Sustainable Investing in Equilibrium

Lubos Pastor (Chicago Booth)

Rob Stambaugh (Wharton)

Luke Taylor (Wharton)

Overview

- Growing interest in **sustainable investing**
  - Objectives: Financial + ESG (**E**nvironmental, **S**ocial, **G**overnance)
- We build a simple **equilibrium model** of sustainable investing
- Analyze **financial and real effects** of sustainable investing

Main Theoretical Results

- Greener assets have lower **alphas**
  - Because agents have green tastes & green assets hedge **climate risk**
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- ESG **industry's size** increases with dispersion in ESG preferences
- Sustainable investing leads to **positive social impact**
  - Green firms invest more, brown firms less
  - Firms become greener

Model Overview

FIRMS

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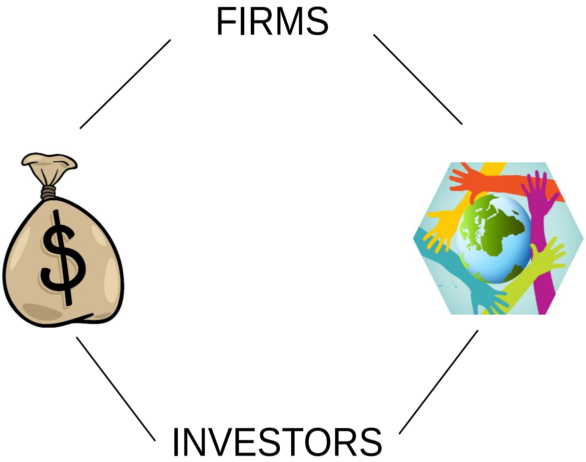

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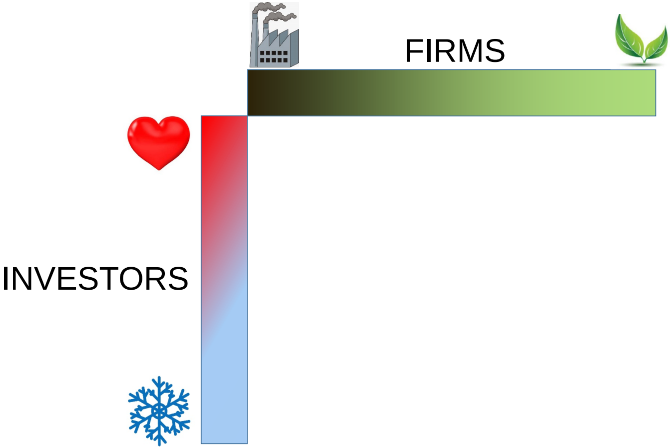

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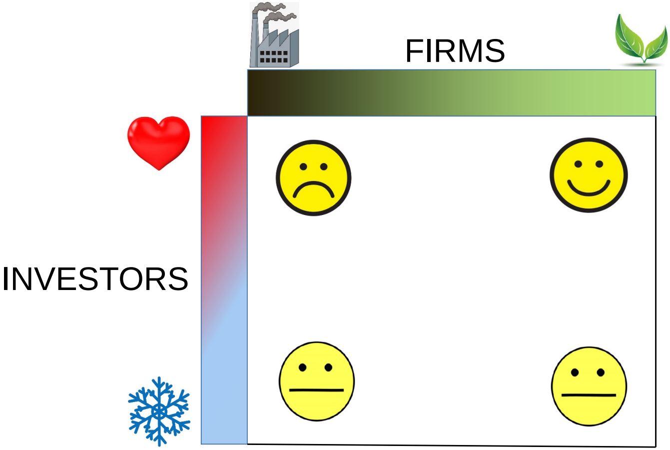

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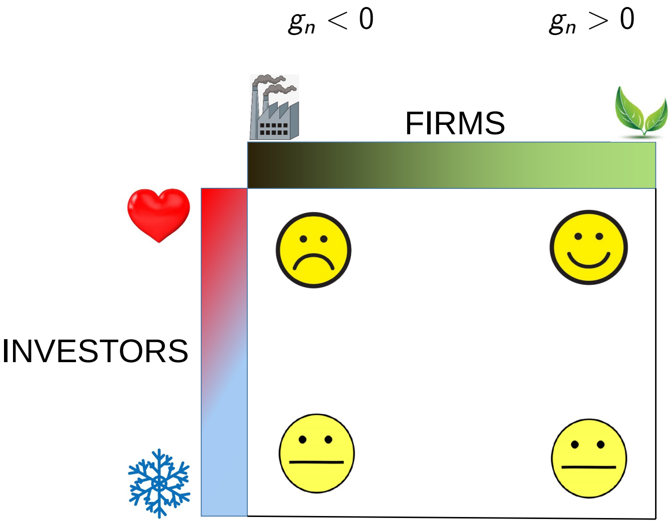

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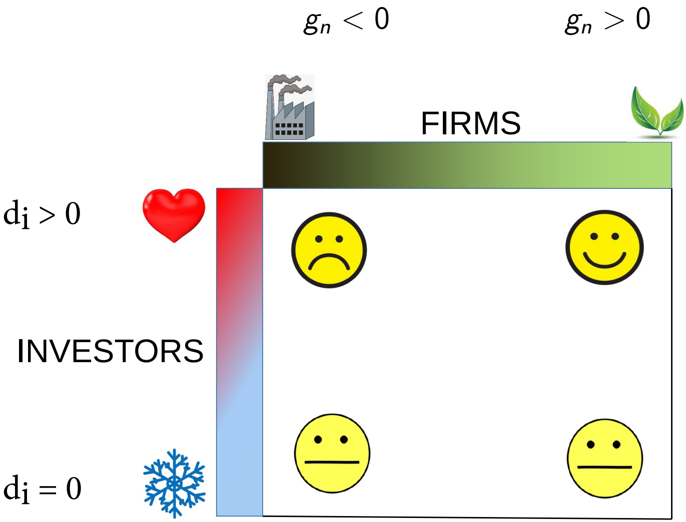

Model

- One period (from 0 to 1)
- **Firms** $n = 1, \ldots, N$
  - ESG characteristics g $(N \times 1)$
    - $g_n > 0$: "green" firm, positive externalities
    - $g_n < 0$: "brown" firm, negative externalities
  - Excess stock returns $\tilde{r} = \mu + \tilde{\epsilon}$, where $\tilde{\epsilon} \sim N(0, \Sigma)$

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- **Agents** i (continuum), with CARA utility $-e^{\overbrace{-A_i \tilde{W}_{1i}}^{\text{Financial}} \overbrace{-b_i' X_i}^{\text{Nonfinancial}}}$
  - A_i: Absolute risk aversion of agent i
  - $\tilde{W}_{1i} = W_{0i} \left(1 + r_f + X_i' \tilde{r}\right)$: Wealth of agent i at time 1
  - X_i: Portfolio weights of agent i $(N \times 1)$
  - $b_{i,n} = d_i g_n$: Nonpecuniary benefit agent i derives from holding stock n
    - $d_i \geq 0$ is agent i's "ESG taste"

Equilibrium Expected Returns: Market-Level

- **Equity premium**:

$$\mu_M = \underbrace{a}_{\substack{\text{rel. risk}\\ \text{aversion}}} \sigma_M^2$$

Equilibrium Expected Returns: Market-Level

- **Equity premium**:

$$\mu_M = \underbrace{a}_{\text{rel. risk aversion}} \sigma_M^2 \underbrace{- \frac{\bar{d}}{a}}_{<0} \underbrace{x'g}_{\text{market's greenness}}$$

where $\mu_M = x'\mu$, $\sigma_M^2 = x'\Sigma x$, $x =$ market portfolio weights, $\bar{d} =$ average d_i across agents (i.e., $\bar{d} \equiv \int_i w_i d_i di$, $w_i \equiv \frac{W_{0i}}{\int_i W_{0i} di}$)

  - $x'g > 0 \Rightarrow \mu_M$ is decreasing in $\bar{d}$
  - $x'g < 0 \Rightarrow \mu_M$ is increasing in $\bar{d}$

- Assume $x'g = 0$ (market portfolio is ESG-neutral)

Equilibrium Expected Returns: Firm-Level

- Expected excess stock returns:

$$\mu = \underbrace{\mu_M \beta}_{CAPM} - \frac{\bar{d}}{a} g$$

- Greener stocks have lower **alphas**:

$$\alpha_n = \underbrace{-\frac{\bar{d}}{a}}_{<0} g_n$$

  - Green stocks have negative alphas
    Brown stocks have positive alphas

Equilibrium Expected Returns: Agent-Level

- Expected excess return on agent i's portfolio:

$$\mathrm{E}(\tilde{r}_i) = \mu_M - \delta_i \underbrace{\left(\frac{\bar{d}}{a^3} g' \Sigma^{-1} g \right)}_{>0}$$

where $\delta_i \equiv d_i - \bar{d}$. Note:

- $\delta_i \uparrow \Rightarrow \mathrm{E}(\tilde{r}_i) \downarrow$
- $\delta_i > 0 \Rightarrow \mathrm{E}(\tilde{r}_i) < \mu_M$
- $\delta_i < 0 \Rightarrow \mathrm{E}(\tilde{r}_i) > \mu_M$

Portfolio Tilts

- Agent i's equilibrium portfolio weights:

$$X_i = x + \underbrace{\frac{\delta_i}{a^2}\left(\Sigma^{-1} g\right)}_{\text{"}ESG\ \ tilt\text{"}}$$

- **Three-fund separation**:
  1. Riskless asset
  2. Market portfolio, x
  3. "ESG portfolio", $\Sigma^{-1} g$
     - Agents with $\delta_i > 0$ (i.e., $d_i > \bar{d}$) go long the ESG portfolio
     - Agents with $\delta_i < 0$ (i.e., $d_i < \bar{d}$) go short the ESG portfolio
     - Agents with $\delta_i = 0$ (i.e., $d_i = \bar{d}$) hold the market

Example

- Two types of agents:
  - **ESG** investors: $d_i = d > 0$ ... Fraction λ of total wealth
  - **Non-ESG** investors: $d_i = 0$ ... Fraction $1 - \lambda$ of total wealth

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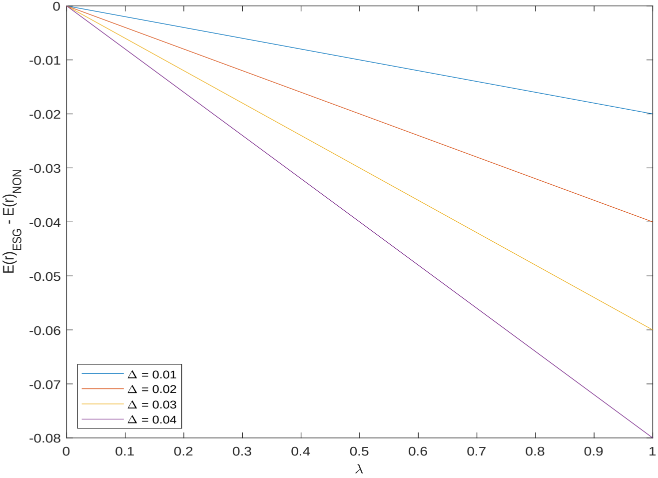
- Parameters:
  - $\mu_M = 0.08$, $\sigma_M = 0.20$ per year, market model $R^2 = 30\%$
  - $\Sigma = \sigma^2 \iota\iota' + \eta^2 I_N$, $x = (1/N)\iota$, $\beta = \iota$, $g'g = 1$

- Vary λ and $\Delta =$ maximum certain return ESG investor is willing to sacrifice to invest in her desired portfolio rather than in M
  - $\Delta \equiv r^*_{esg} - r^*_M$, where r^*_{esg} is the ESG investor's certainty equivalent excess return when investing in the optimal ESG portfolio, and r^*_M is her certainty equivalent if forced to hold the market instead

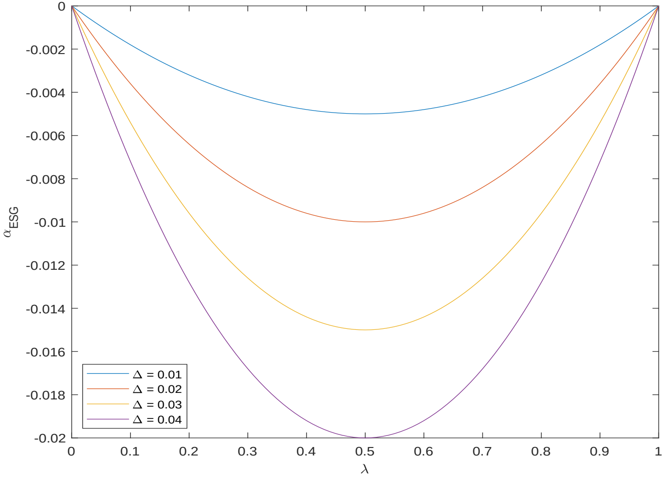
ESG vs. Non-ESG Expected Portfolio Return

$$E\{\tilde{r}_{esg}\} - E\{\tilde{r}_{non}\} = -2\lambda\Delta \leq 0$$



Alphas of ESG Investors: The Role of λ

$$\alpha_{esg} = -2\lambda(1-\lambda)\Delta \ \leq 0$$



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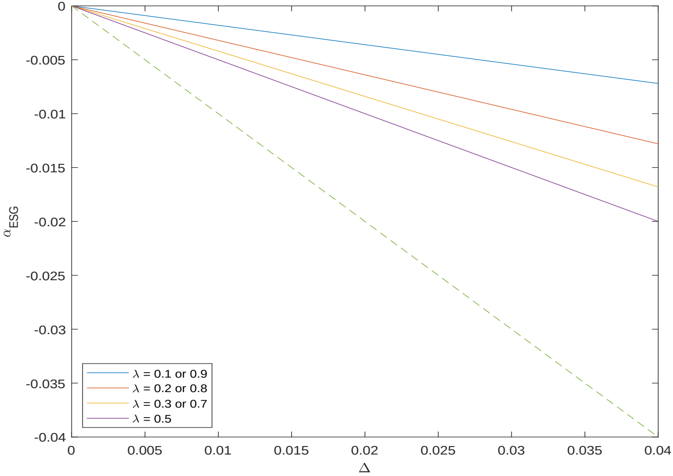
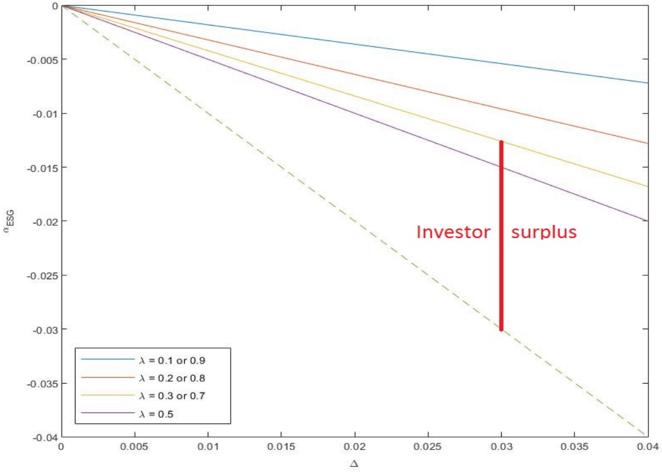


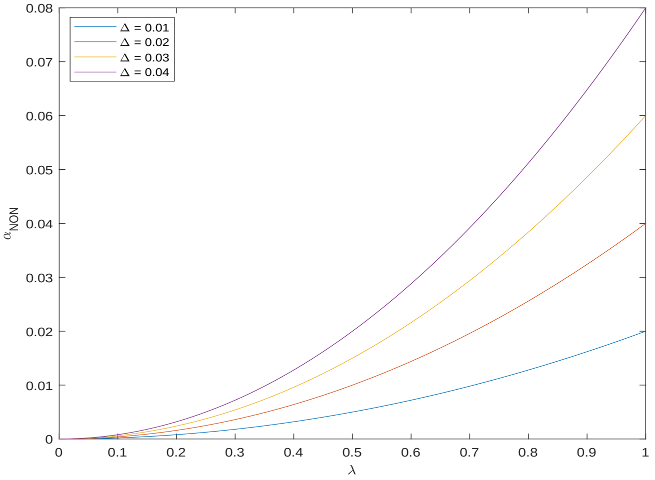
Investor Surplus

$$\mathcal{I} \equiv \alpha_{esg} - (-\Delta) = \Delta[1 - 2\lambda(1 - \lambda)] \geq 0$$

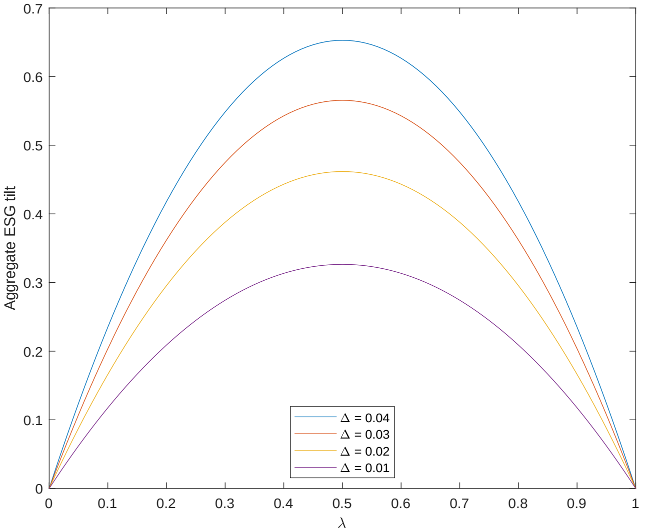


Alphas of Non-ESG Investors

$$\alpha_{non} = 2\lambda^2\Delta \geq 0$$



Size of the ESG Industry (= Aggregate ESG Tilt)



Extension: Climate Risk

- Agent i's utility:

$$-e^{-A_i\tilde{W}_{1i}-b_i'X_i-\overbrace{c_i\tilde{C}}^{new}}$$

where **climate** $\tilde{C} \sim N(0,1)$

  - $c_i \geq 0 \;\Rightarrow\;$ Agents dislike low realizations of $\tilde{C}$
  - Let $\bar{c} \equiv \int_i w_i c_i di$

Extension: Climate Risk (cont'd)

- Expected excess returns in equilibrium:

$$\mu = \mu_M \beta - \frac{\bar{d}}{a} g + \overbrace{\bar{c} \left(1 - \rho_{MC}^2\right) \underbrace{\psi}_{\text{climate betas}}}^{\text{new}}$$

where ψ = slopes on $\tilde{C}$ in a regression of $\tilde{\epsilon}$ on both $\tilde{C}$ and $\tilde{\epsilon}_M$

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- Greener stocks likely better hedge climate risk: $\text{Corr}(\psi_n, g_n) < 0$
  - If $\psi_n = -\xi g_n$, where $\xi > 0$, then

$$\alpha_n = -\left[\frac{\bar{d}}{a} + \bar{c}\left(1 - \rho_{MC}^2\right)\xi\right] g_n$$

  - Greener stocks have lower alphas for two reasons: tastes and risk

Extension: ESG Factor

- Strength of ESG concerns can change over time
  - "Investor" channel: $\bar{d}$ shifts $(\Delta\bar{d})$
  - "Customer" channel: Demand for firms' products shifts $(\tilde{z}_g)$

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  - "Investor" channel: $\bar{d}$ shifts $(\Delta\bar{d})$
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- We show: $\underbrace{\tilde{\epsilon}}_{\text{unexpected returns}} = \underbrace{\tilde{z}_h}_{\text{macro factor}} h + \underbrace{\tilde{f}_g}_{\text{ESG factor}} g + \tilde{\zeta}$,

  where the **ESG factor** has two components:

$$\tilde{f}_g = \underbrace{\tilde{z}_g}_{\text{customer channel}} + \underbrace{\frac{1}{a}(\Delta\bar{d})}_{\text{investor channel}}$$

- Green (brown) stocks perform better (worse) than expected if ESG concerns strengthen unexpectedly via either channel

Two-Factor Asset Pricing Model

- $\text{Corr}(\tilde{f}_g, \tilde{C}) < 0$ (bad climate news $\Rightarrow$ tastes shift toward green)
- If $\text{Corr}(\tilde{f}_g, \tilde{C}) = -1$ then **two-factor pricing** holds:

$$\tilde{r} = \theta \underbrace{\tilde{r}_M}_{\substack{\text{market} \\ \text{factor}}} + g \underbrace{\left(\tilde{f}_g + \mu_g\right)}_{\substack{\text{ESG} \\ \text{factor}}} + \tilde{\nu}$$

where $\theta = h/x'h$ and

$$\mu_g = \underbrace{\mu_M \beta_g}_{\substack{\text{market} \\ \text{risk}}} - \underbrace{\bar{d}/a}_{\substack{\text{investors'} \\ \text{tastes}}} - \underbrace{\bar{c}\left(1 - \rho_{MC}^2\right)}_{\substack{\text{climate} \\ \text{risk}}}$$

- If $\text{Corr}(\tilde{f}_g, \tilde{C}) \neq -1$ then **multiple factors** capture ESG risk

Extension: Social Impact

- **Social impact** of firm n:

$$S_n \equiv g_n K_n$$

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- **Firm maximizes its market value** by choosing ΔK_n and Δg_n
  - Firm is endowed with capital $K_{0,n}$ and ESG characteristic $g_{0,n}$
- Firm's cash flows at time 1: $\Pi_n K_n$ minus adjustment costs
  - Capital adjustment costs: $\frac{\kappa_n}{2}(\Delta K_n)^2$
  - ESG adjustment costs: $\frac{\omega_n}{2}(\Delta g_n)^2$

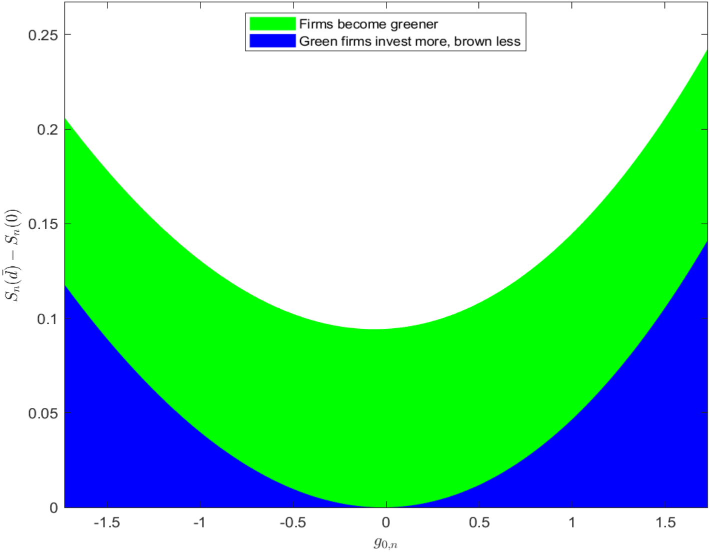
Extension: Social Impact (cont'd)

- Green tastes have **positive social impact**:

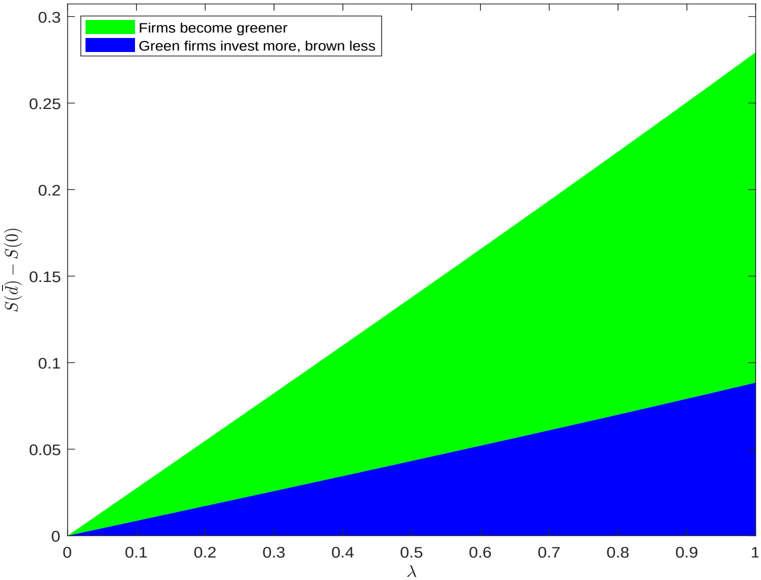
$$S_n(\bar{d}) > S_n(0)$$

  - Green firms invest more (cost of capital $\downarrow$)
    Brown firms invest less (cost of capital $\uparrow$)
  - All firms choose to become greener

Firm-Level Social Impact



Aggregate Social Impact: The Role of λ



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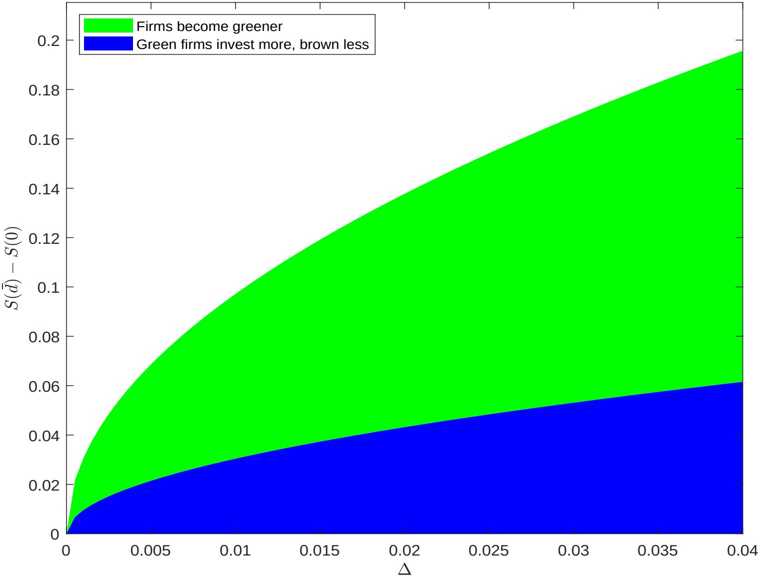

Agents Care about Aggregate Social Impact

- Assume each agent's **utility is increasing in S** $\equiv \sum_{n=1}^{N} S_n$:

$$U(\tilde{W}_{1i}, X_i, S) \;=\; \underbrace{V(\tilde{W}_{1i}, X_i)}_{original\;\;utility\;\;function} \;+\; \underbrace{h_i(S)}_{h_i'(S)>0}$$

- Addition of $h_i(S)$ does not affect asset prices, investment, or S
  - Because agents are infinitesimally small

$\Rightarrow$ Social impact is caused by the inclusion of X_i, not S, in U

Conclusions

In our equilibrium model of sustainable investing,

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