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Perspective

Sustainable information into portfolio optimization models

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ABSTRACT: In the last fifteen years, extreme events such as the global financial and economic crisis of 2007–2008 and the Covid-19 pandemic have highlighted the importance of corporate social responsibility and sustainability in different aspects of our society. The environmental, social, and governance (ESG) disclosures have also gained increasing significance for investors due to initiatives undertaken by international bodies. In particular, with the Action Plan in 2018, the European Commission has assigned specific responsibilities to financial intermediaries to drive flows toward sustainable investments, explicitly requiring portfolio managers to integrate these non-financial factors into their decision-making processes. More and more, asset management firms and insurance companies offer tailored products to meet their customers' sustainable needs and desires. This trend implies a growing recognition of sustainable practices in the financial sector, emphasized by the need to integrate ESG considerations in investment strategies.

KEYWORDS: computational finance; sustainable portfolios; ESG ratings; investor's preferences; single- and multi-objective optimization

The traditional mean-risk framework, which represents the modern portfolio theory's milestone, was first formulated by Markowitz[1] in the 1950s. In this frame, the investors are rational and risk-averse, meaning they seek to maximize their returns while minimizing risk simultaneously. However, this model, which focuses solely on financial features, is blind to the increasing sensitivity of political institutions, portfolio managers, and new generations of investors toward the planet's sustainable development. Thus, a new paradigm involving the impact of investment choices on the environment and society is needed.

Several methodologies have been proposed in the literature to incorporate ESG scores into the portfolio optimization process. In particular, this sustainable information has three main uses: the ESG criteria are employed as a discriminant in the preselection strategies; the ESG ratings are viewed as a constraint of the optimization process; the ESG information is handled as an objective function in the optimization problem.

The first approach for responsible investments involves a preselection strategy based on the ESG information to exclude assets that are not sustainable and ethical enough. For example, Liagkouras *et al.*[2] have adopted a screening procedure to identify a subset of ESG-compliant stocks as constituents of a Mean-Variance (M-V) portfolio. Kaucic *et al.*[3] have studied several ESG-based preselection techniques in a prospect theory-based portfolio model.

In a second approach, the ESG scores are employed to define a constraint establishing the minimum acceptable sustainable grade of portfolios. Following this approach, De Spiegeleer *et al.*[4] have extended the M-V model. Afterward, Morelli[5], exploiting only the environmental scores, has incorporated a constraint on the selected parameter in the Mean-CVaR model.

Alternatively, instead of setting a minimum threshold for the portfolio ESG score, a third approach directly includes the sustainable information into the objective function of the optimization problem. Schmidt[6] has modified the single-objective function of the M-V model so that portfolio weights are simultaneously optimized in terms of return, risk, and ESG value. This formulation includes two parameters: the risk-aversion parameter, which controls the risk-return trade-off, and the so-called ESG-strength parameter, which reflects the investors' sustainable preferences. In the multi-objective optimization context, Garcia-Bernabeu *et al.*[7] have extended the classical bi-criteria M-V framework by directly including sustainability as a third criterion. They formalized the preference relation of an ESG-aware M-V investor and introduced a multi-objective evolutionary algorithm to solve the optimal allocation problem. In a similar way, Hilario-Caballero *et al.*[8] have employed a multi-objective approach to include the investor's preferences toward the portfolio's carbon risk exposure into the bi-criteria M-V optimization problem. Pedersen *et al.*[9] have constructed the ESG-efficient frontier, showing the highest attainable Sharpe ratio for each ESG level, and they have investigated the costs and benefits of responsible investing. Xidonas and Essner[10] have proposed a multi-objective minimax-based optimization model to build up optimal ESG portfolios that maximize the risk performance across the environmental, social and governance components of the ESG criteria. Cesarone *et al.*[11] have implemented the standard ε-constrained method to solve the tri-objective M-V-ESG optimization problem. Finally, Lindquist *et al.*[12] have combined ESG scores with financial returns to generate an ESG-valued return and applied this measure in a general mean-risk optimization framework.

To sum up, the last twenty years have strengthened the importance of ESG in finance, not only from the stakeholder point of view but also from the shareholder perspective. As a consequence, some questions arise naturally:

- What is the impact of ESG investing on risk premia?
- What is the impact of ESG screening on portfolio returns?

Conflict of interest

The author declares no conflict of interest.

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