

Dynamic ESG Equilibrium

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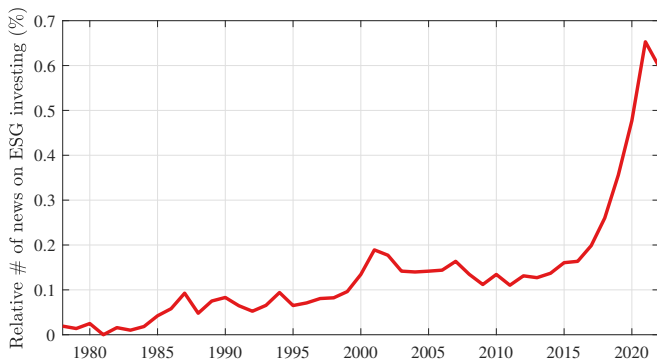
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Background: surge in press attention for ESG investing



- ▶ Number of newspaper articles in Factiva including keywords on sustainable investing, relative to number of articles on investing

Background: ESG-return relation

Existing asset pricing models with preferences for ESG
(e.g., Heinkel, 2001; Pastor et al., 2021; Pedersen et al., 2021)
based on **one period**

- ▶ Green assets provide **nonpecuniary benefits**
- ▶ In a static equilibrium, **negative ESG-return relation**

Empirical evidence on ESG-return relation is mixed

- ▶ **ESG uncertainty** (e.g., Gibson et al., 2021; Berg et al., 2022; Avramov et al., 2022)
- ▶ Tastes for ESG are dynamically **time varying**
 - ▶ Pastor et al. (2022): increasing climate concerns drive positive contemporaneous returns of green-minus-brown portfolio

This paper: dynamic ESG demand and supply

Model

- ▶ Equilibrium model with long-run risk (Bansal and Yaron, 2004)
- ▶ Agent's utility from consumption and portfolio ESG profile
- ▶ Time-varying preferences for ESG (ESG demand)
- ▶ Time-varying ESG scores (ESG supply)

Implications for green assets

- ▶ Time-varying **negative** convenience yield premium
- ▶ Unexpected returns **positively correlated** with **ESG demand** shocks
- ▶ **Positive** ESG demand risk premium

Representative agent's optimization problem

$$U_t = \max_{C_t, \omega_t} \left((1 - \beta) A_t^{1 - \frac{1}{\psi}} + \beta E_t \left[U_{t+1}^{1 - \gamma} \right]^{\frac{1}{\theta}} \right)^{\frac{1}{1 - \frac{1}{\psi}}} \quad (\text{utility})$$

$$A_t = \underbrace{C_t}_{\text{physical consumption}} + \underbrace{\delta_t}_{\text{ESG demand}} \underbrace{G_{W,t}}_{\text{ESG supply}} \underbrace{(W_t - C_t)}_{\text{investable wealth}} \quad (\text{consumption bundle})$$

$$G_{W,t} = \sum_{n=1}^N \underbrace{\omega_{n,t}}_{\text{portfolio weight}} \underbrace{G_{n,t}}_{\substack{\text{ESG score} \\ > 0 \text{ (green)} \\ < 0 \text{ (brown)}}} \quad (\text{aggregate ESG supply})$$

$$W_{t+1} = (W_t - C_t) \left(R_{f,t+1} + \sum_{n=1}^N \omega_{n,t} (R_{n,t+1} - R_{f,t+1}) \right) \quad (\text{wealth})$$

Euler equation for risky asset return

$$E_t \left[\underbrace{e^{m_{t+1}}}_{\text{SDF}} R_{n,t+1} \right] = 1 - \underbrace{\delta_t G_{n,t}}_{\text{convenience yield}}$$

To solve for the SDF, the following dynamics are specified:

$$\Delta c_{t+1} = \mu_c + x_t + \sigma_c \varepsilon_{c,t+1} \quad (\text{consumption growth})$$

$$x_{t+1} = \rho_x x_t + \sigma_x \varepsilon_{x,t+1} \quad (\text{expected consumption growth})$$

$$G_{W,t+1} = \mu_G + \rho_G G_{W,t} + \sigma_G \varepsilon_{G,t+1} \quad (\text{aggregate ESG supply})$$

$$\delta_{t+1} = \mu_\delta + \rho_\delta \delta_t + \sigma_\delta \varepsilon_{\delta,t+1} \quad (\text{aggregate ESG demand})$$

► Systematic risks: $\varepsilon_{c,t+1}, \varepsilon_{G,t+1}, \varepsilon_{\delta,t+1}, \varepsilon_{x,t+1} \sim \mathcal{N}(0, 1)$ i.i.d.

For $\psi > 1$, $\bar{G}_W > 0$, and $\bar{\delta} > 0$, equilibrium SDF:

$$m_{t+1} - E_t[m_{t+1}] = - \underbrace{\lambda_c}_{>0} \varepsilon_{c,t+1} - \underbrace{\lambda_G}_{>0} \varepsilon_{G,t+1} - \underbrace{\lambda_\delta}_{>0} \varepsilon_{\delta,t+1} - \underbrace{\lambda_x}_{>0} \varepsilon_{x,t+1}$$

Risky asset ESG score and dividend growth dynamics

Asset- n ESG score dynamics:

$$G_{n,t+1} = \mu_{Gn} + \rho_{Gn} G_{n,t} + \sigma_{Gn,G} \varepsilon_{G,t+1} + \sigma_{Gn} \varepsilon_{Gn,t+1}$$

Asset- n dividend growth:

$$\Delta d_{n,t+1} = \mu_{dn} + \rho_{dn,x} x_t + \sigma_{dn,c} \varepsilon_{c,t+1} + \sigma_{dn,dM} \varepsilon_{dM,t+1} + \sigma_{dn} \varepsilon_{dn,t+1}$$

Risky asset price-to-dividend ratio and unexpected return

For $\psi > 1$, $\bar{G}_W > 0$, and $\bar{\delta} > 0$, equilibrium price-to-dividend ratio:

$$pd_{n,t} = A_{n,0} + \underbrace{A_{n,G}}_{>0} G_{W,t} + \underbrace{A_{n,\delta}}_{>0 \text{ if } \bar{G}_n > 0} \delta_t + A_{n,x} x_t + \underbrace{A_{n,Gn}}_{>0} G_{n,t}$$

increasing in \bar{G}_n

Unexpected asset return:

$$\begin{aligned} r_{n,t+1} - E_t[r_{n,t+1}] &= \sigma_{dn,c} \varepsilon_{c,t+1} + \underbrace{\kappa_{rn,pd} A_{n,G} \sigma_G}_{>0} \varepsilon_{G,t+1} \\ &\quad + \underbrace{\kappa_{rn,pd} A_{n,\delta} \sigma_\delta}_{>0 \text{ if } \bar{G}_n > 0} \varepsilon_{\delta,t+1} + \kappa_{rn,pd} A_{n,x} \sigma_x \varepsilon_{x,t+1} \\ &\quad + \underbrace{\kappa_{rn,pd} A_{n,Gn} \sigma_{Gn}}_{>0} \varepsilon_{Gn,t+1} + \sigma_{dn,dM} \varepsilon_{dM,t+1} \\ &\quad + \sigma_{dn} \varepsilon_{dn,t+1} \end{aligned}$$

Risky asset expected excess return

$$\begin{aligned} E_t[r_{n,t+1} - r_{f,t+1}] = & \underbrace{-y_{n,t}}_{< 0 \text{ if } \bar{G}_{n,t} > 0} - \frac{1}{2} \text{Var}_t[r_{n,t+1}] \\ & + \text{Cov}_t[r_{n,t+1}, \varepsilon_{c,t+1}] \cdot \lambda_c + \text{Cov}_t[r_{n,t+1}, \varepsilon_{G,t+1}] \cdot \lambda_G \\ & + \underbrace{\text{Cov}_t[r_{n,t+1}, \varepsilon_{\delta,t+1}] \cdot \lambda_\delta}_{\kappa_{m,pd} A_{n,\delta} \sigma_\delta > 0 \text{ if } \bar{G}_n > 0} + \text{Cov}_t[r_{n,t+1}, \varepsilon_{x,t+1}] \cdot \lambda_x \end{aligned}$$

Expected return contributions of ESG

- ▶ ESG supply risk premium (empirically negligible)
- ▶ ESG demand risk premium > 0 for green assets (< 0 brown)
- ▶ Convenience yield premium < 0 for green assets (> 0 brown)

Data and estimation

Monthly asset-level ESG scores from MSCI IVA (2007–2022)

- ▶ Normalize between -0.5 and 0.5
- ▶ U.S. stocks with returns available on CRSP are retained
- ▶ Value-weighted market and brown/neutral/green portfolios

Estimation of the log-linearized model

- ▶ VAR(1) obtained stacking state variables and portfolio returns
- ▶ Unobservable long-run risk and ESG demand: Kalman filter

Parameter estimates

Economy-wide parameters (Θ_E) and market prices of risk

γ	μ_c	σ_c	x_0	μ_G	ρ_G	σ_G	δ_0	$\bar{\delta}$	σ_δ
13.11425 (3.21318)	0.00142 (0.00133)	0.01213 (0.00061)	-0.00011 (0.00372)	0.00063 (0.00041)	0.98615 (0.00898)	0.00993 (0.00050)	0.00020 (0.00014)	0.00046 (0.00015)	0.00004 (0.00000)
λ_c	λ_G	λ_δ	λ_x						
0.15902 (0.04053)	0.00487 (0.00170)	0.01072 (0.00277)	0.18367 (0.04511)						

Market portfolio parameters (Θ_M)

μ_{dM}	$\rho_{dM,x}$	$\sigma_{dM,c}$	σ_{dM}
0.00629 (0.00163)	3.54756 (0.62219)	0.00032 (0.00344)	0.01413 (0.01143)

Brown portfolio parameters (Θ_{br})

μ_{dbr}	$\rho_{dbr,x}$	$\sigma_{dbr,c}$	$\sigma_{dbr,dM}$	σ_{dbr}	μ_{Gbr}	ρ_{Gbr}	σ_{GbrG}	σ_{Gbr}
0.00683 (0.00212)	3.63920 (0.75289)	0.00235 (0.00390)	0.02306 (0.01618)	0.00005 (0.00166)	-0.00325 (0.00373)	0.99124 (0.01006)	-0.01618 (0.00139)	0.01543 (0.00077)

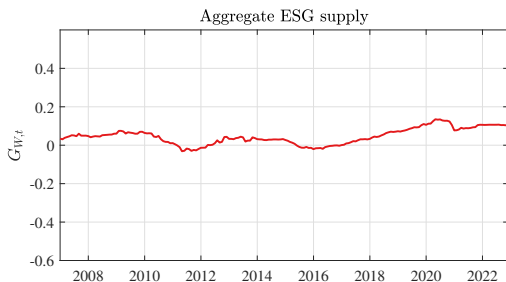
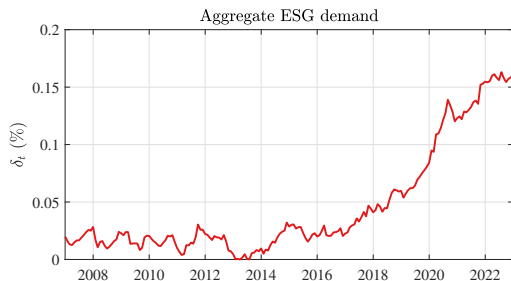
Neutral portfolio parameters (Θ_{neu})

μ_{dneu}	$\rho_{dneu,x}$	$\sigma_{dneu,c}$	$\sigma_{dneu,dM}$	σ_{dneu}	μ_{Gneu}	ρ_{Gneu}	σ_{GneuG}	σ_{Gneu}
0.00656 (0.00139)	3.71070 (0.60155)	-0.00127 (0.00354)	0.00658 (0.01101)	0.00290 (0.00116)	-0.00196 (0.00138)	0.97152 (0.01999)	0.00115 (0.00062)	0.00863 (0.00044)

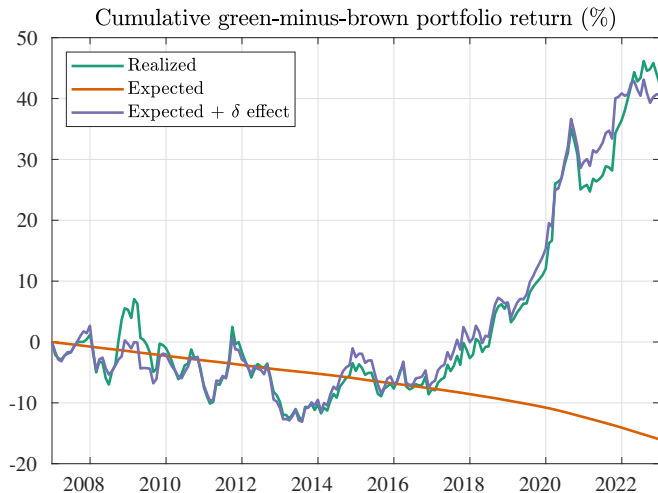
Green portfolio parameters (Θ_{gr})

μ_{dgr}	$\rho_{dgr,x}$	$\sigma_{dgr,c}$	$\sigma_{dgr,dM}$	σ_{dgr}	μ_{Ggr}	ρ_{Ggr}	σ_{GgrG}	σ_{Ggr}
0.00581 (0.00175)	3.37996 (0.62662)	0.00078 (0.00333)	0.01692 (0.01239)	0.00000 (0.00064)	0.00566 (0.00348)	0.98229 (0.01090)	0.02059 (0.00161)	0.01668 (0.00080)

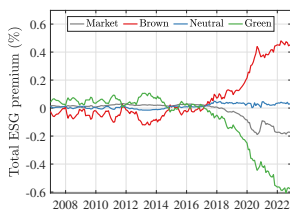
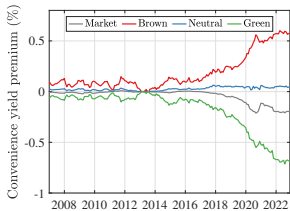
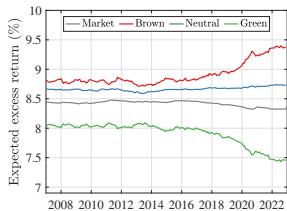
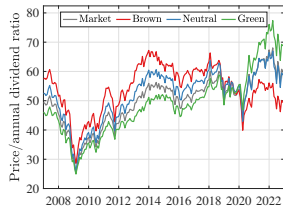
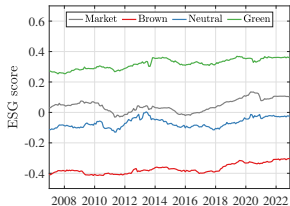
Aggregate ESG demand and supply



Returns of green-minus-brown portfolio



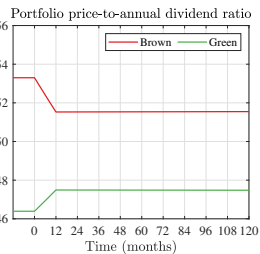
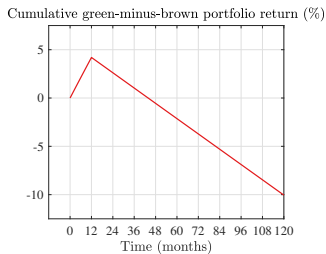
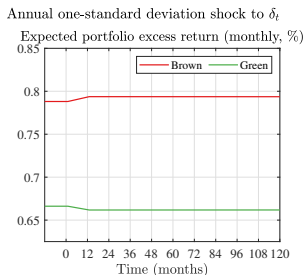
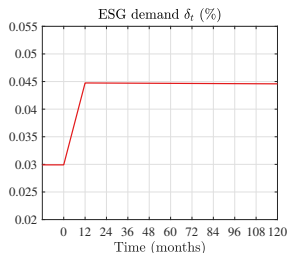
Estimated time series



Estimated decomposition of portfolio returns

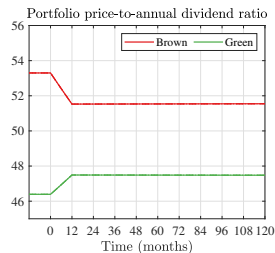
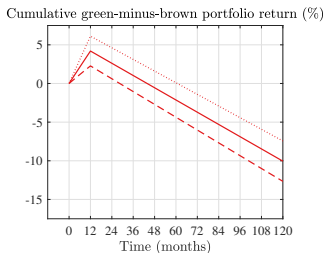
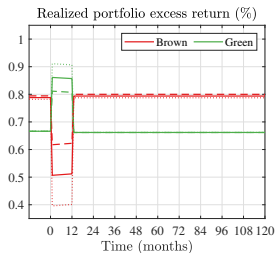
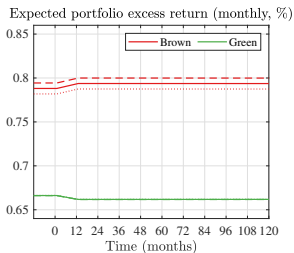
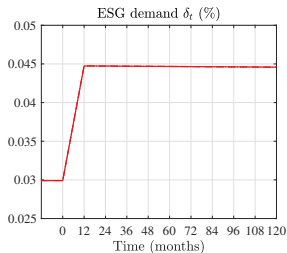
Portfolio	Market	Brown	Green	Green-Brown
Short-run consumption risk premium	0.06% (0.71%)	0.45% (0.78%)	0.15% (0.67%)	-0.30% (0.27%)
Long-run consumption risk premium	9.63% (2.03%)	9.99% (2.52%)	9.05% (2.06%)	-0.94% (0.58%)
ESG supply risk premium	0.01% (0.01%)	0.00% (0.01%)	0.01% (0.01%)	0.01% (0.00%)
ESG demand risk premium	0.01% (0.00%)	-0.12% (0.03%)	0.10% (0.02%)	0.22% (0.06%)
Average convenience yield premium	-0.04% (0.01%)	0.19% (0.07%)	-0.18% (0.06%)	-0.37% (0.13%)
Average expected excess return	8.40% (1.93%)	8.89% (2.43%)	7.90% (2.03%)	-1.00% (0.62%)
Average expected excess return + δ -induced return	8.61% (1.92%)	6.88% (2.45%)	9.42% (1.98%)	2.54% (0.59%)
Average observed excess return	7.92%	5.96%	8.61%	2.65%

Shock to aggregate ESG demand



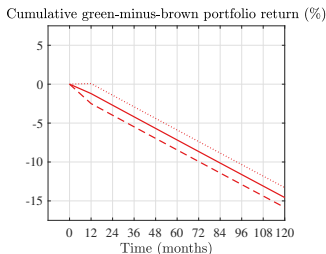
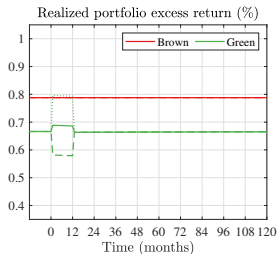
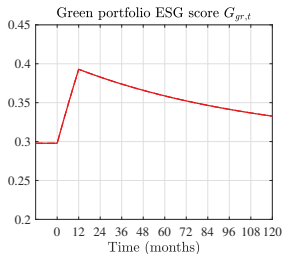
Impact of casflows' correlation with ESG demand

Response to annual one-std shock to δ_t
 $\text{Corr}_t [\Delta d_{gr,t+1}, \delta_{t+1}] = -\text{Corr}_t [\Delta d_{br,t+1}, \delta_{t+1}] = -0.5$ (dashed), 0 (solid), 0.5 (dotted)



Impact of casflows' correlation with ESG score

Response to annual shock to G_{gr} (+0.1)
 $\text{Corr}_t[\Delta d_{gr,t+1}, G_{gr,t+1}] = -0.5$ (dashed), 0 (solid), 0.5 (dotted)



Conclusion

- ▶ ESG demand strongly time-varying with positive price of risk
- ▶ Expected return of green assets
 - ▶ Time-varying negative convenience yield premium
 - ▶ Positive ESG demand risk premium
 - ▶ ESG-expected return relation can be either positive or negative
- ▶ Realized return of green assets
 - ▶ Increasing ESG demand drives contemporaneous positive and large return
 - ▶ The cumulative effect could last for several years

Additional material

Expected excess asset return

Compensation for exposure to 3 risk factors and convenience yield

$$\begin{aligned} E_t [r_{n,t+1} - r_{f,t+1}] + \frac{1}{2} \text{Var}_t [r_{n,t+1}] = \\ \frac{\theta}{\psi} \text{Cov}_t [\Delta c_{t+1}, r_{n,t+1}] + (1 - \theta) \text{Cov}_t [\tilde{r}_{W,t+1}, r_{n,t+1}] \\ + \frac{\theta}{\psi} \text{Cov}_t \left[\log \left(\frac{1 + \delta_{t+1} G_{W,t+1} \frac{W_{t+1} - C_{t+1}}{C_{t+1}}}{1 + \delta_t G_{W,t} \frac{W_t - C_t}{C_t}} \right), r_{n,t+1} \right] - y_{n,t} \end{aligned}$$

- ▶ $\Delta c_{t+1} = \log \frac{C_{t+1}}{C_t}$
- ▶ $r_{n,t+1} = \log R_{n,t+1}$, $r_{f,t+1} = \log R_{f,t+1}$, $\tilde{r}_{W,t+1} = \log \tilde{R}_{W,t+1}$
- ▶ Convenience yield: $y_{n,t} = -\log(1 - \delta_t G_{n,t})$

Price-to-consumption ratio, return on wealth, SDF

$$p_{c,t} = A_{pc,0} + A_{pc,G} G_{W,t} + A_{pc,\delta} \delta_t + A_{pc,x} x_t \quad (\text{price/consumption})$$

$$\begin{aligned} r_{W,t+1} = & r_{W,0} - A_{pc,G} (1 - \kappa_{rW,pc} \rho_G) G_{W,t} - A_{pc,\delta} (1 - \kappa_{rW,pc} \rho_\delta) \delta_t \\ & + (1 - A_{pc,x} (1 - \kappa_{rW,pc} \rho_x)) x_t \\ & + A_{pc,G} \kappa_{rW,pc} \sigma_G \varepsilon_{G,t+1} + A_{pc,\delta} \kappa_{rW,pc} \sigma_\delta \varepsilon_{\delta,t+1} \\ & + A_{pc,x} \kappa_{rW,pc} \sigma_x \varepsilon_{x,t+1} + \sigma_c \varepsilon_{c,t+1} \quad (\text{return on wealth}) \end{aligned}$$

$$\begin{aligned} m_{t+1} = & m_0 + m_G G_{W,t} + m_\delta \delta_t + m_x x_t \\ & - \lambda_c \varepsilon_{c,t+1} - \lambda_G \varepsilon_{G,t+1} - \lambda_\delta \varepsilon_{\delta,t+1} - \lambda_x \varepsilon_{x,t+1} \quad (\text{SDF}) \end{aligned}$$

where

- ▶ $A_{pc,G}, A_{pc,\delta}, A_{pc,x} > 0$ (assuming $\bar{\delta} > 0$ and $\bar{G}_W \geq 0$)
- ▶ Four sources of systematic risk: $\varepsilon_{c,t+1}, \varepsilon_{G,t+1}, \varepsilon_{\delta,t+1}, \varepsilon_{x,t+1}$
- ▶ Market prices of risk: $\lambda_c, \lambda_G, \lambda_\delta, \lambda_x > 0$

Risk-free rate of return

$$r_{f,t+1} = -m_0 - \frac{\lambda_c^2}{2} - \frac{\lambda_G^2}{2} - \frac{\lambda_\delta^2}{2} - \frac{\lambda_x^2}{2} - \underbrace{m_G}_{>0} G_{W,t} - \underbrace{m_\delta}_{>0} \delta_t - \underbrace{m_x}_{<0} x_t$$

Market price-to-dividend ratio and return

Market ESG score and dividend growth process:

$$G_{M,t} = G_{W,t}$$

$$\Delta d_{M,t+1} = \mu_{dM} + \rho_{dM,x} x_t + \sigma_{dM,c} \varepsilon_{c,t+1} + \sigma_{dM} \varepsilon_{dM,t+1}$$

Assume $\psi > 1$ and $\bar{\delta} > 0$, in equilibrium:

$$pd_{M,t} = A_{M,0} + \underbrace{A_{M,G}}_{>0} G_{W,t} + \underbrace{A_{M,\delta}}_{>0 \text{ if } \bar{G}_W > 0} \delta_t + \underbrace{A_{M,x}}_{>0} x_t$$

$$r_{M,t+1} = r_{M,0} + \underbrace{(\kappa_{W,G} - m_G)}_{<0} G_{W,t} + \underbrace{(\kappa_{W,\delta} - m_\delta)}_{<0 \text{ if } \bar{G}_W > 0} \delta_t - \underbrace{m_x}_{>0} x_t$$

$$+ \underbrace{\kappa_{rM,pd} A_{M,G} \sigma_G}_{>0} \varepsilon_{G,t+1} + \underbrace{\kappa_{rM,pd} A_{M,\delta} \sigma_\delta}_{>0 \text{ if } \bar{G}_W > 0} \varepsilon_{\delta,t+1}$$

$$+ \underbrace{\kappa_{rM,pd} A_{M,x} \sigma_x}_{>0} \varepsilon_{x,t+1} + \underbrace{\sigma_{dM,c}}_{>0} \varepsilon_{c,t+1} + \sigma_{dM} \varepsilon_{dM,t+1}$$

Market expected excess return

$$\begin{aligned}
 E_t [r_{M,t+1} - r_{f,t+1}] + \frac{1}{2} \text{Var}_t [r_{M,t+1}] = & \\
 & \underbrace{\sigma_{dM,c}}_{\text{Cov}_t[r_{M,t+1}, \varepsilon_{c,t+1}] > 0} \lambda_c + \underbrace{\kappa_{rM,pd} A_{M,G} \sigma_G}_{\text{Cov}_t[r_{M,t+1}, \varepsilon_{G,t+1}] > 0} \lambda_G \\
 & + \underbrace{\kappa_{rM,pd} A_{M,\delta} \sigma_\delta}_{\text{Cov}_t[r_{M,t+1}, \varepsilon_{\delta,t+1}] > 0 \text{ if } \bar{G}_W > 0} \lambda_\delta + \underbrace{\kappa_{rM,pd} A_{M,x} \sigma_x}_{\text{Cov}_t[r_{M,t+1}, \varepsilon_{x,t+1}] > 0} \lambda_x \\
 & + \underbrace{\log(1 - \bar{\delta} \bar{G}_W) - \frac{\bar{\delta} (G_{W,t} - \bar{G}_W)}{1 - \bar{\delta} \bar{G}_W} - \frac{\bar{G}_W (\delta_t - \bar{\delta})}{1 - \bar{\delta} \bar{G}_W}}_{-y_{M,t} \text{ (convenience yield premium)}}
 \end{aligned}$$

Risky asset price-to-dividend ratio and return

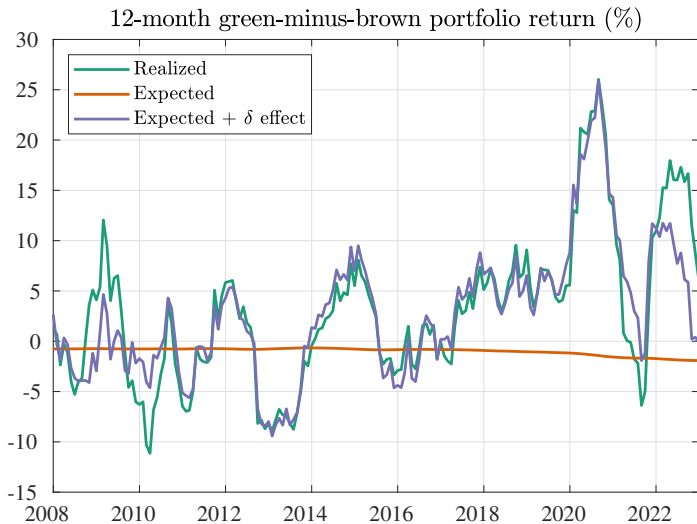
Assume $\psi > 1$, $\bar{G}_W > 0$, and $\bar{\delta} > 0$, in equilibrium:

$$pd_{n,t} = A_{n,0} + \underbrace{A_{n,G}}_{>0} G_{W,t} + \underbrace{A_{n,\delta}}_{>0 \text{ if } \bar{G}_n > 0} \delta_t + A_{n,x} x_t + \underbrace{A_{n,Gn}}_{>0} G_{n,t}$$

increasing in \bar{G}_n

$$\begin{aligned} r_{n,t+1} = & r_{n,0} \underbrace{-m_G}_{<0} G_{W,t} + \underbrace{(\kappa_{n,\delta} - m_\delta)}_{<0 \text{ if } \bar{G}_n > 0} \delta_t \underbrace{-m_x}_{>0} x_t + \underbrace{\kappa_{n,Gn}}_{<0} G_{n,t} \\ & + \sigma_{dn,c} \varepsilon_{c,t+1} + \underbrace{\kappa_{rn,pd} A_{n,G} \sigma_G}_{>0} \varepsilon_{G,t+1} \\ & + \underbrace{\kappa_{rn,pd} A_{n,\delta} \sigma_\delta}_{>0 \text{ if } \bar{G}_n > 0} \varepsilon_{\delta,t+1} + \kappa_{rn,pd} A_{n,x} \sigma_x \varepsilon_{x,t+1} \\ & + \underbrace{\kappa_{rn,pd} A_{n,Gn} \sigma_{Gn}}_{>0} \varepsilon_{Gn,t+1} + \sigma_{dn,dM} \varepsilon_{dM,t+1} + \sigma_{dn} \varepsilon_{dn,t+1} \end{aligned}$$

Returns of green-minus-brown portfolio



Parameter estimates (E scores)

Economy-wide parameters (Θ_E) and market prices of risk

γ	μ_c	σ_c	x_0	μ_G	ρ_G	σ_G	δ_0	$\bar{\delta}$	σ_δ
11.90782 (2.14109)	0.00126 (0.00131)	0.01210 (0.00061)	0.00060 (0.00361)	0.00482 (0.00143)	0.94828 (0.01539)	0.01171 (0.00059)	0.00010 (0.00017)	0.00074 (0.00020)	0.00004 (0.00000)
λ_c	λ_G	λ_δ	λ_x						
0.14406 (0.02711)	0.00447 (0.00150)	0.01966 (0.00557)	0.16618 (0.03100)						

Market portfolio parameters (Θ_M)

μ_{dM}	$\rho_{dM,x}$	$\sigma_{dM,c}$	σ_{dM}
0.00591 (0.00130)	3.67321 (0.44889)	0.00045 (0.00351)	0.00360 (0.01000)

Brown portfolio parameters (Θ_{br})

μ_{dbr}	$\rho_{dbr,x}$	$\sigma_{dbr,c}$	$\sigma_{dbr,dM}$	σ_{dbr}	μ_{Gbr}	ρ_{Gbr}	σ_{GbrG}	σ_{Gbr}
0.00635 (0.00159)	3.83717 (0.54060)	0.00021 (0.00390)	0.01347 (0.01568)	0.00243 (0.00140)	-0.04111 (0.01032)	0.88881 (0.02790)	-0.01880 (0.00173)	0.01983 (0.00098)

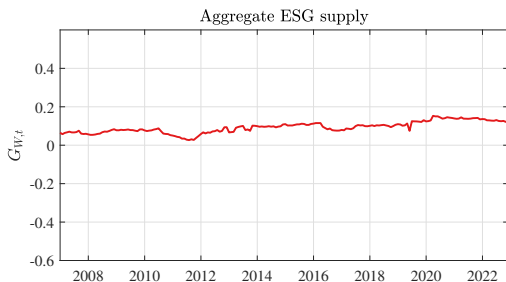
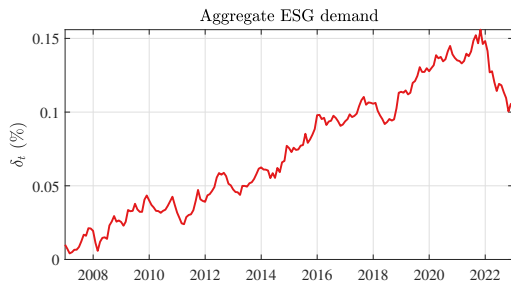
Neutral portfolio parameters (Θ_{neu})

μ_{dneu}	$\rho_{dneu,x}$	$\sigma_{dneu,c}$	$\sigma_{dneu,dM}$	σ_{dneu}	μ_{Gneu}	ρ_{Gneu}	σ_{GneuG}	σ_{Gneu}
0.00645 (0.00131)	3.85533 (0.48365)	0.00082 (0.00373)	-0.00186 (0.01061)	0.00002 (0.00061)	-0.00747 (0.00225)	0.88316 (0.03513)	-0.00010 (0.00080)	0.01124 (0.00057)

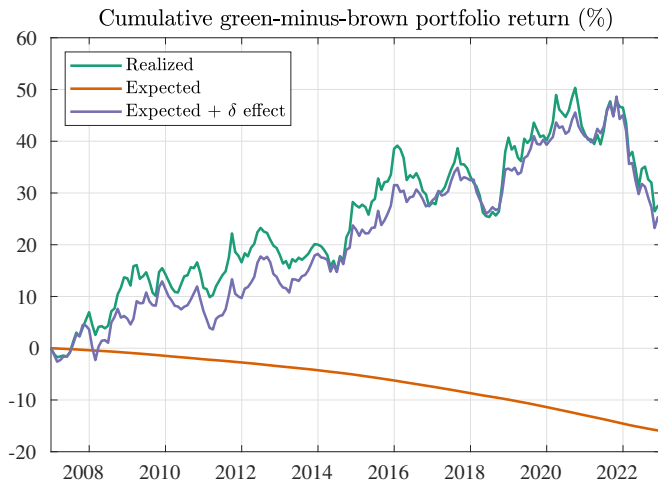
Green portfolio parameters (Θ_{gr})

μ_{dgr}	$\rho_{dgr,x}$	$\sigma_{dgr,c}$	$\sigma_{dgr,dM}$	σ_{dgr}	μ_{Ggr}	ρ_{Ggr}	σ_{GgrG}	σ_{Ggr}
0.00537 (0.00132)	3.46500 (0.42140)	0.00012 (0.00332)	0.00488 (0.00975)	0.00127 (0.00032)	0.03025 (0.00772)	0.91331 (0.02213)	0.02521 (0.00170)	0.01528 (0.00073)

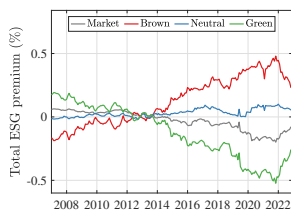
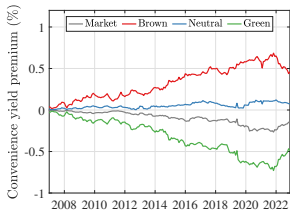
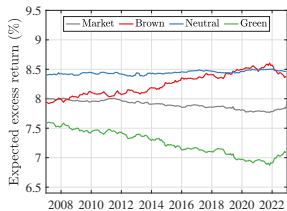
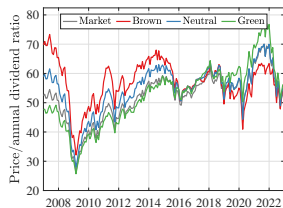
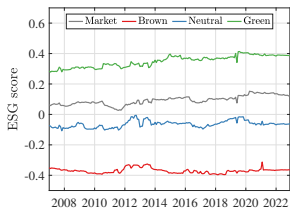
Aggregate ESG demand and supply (E scores)



Returns of green-minus-brown portfolio (E scores)



Estimated time series (E scores)



Estimated decomposition of portfolio returns (E scores)

Portfolio	Market	Brown	Green	Green-Brown
Short-run consumption risk premium	0.08%	0.04%	0.02%	-0.02%
	(0.69%)	(0.77%)	(0.65%)	(0.30%)
Long-run consumption risk premium	9.10%	9.66%	8.48%	-1.19%
	(1.41%)	(1.88%)	(1.35%)	(0.78%)
ESG supply risk premium	0.01%	0.01%	0.01%	0.00%
	(0.01%)	(0.01%)	(0.02%)	(0.00%)
ESG demand risk premium	0.05%	-0.22%	0.19%	0.41%
	(0.02%)	(0.06%)	(0.05%)	(0.12%)
Average convenience yield premium	-0.10%	0.33%	-0.33%	-0.66%
	(0.02%)	(0.09%)	(0.08%)	(0.17%)
Average expected excess return	7.89%	8.25%	7.23%	-1.02%
	(1.27%)	(1.69%)	(1.27%)	(0.83%)
Average expected excess return + δ -induced return	8.19%	6.83%	8.42%	1.59%
	(1.25%)	(1.72%)	(1.20%)	(0.81%)
Average observed excess return	7.92%	6.72%	8.44%	1.72%