio and at the same time the investor prefers low, medium or high exposure to ESG risks. The resulting portfolios are shown in Table 4. The portfolio that maximizes the Sharpe ratio (SR) according to the preferences of the investor with medium exposure achieves an expected return of 19.18%. This portfolio achieves higher expected returns than the investor would achieve for the portfolio with low exposure to ESG risks selected by the investor, but at the same time achieves a higher risk explained by volatility equal to 41.47% of the portfolio value. This result leads to a lower value of SR than in the case of the portfolio with low exposure to ESG risks selected by this investor. The portfolio that maximizes the SR according to the preferences of the investor preferring high exposure to risk achieves the lowest expected annual return of 9.87% compared to the other two portfolios. At the same time, its riskiness is the highest. The Sharpe ratio (SR) reached a value of 0.2271.

To what extent can the investor's ESG preferences influence the resulting SR of the chosen portfolio? We can find out by adding the ESG preferences. We divide the data again into intervals 0-25 (low exposure), 0-49 (low or medium exposure) and 0-59 (low or medium or higher exposure) and calculate the maximum SR for each case. Again, the results show that regardless of ESG preferences, the investor chooses the same portfolio composition as in the case without ESG preferences. The resulting values of expected returns, riskiness and overall performance measured through Sharpe Ratio remain unchanged regardless of the selected exposure. From our point of view, this means that the investor can create a portfolio from the set of institutions we selected, which achieves the maximum SR and, at the same time, meets the condition of low exposure to ESG risks.

Based on the results of our observation, we can conclude that the enrichment of investment decision-making with the criterion of considering ESG risks influences how the investor makes decisions in general. An investor who decides to monitor ESG risks as one of the factors that can potentially affect his investment must adopt the model according to which he makes decisions regarding these risks, even if his final decision remains unchanged.

In the case of the data set we selected, it turned out that the ESG risk criterion was sufficiently taken into account in the riskiness and profitability of the shares. The portfolio with minimal risk and the highest Sharpe ratio in both cases met the condition of the strictest ESG preferences. Thus, the investor was not forced to compromise between the optimal situation and his ESG preferences. The research showed that if an investor decided to invest in a portfolio with higher than low exposure to ESG risks, this decision would lead to a higher minimum riskiness or a lower Sharpe ratio. Under these circumstances, investing in a portfolio with low exposure to ESG risks is most advantageous for an investor.

As far as rational investors are concerned, we believe that they should incorporate the assessment of ESG investment risks into their investment decisions, as this type of investor should be guided by the rule of using and considering all available information. The impact of ESG risks and investor preferences on the final performance of the portfolio depends on the set of underlying assets from which the investor can choose.

4 Conclusion

Investors are undoubtedly one of the crucial components of the transition to a sustainable economy, as they represent a source of capital for financing economic activities. Their need for capital in financing sustainable activities is growing every year. Concerning the goal of this article, we investigated how the consideration of ESG risks will affect the investment decision-making process and the creation of a portfolio and what impact the consideration of sustainability factors has on the overall profitability and riskiness of the investment.

Our analysis showed that the investor's preference for low exposure of the portfolio to ESG risks does not harm risk in the case of an optimal portfolio. Likewise, it does not harm the portfolio performance expressed by the maximum Sharpe ratio. This result may not generally apply to any set of underlying assets and is wholly dependent on the selected set of underlying assets. This result might be biased due to how the investment universe was chosen. What is generally applicable, however, is the proof that the

limitation of ESG preferences does not automatically mean increased riskiness or reduced profitability of the portfolio. We consider this result to be positive and highly motivating for investors who care about the long-term side effects of their investments. Our results are consistent with the findings in the article (Pedersen *et al*., 2021).
Possible extension of this research is creating less concentrated portfolios by adding constraints to the optimisation to benefit from greater diversification of the portfolio or creating the portfolio dynamically in time with weights rebalansing.

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References
Breitenlechner, M., Geiger, M. and Scharler, J. 2022. Bank liquidity and uncertainty propagation in the US, Finance Research Letters, Volume 46, Part B, 2022, 102467, https://doi.org/10.1016/j.frl.2021.102467.
Bureau van Dijk. 2023: A Moodys Analytics Company. Orbis Europe. 2023. Available at: https://orbiseurope-r1.bvdinfo.com/version-20230324-2-3/Orbis4Europe/1/Companies/Search.
Chen, L., Zhang, L., Huang, J., Xiao, H., and Zhou, Z. 2021. Social responsibility portfolio optimisation incorporating ESG criteria. In Journal of Management Science and Engineering 6. 75–85.
Cerqueti, R., Ciciretti, R., Dalò, A., and Nicolosi, M. 2021. ESG investing: A chance to reduce systemic risk. In Journal of Financial Stability (54). 100887: 1–13.
EBA. 2020. Discussion paper on management and supervision of ESG risks for credit institutions and investment firms. (EBA/DP/2020/03). Available at https://www.eba.europa.eu/calendar/discussion-paper-management-and-supervision-esg-risks-credit-institutions-and-investment
Fabozzi, J. F., Gupta, F., and Markowitz, M. H. 2002. The Legacy of Modern Portfolio Theory. In The Journal of Investing. Fall 2002: 7–22.
Hill, J. 2020. Chapter 2 - ESG, SRI, and impact investing. Editor(s): Hill, J. Environmental, Social, and Governance (ESG) Investing, Academic Press, pp. 13-27, https://doi.org/10.1016/B978-0-12-818692-3.00002-5
Hong, H. , Kacperczyk, M., 2009. The price of sin: the effects of social norms on markets. J. Financ. Econ. 93 (1), 15–36.
Melas, D., Nagy, Z., Kulkarni, P. 2017. 15 - Factor Investing and ESG Integration. Editor(s): Jurczenko, E. Factor Investing, Elsevier, pp. 389-413, https://doi.org/10.1016/B978-1-78548-201-4.50015-5
Pedersen, H. L., Fitzgibbons, S., and Pomorski, L. 2021. Responsible investing: The ESG-efficient frontier. In Journal of Financial Economics (142): 572–597.
Prol, J. L., Kim, K., 2022. Risk-return performance of optimized ESG equity portfolios in the NYSE. Finance Research Letters, Vol. 50, December 2022, https://doi.org/10.1016/j.frl.2022.103312.
RepRisk. 2023. RepRisk Methodology Overview. [online]. 2023. [cited 2023-04-14]. Available at: https://www.reprisk.com/news-research/resources/methodology