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Tracking-Based Green Portfolio Optimization: Bridging Sustainability and Market Performance

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Executive summary

The accelerating shift toward sustainable finance requires investment strategies that combine financial performance with measurable environmental progress. Traditional green portfolios often achieve sustainability gains at the cost of benchmark deviation or reduced diversification (Friede et al. 2015). To address this, new quantitative approaches are needed to align financial market behaviour with the European Union's green transition and climate neutrality goals.

This policy brief draws on the study "*Tracking-Based Green Portfolio Optimisation*" by D. Barro, M. Corazza and G. Filograsso, to translate its analytical results into actionable insights for policymakers, financial institutions, and sustainability regulators. The research demonstrates how portfolio optimisation techniques can incorporate ESG and carbon data directly into investment decision processes, offering a scientifically grounded pathway to green financial products.

Context

Achieving the European Union's objectives of climate neutrality and sustainable finance requires a profound reorientation of private capital flows toward environmentally responsible and socially sustainable activities. Financial intermediaries and asset managers are pivotal in this transition but

face the dual challenge of maintaining competitive performance benchmarks while gradually reducing exposure to carbon-intensive and transition-risk assets.

Traditional “green” or “ethical” funds—often built on rigid exclusions or qualitative ESG screens—have shown mixed results, frequently underperforming diversified benchmarks or only partially aligning with environmental targets (see, for example, Bauer et al. 2021, Bolton et al. 2021). This experience has generated a growing demand from both institutional and retail investors for *data-driven* investment solutions capable of achieving measurable sustainability outcomes without sacrificing financial efficiency (Eurosif 2023). Such approaches are essential to strengthen investor confidence, enhance market transparency, and reduce the risk of greenwashing as ESG investing becomes mainstream. Investor preferences have also become more diverse.

Many investors now favour progressive green-transitions portfolios that gradually reduce carbon intensity while preserving risk–return profiles close to the benchmark; others prioritise long-term climate alignment or impact strategies, accepting temporary performance deviations in exchange for more profound environmental impact (see, for example, Assaf et al. 2024, Rojo-Suárez et al. 2024). This heterogeneity underscores the need for *flexible portfolio frameworks* that integrate sustainability preferences as adjustable parameters, allowing a transparent and adaptive evolution of investment practices across market participants.

Quantitative optimisation models offer a rigorous, evidence-based pathway to reconcile financial and sustainability objectives. By embedding environmental and ESG indicators directly within the portfolio construction process, such models enable explicit control over sustainability exposure and facilitate verification of results (Pedersen et al. 2021, Pastor et al. 2021). This marks a shift from traditional screening methods toward a new generation of adaptive, preference-sensitive investment tools that balance market performance with environmental accountability. The tracking-based green portfolio optimisation framework developed in this study illustrates how climate and ESG considerations can be internalised within portfolio construction without undermining market efficiency. It shows that environmental goals can be achieved through gradual, quantifiable adjustments to index-tracking portfolios—preserving liquidity, diversification, and transparency. The approach provides policymakers and practitioners with a replicable, data-informed method for advancing Europe’s sustainable investment ecosystem.

Methodology

The proposed framework integrates sustainability objectives into an index-tracking optimisation model that explicitly accounts for heterogeneous investor preferences. Starting from two reference indices—a traditional market benchmark and a sustainability-enhanced or green benchmark—the model constructs portfolios that balance financial replication with improved environmental and ESG performance. This dual-index design allows investors to position their portfolios anywhere along a continuum ranging from purely financial tracking to strong green alignment, according to their individual objectives and tolerance for tracking deviation. Formally, the portfolio problem is formulated as a multi-objective program that simultaneously:

- Minimises the tracking error with respect to the financial benchmark, ensuring consistency with market performance;
- Maximises proximity to the sustainability-enhanced index, improving alignment with ESG or carbon objectives.

The model allows to control for the overall portfolio risk through explicit constraints that guarantee implementability and cost efficiency. Beyond these core objectives, the model is able to account for additional *flexible constraints* that reflect investor or regulatory requirements—such as limits on sector exposure, minimum portfolio-level ESG scores, or caps on carbon intensity. These features enable a transparent integration of both financial and sustainability mandates within a single optimisation framework, making it suitable for diverse policy and market contexts.

The trade-off between financial tracking and sustainability enhancement is governed by a scalar parameter, λ , which reflects the investor's tolerance for deviation from the benchmark in exchange for improved environmental performance. Varying λ generates a continuum of portfolios—from pure financial trackers to strongly green-tilted allocations—allowing explicit representation of different investor preferences. Investors and policymakers can explore alternative portfolio configurations that illustrate the cost–benefit dynamics of transitioning toward greener investment strategies.

Data and implementation

The empirical application uses ESG and carbon-intensity data for major European equity markets. Green scores are derived from publicly available ESG ratings harmonised under EU Taxonomy categories and standardised across sectors to ensure comparability. The optimisation problem is solved using standard quadratic programming techniques.

Portfolio performance and sustainability outcomes are assessed using three complementary indicators:

- Tracking Error measures –capturing the deviation of portfolio returns from the financial benchmark, indicating the level of tracking precision;
- Carbon Footprint Reduction – quantifying the percentage decrease in portfolio carbon intensity (tCO₂e per unit of turnover) relative to the benchmark, capturing the decarbonization effect;
- Average Environmental Score Improvement – representing the increase in the portfolio's average Bloomberg Environmental (E) score compared with the benchmark, reflecting enhancement in environmental performance.

These indicators jointly describe the trade-offs between financial accuracy, environmental efficiency, and sustainability enhancement achieved through the optimisation model.

Policy Takeaways and Analysis

1. Quantitative tools enable realistic green transitions in investment. Tracking-based optimization demonstrates that sustainability objectives can be embedded directly in financial algorithms without compromising performance. This evidence supports the development of scientifically grounded green indices and benchmark-linked climate portfolios.
2. Transparent modelling enhances credibility of sustainable finance. The mathematical formulation and data requirements of the model are fully auditable. Such transparency aligns with EU regulatory goals for verifiable ESG disclosures, reducing the risk of greenwashing.
3. Gradual adjustment mechanisms help mitigate transition risk. By allowing a continuous preference parameter λ , investors can progressively increase portfolio greenness while managing

short-term financial volatility. This dynamic adjustment is crucial to ensure financial stability during the decarbonization process.

4. Integration with EU sustainable finance frameworks. The approach complements EU Taxonomy and SFDR by providing an operational link between disclosure data and portfolio allocation.

It could inform the design of taxonomy-aligned benchmarks or climate transition indices.

5. Implications for public and private actors. Public institutions can use the model to evaluate the environmental impact of sovereign and pension fund portfolios. At the same time, private investors can adopt it as a decision-support tool for ESG integration. This dual applicability underlines its potential for monitoring sustainability in financial systems.

Recommendations

Policymakers, financial institutions, and data providers should work jointly to strengthen the methodological, informational, and institutional foundations of sustainable finance.

The following priorities emerge from the study's findings:

- **Promote quantitative and transparent integration of sustainability criteria.**

Establish shared standards for incorporating environmental and ESG indicators into portfolio optimization models, ensuring comparability, transparency, and alignment with EU sustainable finance regulations.

- **Develop consistent and measurable green benchmarks.**

Support the creation of taxonomy-aligned reference indices and dual-benchmark approaches that combine financial tracking with sustainability objectives, enabling measurable and verifiable progress toward climate goals.

- **Improve access to harmonized ESG and carbon data.**

Expand open data infrastructures and public–private partnerships to provide reliable, standardized sustainability information across markets and sectors, reducing information asymmetries.

- **Align investment practices with investor preferences and risk management.**

Integrate preference-based parameters into portfolio design and advisory tools to make

trade-offs between sustainability and financial performance explicit, while employing stress testing to ensure resilience under different transition scenarios.

Conclusions

The *tracking-based green portfolio optimisation* framework demonstrates that sustainability objectives can be integrated into portfolio construction without compromising financial performance. By combining dual benchmarks, investor preferences, and flexible environmental constraints, it provides a transparent and adaptable method for aligning investment choices with climate and sustainable finance goals.

The study indicates that quantitative methods can support the practical application of the EU Taxonomy and the Sustainable Finance Disclosure Regulation (SFDR) within portfolio management. Its transparent, linear design and reliance on publicly available ESG and carbon data facilitate clearer assessment of sustainability outcomes and contribute to greater coherence and reliability in sustainable finance practices.

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