



Mechanisms to incentivise fossil fuel divestment and implications for investors risk and return

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Software Paper available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4357488

Software available on <https://github.com/QuantFILab/Divfolio>

Sidles and Materials available on <https://github.com/QuantFILab/IME2023-Presentation>



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Fossil Fuel Divestment Strategies?

Fossil Fuel Divestment Strategies?



UN Website

- Global Environmental Challenge
- Divestment Campaigns
- Paris Agreement/COP26
- SDGs
 - Climate Action (13)
- Principal of Sustainable Finance
 - Environment

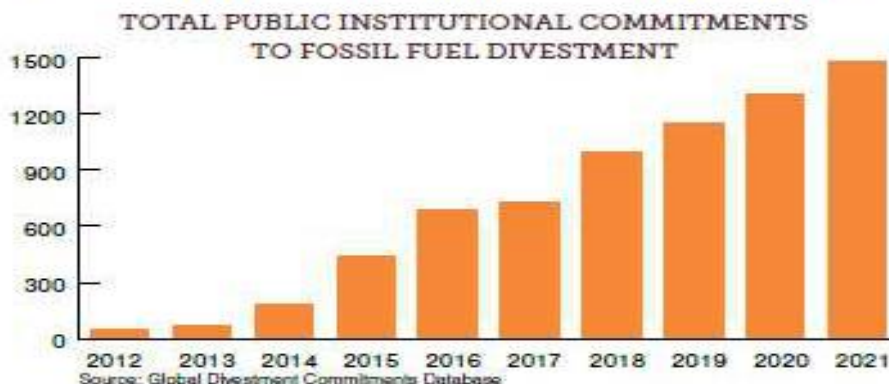


Toronto350.org

Pasin Marupanthorn, <https://github.com/QuantFILab/Divfolio>

Fossil Fuel Divestment Strategies?

GROWTH IN DIVESTMENT COMMITMENTS



- Investors total committed funds US\$40.43 trillion (AUM) –
- Public institutions >1500
 - Global Fossil Fuel Commitment Database (<https://divestmentdatabase.org/>)
- Not only institutions and assets under management continuously increasing but accelerating.
 - pension funds
 - Endowments
 - COP26/World Economic Forum

Open problems addressed by our case studies

- What are the effects of different rates of divestment?
- How should divested capital be optimally redeployed?
- How does divestment influence diversified versus concentrated portfolios?
- How do we quantify carbon footprint of divestment and non-divested portfolios?
- Does divestment adversely select particular demographic profiles for investors?
- Does divestment influence the robust covariance structure of portfolio

Marupanthorn, Pasin and Sklibosios Nikitopoulos, Christina and Ofosu-Hene, Eric and Peters, Gareth and Richards, Kylie-Anne, ***Mechanisms to Incentivise Fossil Fuel Divestment and Implications on Portfolio Risk and Returns*** (June 8, 2022). Available at SSRN: <https://ssrn.com/abstract=4131449> or <http://dx.doi.org/10.2139/ssrn.4131449>

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Software available on <https://github.com/QuantFILab/Divfolio>

DivFolio App v. Beta

Welcome

User Guide

Divestment Plan

Our Team

Divfolio: Green Finance Wealth Management Software

- Sustainablising portfolio by divestment
- Comparing performance of portfolios before and after divestment
- Comparing performance of portfolios in general purpose

Changes in the contemporary climate include both global warming and its effects on the planet's weather patterns. Climate change has occurred in the past, but the current rate of change is significantly more fast and is not attributable to natural causes. It is instead caused by the release of greenhouse gases, primarily carbon dioxide (CO₂) and methane. The majority of these emissions are caused by the burning of fossil fuels for energy production. At the current warming level of 1.2 C (2.2 F), several of these effects can already be noticed. Additional warming will amplify these effects and may set off tipping points, such as the Greenland ice sheet melting. Under the Paris Agreement of 2015, governments pledged to limit global warming 'well below 2 C'. Despite the commitments made under the Agreement, global warming would still reach roughly 2.7 degrees Celsius (4.9 degrees Fahrenheit) by the end of the century. To limit warming to 1.5 C, emissions must be cut in half by 2030 and reach net-zero levels by 2050.

Divestment and exclusion are approaches that limit investment in carbon-intensive assets or industries, based on an organization or its stakeholders guiding principles. Thus, individuals who seek to avoid carbon-intensive assets frequently favor this policy. These stakeholders say that divestment and exclusion increase the cost of capital for carbon-intensive operations, provide a market signal to enterprises engaged in these activities to encourage a more rapid transition, and ensure that investors are comfortable with the sources of their returns.

Divfolio offers a comparison of the risk profiles, ESG scores, and customized attributes of portfolios, such as carbon intensity, before and after divestment based on the simulation using historical data as well as advanced options such as assessing stability of portfolio via clustering and correlation structure. The tool is useful for investigating the impact of divestment on portfolio performance in multidimensional views.

DEADLINE TIME LEFT TO LIMIT GLOBAL WARMING TO 1 **LIFELINE** LOSS & DAMAGE OWED BY G7 NATIONS
6 YRS 193 DAYS 23:58:51 **\$12.40113897 TRILL**
LULA TAKES OVER WITH PLANS TO END DEFORESTATION IN BRAZIL | ~200 COUNTRIES APPROVE BIODI #ActInTime



Multi-period Approach to Divestment and Reinvestment

Multi-period Portfolio Optimization Approach to Divestment

h-period optimization

$$w^* = \underset{w_{t+1}, w_{t+2}, \dots, w_{t+h}}{\operatorname{argmax}}$$

$$\mathbb{E}[U(r_{t+1}w_{t+1}, r_{t+2}w_{t+2}, \dots, r_{t+h}w_{t+h} | \mathcal{F}_t)]$$

- r_t is the return at time t
- w_t is the investment weight at time t
- I is the set of investable assets
- J is the set of divestable assets
- N_I is the number of investable assets
- N_J is the number of divestable assets
- D_t is the limit of the divestable weight
- \mathcal{F} is the information filtrations at time t

$$\begin{aligned} \text{s.t.} \quad & \sum_{i=1}^{N_I} w_{i,t+k} + \sum_{j=1}^{N_J} w_{j,t+k} = 1 \quad \text{Full investment} \\ & \sum_{i=1}^{N_I} |w_{i,t+k}| + \sum_{j=1}^{N_J} |w_{j,t+k}| \leq 1.3 \quad \text{Leverage constraint} \\ & \sum_{j=1}^{N_J} w_{j,t+k} \leq D_{t+k} \quad \text{Divestment constraint} \end{aligned}$$

$$\text{where } k = t+1, t+2, \dots, t+h$$

Multi-period Portfolio Optimization Approach to Divestment

Challenges

- Complicated to solve analytically in the closed form
- Computationally expensive to compute in large portfolio over many time steps
- Path-dependent optimization in both backward and forward solving
- Leverage and divestment constraints to be considered

Approximation

- Local linearising the utility function to be additive, leading to simplifying the problem to solving sequential local single portfolio optimization
- Approximating constrained optimization using rounding approximation

Approximation of Multi-period Portfolio Optimization

Objectives Function: Local linearising the utility function to be additive, leading to simplifying the problem to solving sequential local single portfolio optimization

$$\begin{aligned} w^* &= \operatorname{argmax}_{w_{t+1}, w_{t+2}, \dots, w_{t+h}} \mathbb{E}[U(r_{t+1}w_{t+1}, r_{t+2}w_{t+2}, \dots, r_{t+h}w_{t+h} | \mathcal{F}_t)] \\ &\approx \operatorname{argmax}_{w_{t+1}, w_{t+2}, \dots, w_{t+h}} \mathbb{E}[U(r_{t+1}w_{t+1}) + U(r_{t+2}w_{t+2}) + \dots + U(r_{t+h}w_{t+h}) | \mathcal{F}_t)] \\ &\approx \operatorname{argmax}_{w_{t+1}, w_{t+2}, \dots, w_{t+h}} \mathbb{E}[U(r_{t+1}w_{t+1}) | \mathcal{F}_t)] + \mathbb{E}[U(r_{t+2}w_{t+2}) | \mathcal{F}_{t+1})] + \dots + \mathbb{E}[U(r_{t+h}w_{t+h}) | \mathcal{F}_{t+h-1})] \end{aligned}$$

Feasibility Refinement for Multi-period Portfolio Optimization

Constraints: for every time rebalancing of the unconstrained single-period optimization

1. Rounding leverage constraint

$$w_{box}^s = \begin{cases} 0.3 \times (w^s / \sum_{s \in S} w^s), & \sum_s w^s > 0.3, \\ w^s, & \sum_s w^s \leq 0.3, \end{cases}$$

- L is the set of long position assets

- S is the set of short position assets

$$w_{box}^l = \begin{cases} 1.3 \times (w^l / \sum_{l \in L} w^l), & \sum_l w^l > 1.3, \\ w^l, & \sum_l w^l \leq 1.3, \end{cases}$$

2. Rounding divestment constraint

$$\tilde{w}^{l,div} = D(t) \times \frac{w_{box}^{l,div}}{\sum_{l \in L} w_{box}^{l,div}} \quad \text{or/and} \quad \tilde{w}^{s,div} = -D(t) \times \frac{w_{box}^{s,div}}{\sum_{s \in S} w_{box}^{s,div}}.$$

Feasibility Refinement for Multi-period Portfolio Optimization

3. Rounding reinvestment constraint

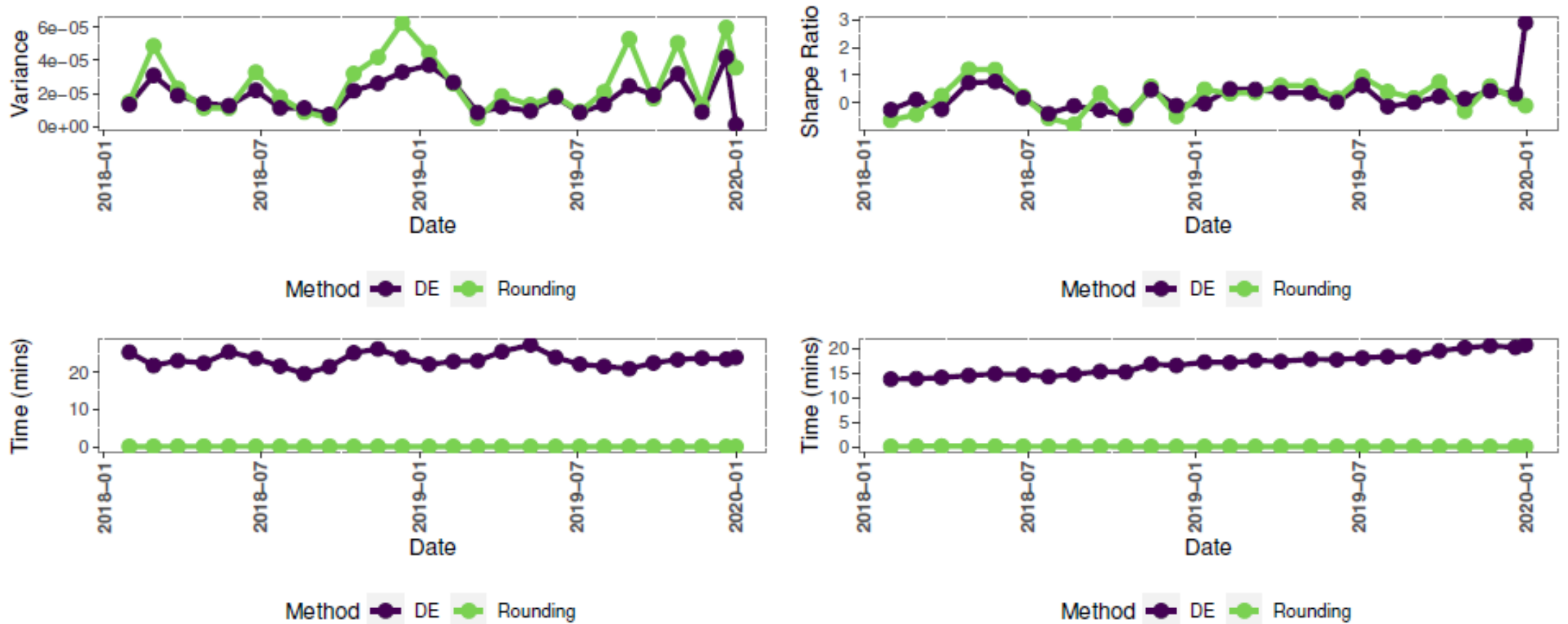
$$w_{ex} = \begin{cases} \sum_{l \in L} \tilde{w}_{box}^{l,div} - D(t), & \text{if } \sum_{l \in L} w_{box}^{l,d} \geq D(t) \\ \sum_{s \in S} w_{box}^{s,div} + D(t), & \text{if } \sum_{s \in S} w_{box}^{s,div} \leq -D(t) \\ \sum_{l \in L} w_{box}^{l,div} + \sum_{s \in S} w_{box}^{s,div}, & \text{if } \sum_{l \in L} w_{box}^{l,div} \geq D(t) \text{ and } \sum_{s \in S} w_{box}^{s,div} \leq -D(t) \\ 0, & \text{otherwise.} \end{cases}$$

$$\tilde{w}^{inv} = w^{inv} + \frac{w^{inv}}{\sum_{l \in L} w^{inv}} \times w_{ex}.$$

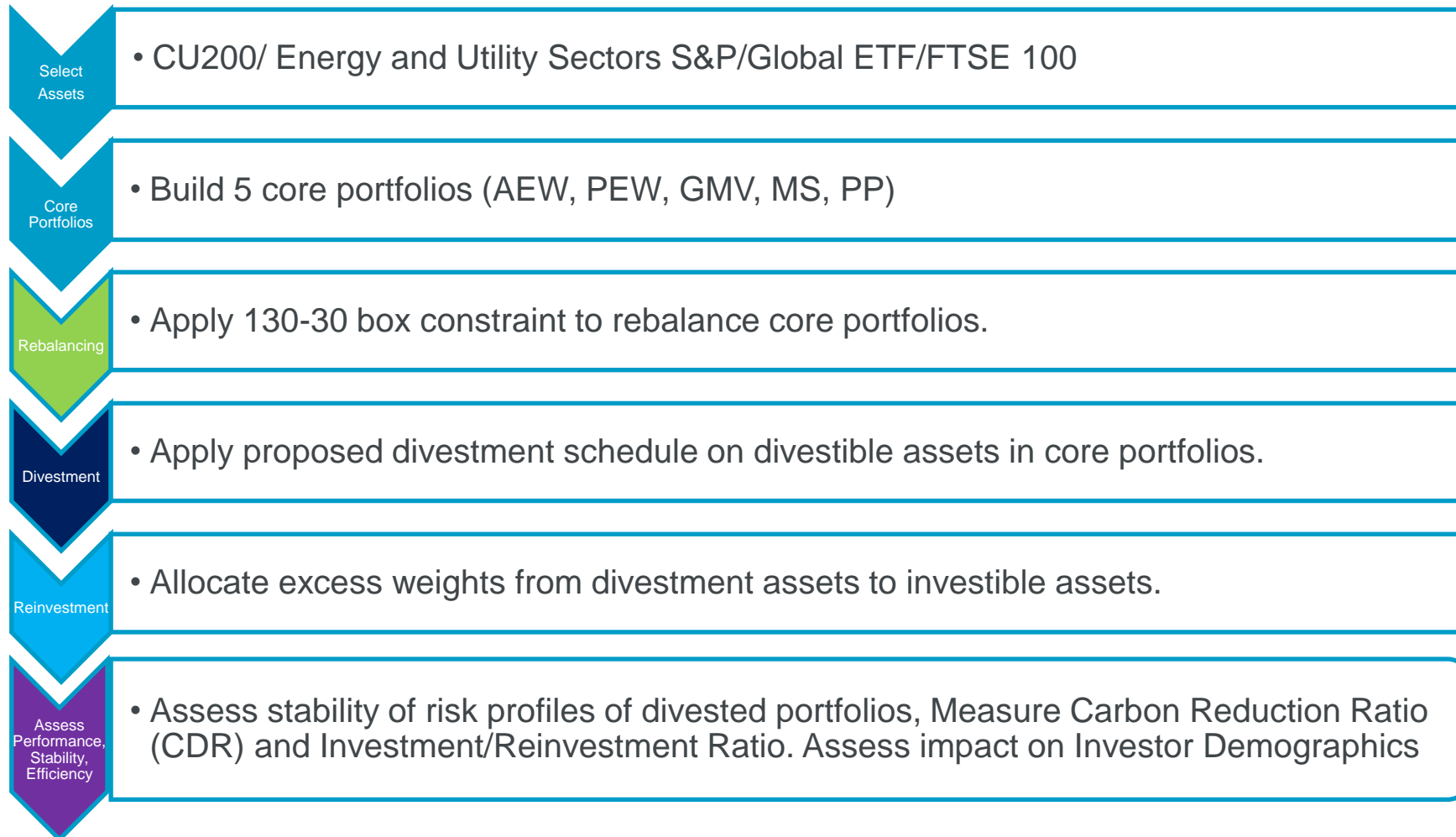
It is not difficult to verify that $\tilde{w}^{l,div} 1 + \tilde{w}^{s,div} 1 + \tilde{w}^{inv} 1 = 1$.

Approximation of Multi-period Portfolio Optimization

Rounding approximation compares to Differential Evolution – Very closed in risk profiles



Divestment and reinvestment framework



Experimental Design

- S&P 500, with the divested funds (CU200, energy and utilities) reinvested in other sectors.

We study the impact and stability on the portfolio's risk and return behaviour by divesting from fossil-fuel intensive sectors and reinvesting this capital in other sectors as well as allowing divestment by using leveraged positions.

- ETFs, with the divested carbon intensive assets

We study the impact on key investors demographics: management fees, ESG score and carbon footprint change, and the dividend yields attributed to divestment practices.

- FTSE 100, with the divested high ESG risk

We study the impact on portfolio diversification and robust covariance structure.



DivFolio: A Shiny Application for Portfolio Divestment in Green Finance Wealth Management

Guideline of using divestment software

- Full guideline available on <https://github.com/QuantFILab/Divfolio>
- Example CSV Files available on <https://github.com/QuantFILab/IME2023-Presentation>
- Web application available on <https://quantfilab.shinyapps.io/divfolioserveri/>