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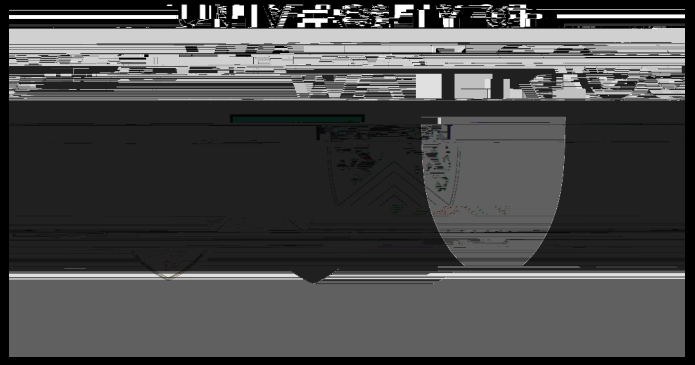


Portfolio Optimization under Climate Change

Joint work with Professor Mary Hardy & Professor Ben Feng

AFRIC 2023

Question

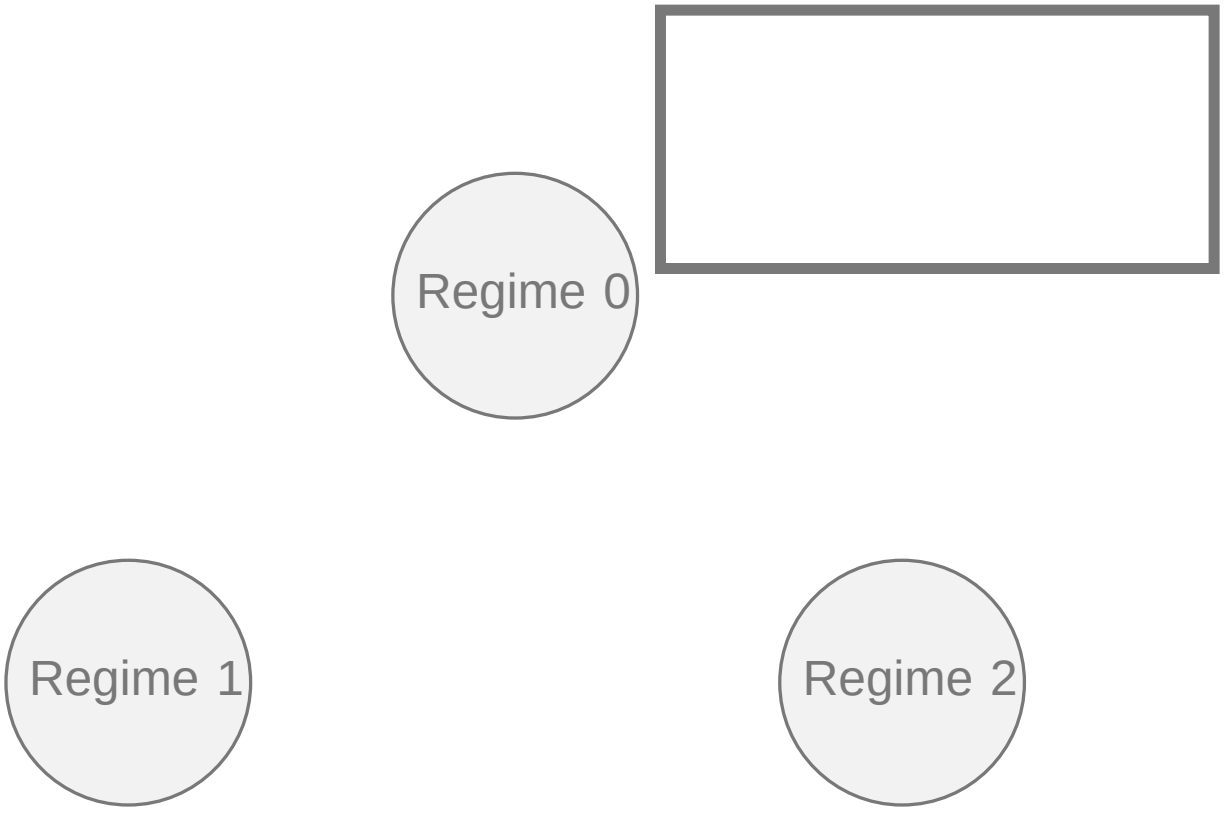
Explore long-term and short-term returns of pension plan[1] portfolios while adapting to a low-carbon economy.

[1] [illegible]

Climate Risks

1. Transition Risks
   - [illegible]
   - [illegible]
   - [illegible]
2. Physical Risks
   - [illegible]
   - [illegible]
   - [illegible]
   - [illegible]

Climate Scenario Assumptions



Climate Model

- Conditional Multivariate Normal Model
  - Simulated quarterly returns
  - Allow for impacts of physical and transition risks, depending on
    - Sector of the economy
    - Regime
    - Time since the transition

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Climate Risk Phase

Exogenous vs Endogenous Processes

Exogenous Process: Economic Scenarios

1. No Transition
2. Early Transition
   - Transition to Regime 1 at t = 2
3. Mid Transition
   - Transition to Regime 2 at t = 5

Endogenous Process: Decarbonization Strategy

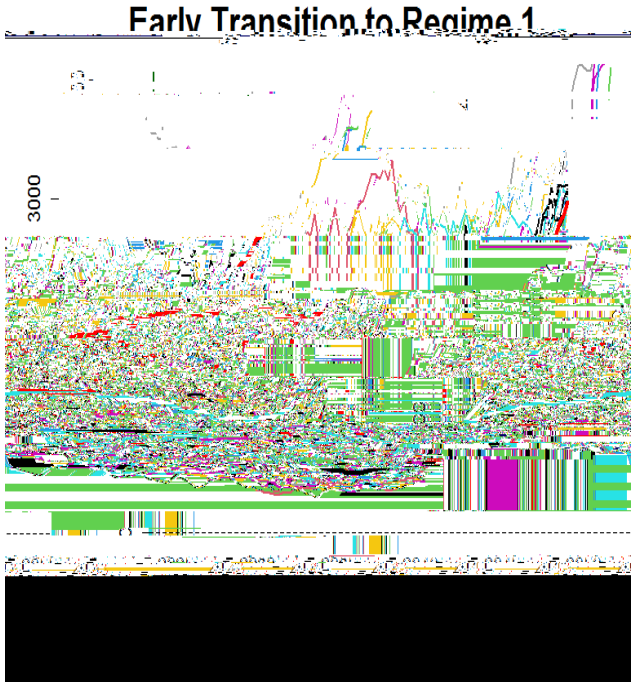
1. No Decarbonization
2. Slow Decarbonization
   - 10-year decarbonization pathway: untargeted
3. Quick Decarbonization
   - 5-year decarbonization pathway: untargeted

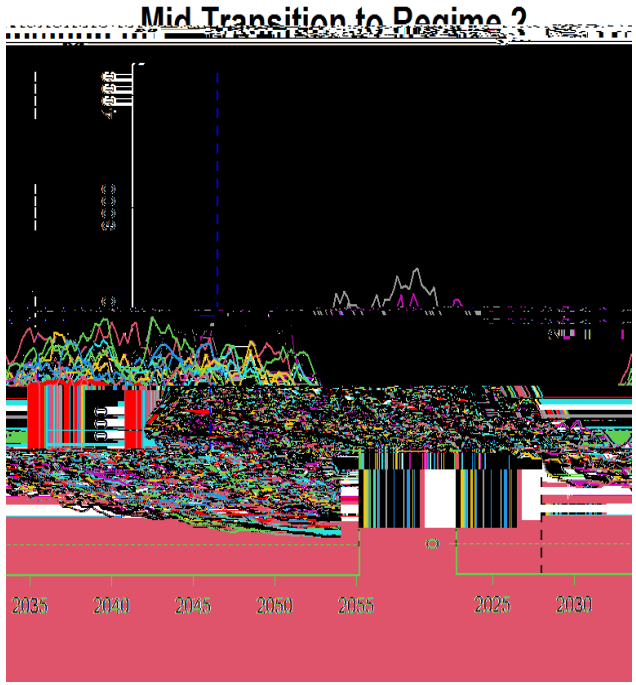
Portfolio Assumptions

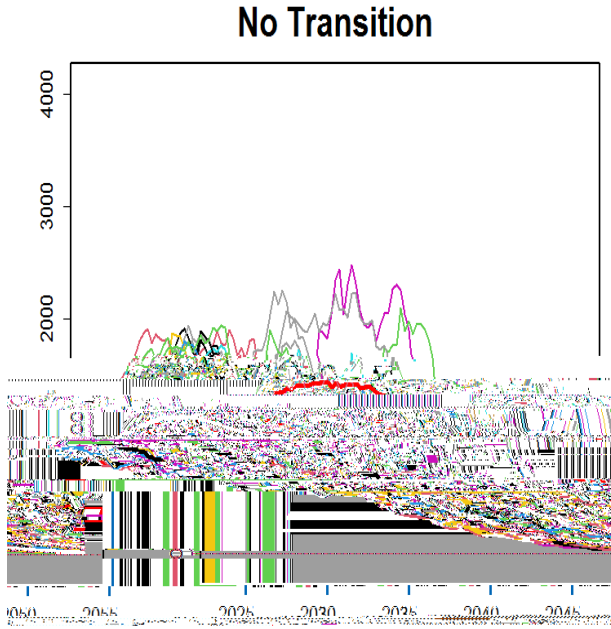
1. Assets:
   - [illegible]
   - [illegible]
2. Base Strategy; no decarbonization
   - [illegible] $\frac{1}{12}$ [illegible] $(T = 30)$
   - [illegible]
3. Decarbonization
   - [illegible] $\frac{1}{12}$ [illegible] $\frac{1}{9}$

Wealth Process: No Decarbonization

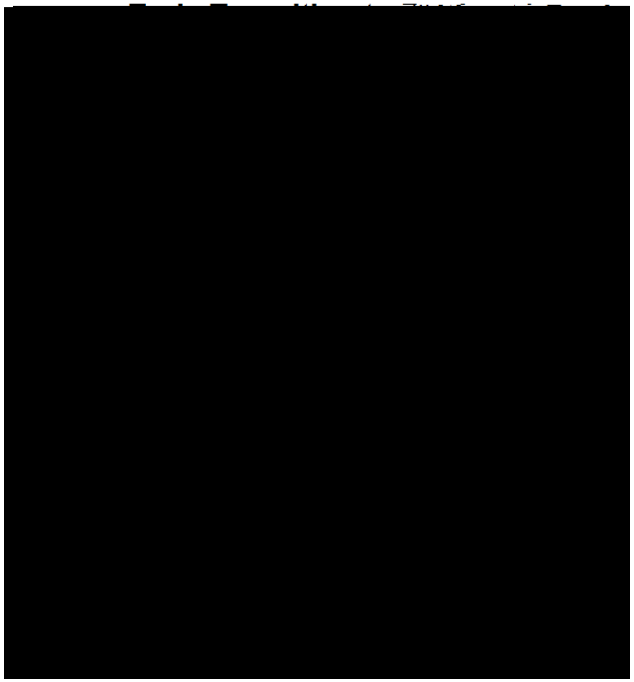
Wealth Process: Slow Decarbonization

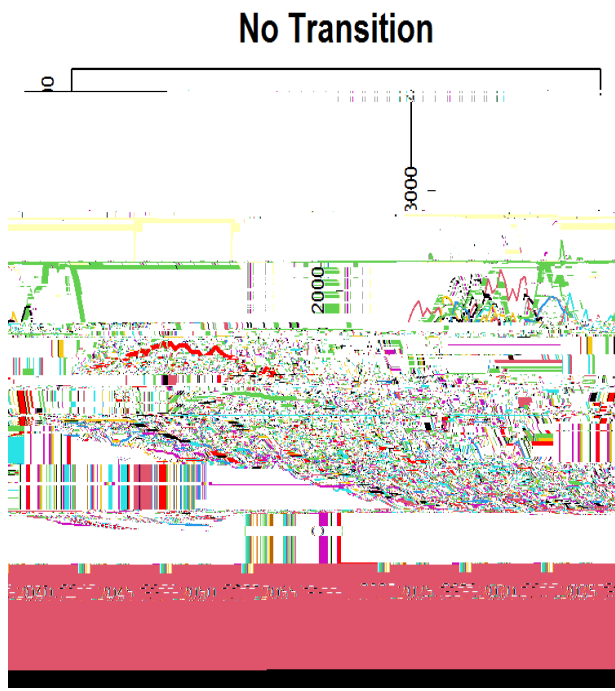






Wealth Process: Quick Decarbonization





Comparison at Median

Plan Participant Backlash

Plan Participant Backla

Case against Decarbonization?

1. Short term views
   - Brown energy remains high performing
2. Climate change skepticism
   - Disagreement on timing
   - Disagreement on capital market impact

References

1. Scott Kelly, Zhiyi Yeo, Andrew Coburn, Jennifer Copic, Doug Crawford-Brown, Aideen Foley, Eugene Neduv, Danny Ralph, and Farzad Saidi. Unhedgeable Risk: How Climate Change Sentiments Impacts Investors. University of Cambridge, 2015.

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4. Davide Benedetti, Enrico Bi s, Fotis Chatzimichalakis, Luciano Lilloy Fedele, and Ian Simm. Climate change investment risk: Optimal portfolio construction ahead of the transition to a lower-carbon economy. Annals of Operations Research, 299(1):847{871, 2021.

Climate Model

Annual Expected return & volatility under sector s, at time t

$$_{t;s} = E[R_{t;s} \mid F_t] = \bar{r}_{t;s} + {}^{T}!_t \; {}^{T}I_s \; f(\;) + {}^{P}!_t \; {}^{P}I_s$$

$$_{t;s} = \sqrt{Var[R_{t;s} \mid F_t]} =$$

Plan Portfolio Assumptions

1. Investment Strategy: Long-Term $\frac{1}{N}$ Investor $(T = 30)$
2. Asset Structure:
   - [illegible]
   - Wealth Process:

$$P_{t+1} = P_t \exp\left(\hat{}_t \quad t + \quad _{t;ij} \quad \frac{1}{2} p \overline{\quad} t Z_t \right) \quad [illegible]$$

where $Z_t \quad N(0;1)$ and $_{t;ij} = \hat{}_{t;ij}$