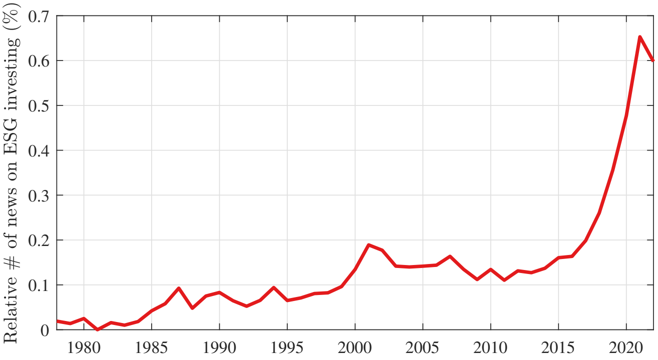
Dynamic ESG Equilibrium

Doron Avramov[1] Abraham Lioui[2] Yang Liu[3] Andrea Tarelli[4]

[1]Reichman University (IDC), Herzliya, Israel
[2]EDHEC Business School, Nice, France
[3]The University of Hong Kong, Hong Kong, China
[4]Catholic University of Milan, Italy

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

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

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

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

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

Euler equation for risky asset return

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

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

$$\begin{aligned}
\Delta c_{t+1} &= \mu_c + x_t + \sigma_c \varepsilon_{c,t+1} \quad \text{(consumption growth)}\\
x_{t+1} &= \rho_x x_t + \sigma_x \varepsilon_{x,t+1} \quad \text{(expected consumption growth)}\\
G_{W,t+1} &= \mu_G + \rho_G G_{W,t} + \sigma_G \varepsilon_{G,t+1} \quad \text{(aggregate ESG supply)}\\
\delta_{t+1} &= \mu_\delta + \rho_\delta \delta_t + \sigma_\delta \varepsilon_{\delta,t+1} \quad \text{(aggregate ESG demand)}
\end{aligned}$$

- 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:

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

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:

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

Unexpected asset return:

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

Risky asset expected excess return

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

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	0.00142	0.01213	-0.00011	0.00063	0.98615	0.00993	0.00020	0.00046	0.00004
(3.21318)	(0.00133)	(0.00061)	(0.00372)	(0.00041)	(0.00898)	(0.00050)	(0.00014)	(0.00015)	(0.00000)
λ_c	λ_G	λ_δ	λ_x						
0.15902	0.00487	0.01072	0.18367						
(0.04053)	(0.00170)	(0.00277)	(0.04511)						

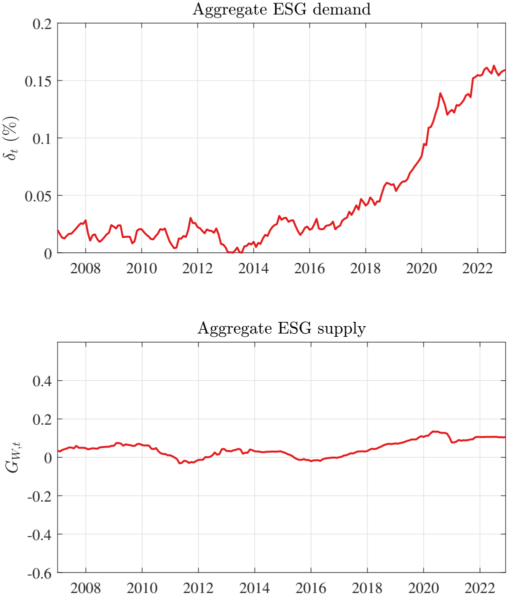
Market portfolio parameters (Θ_M)			
μ_{dM}	$\rho_{dM,x}$	$\sigma_{dM,c}$	σ_{dM}
0.00629	3.54756	0.00032	0.01413
(0.00163)	(0.62219)	(0.00344)	(0.01143)

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	3.63920	0.00235	0.02306	0.00005	-0.00325	0.99124	-0.01618	0.01543
(0.00212)	(0.75289)	(0.00390)	(0.01618)	(0.00166)	(0.00373)	(0.01006)	(0.00139)	(0.00077)

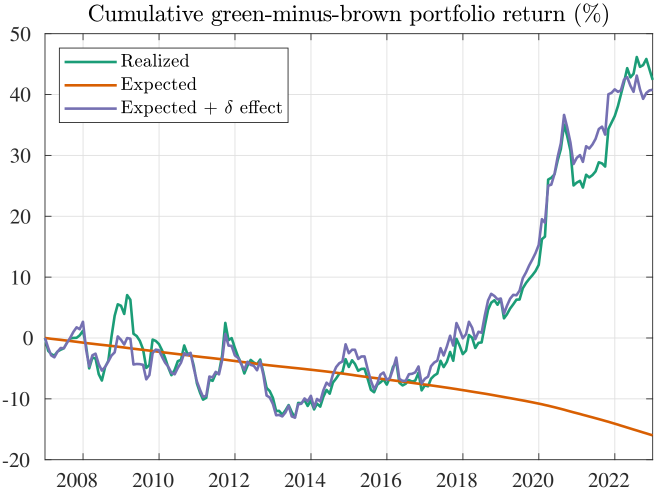
Neutral portfolio parameters (Θ_{neu})								
μ_{dneu}	$\rho_{dneu,x}$	$\sigma_{dneu,c}$	$\sigma_{dneu,dM}$	σ_{dneu}	μ_{Gneu}	ρ_{Gneu}	σ_{GneuG}	σ_{Gneu}
0.00656	3.71070	-0.00127	0.00658	0.00290	-0.00196	0.97152	0.00115	0.00863
(0.00139)	(0.60155)	(0.00354)	(0.01101)	(0.00116)	(0.00138)	(0.01999)	(0.00062)	(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	3.37996	0.00078	0.01692	0.00000	0.00566	0.98229	0.02059	0.01668
(0.00175)	(0.62662)	(0.00333)	(0.01239)	(0.00064)	(0.00348)	(0.01090)	(0.00161)	(0.00080)

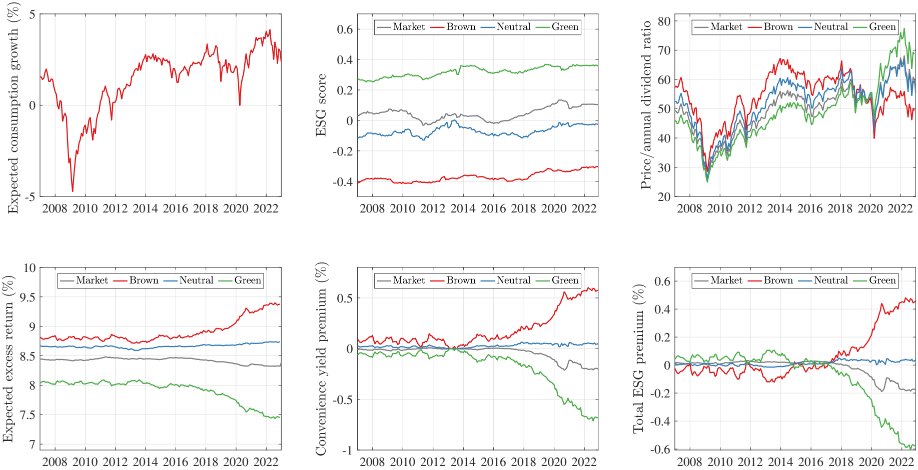
Aggregate ESG demand and supply



Returns of green-minus-brown portfolio



Estimated time series

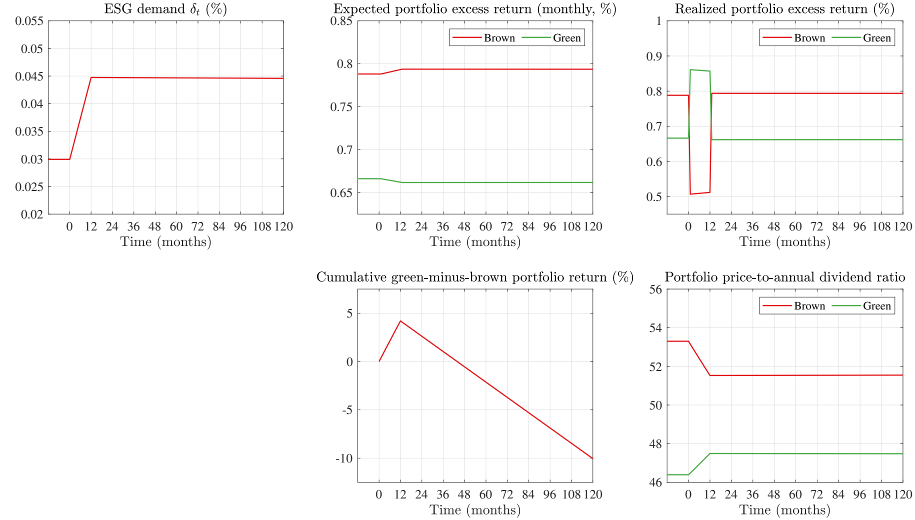


Estimated decomposition of portfolio returns

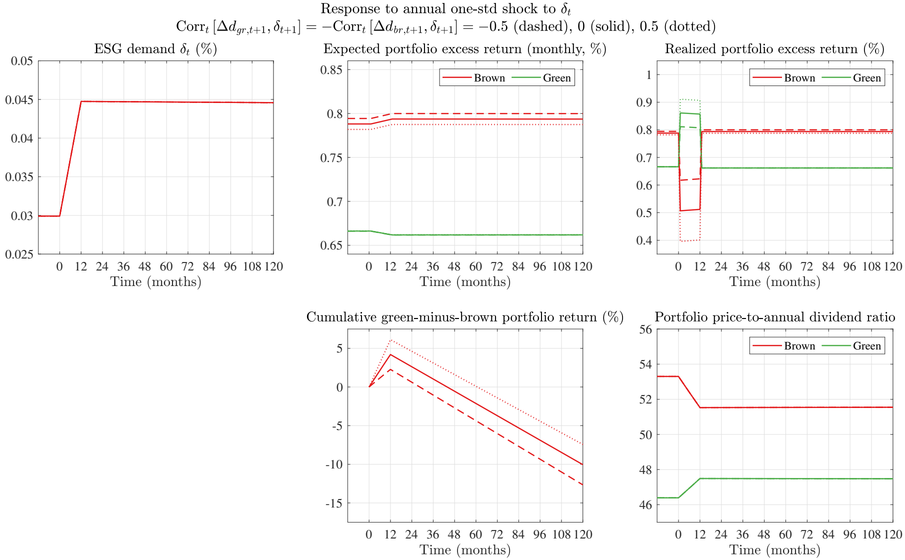
Portfolio	Market	Brown	Green	Green-Brown
Short-run consumption risk premium	0.06%	0.45%	0.15%	-0.30%
	(0.71%)	(0.78%)	(0.67%)	(0.27%)
Long-run consumption risk premium	9.63%	9.99%	9.05%	-0.94%
	(2.03%)	(2.52%)	(2.06%)	(0.58%)
ESG supply risk premium	0.01%	0.00%	0.01%	0.01%
	(0.01%)	(0.01%)	(0.01%)	(0.00%)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

Shock to aggregate ESG demand

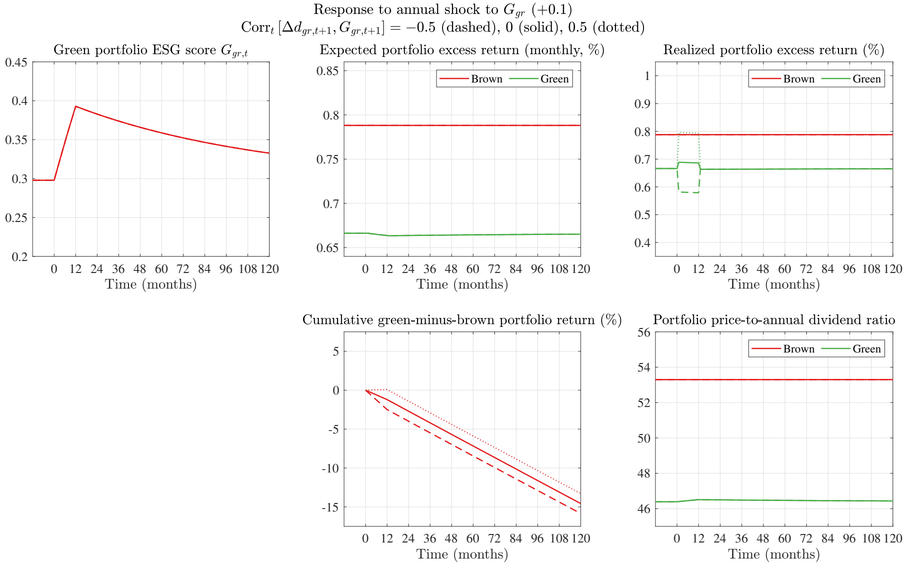
Annual one-standard deviation shock to δ_t



Impact of casflows' correlation with ESG demand



Impact of casflows' correlation with ESG score



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

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

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

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

$$
\begin{aligned}
pc_t &= A_{pc,0} + A_{pc,G} G_{W,t} + A_{pc,\delta}\delta_t + A_{pc,x} x_t \quad \text{(price/consumption)} \\
r_{W,t+1} &= r_{W,0} - A_{pc,G}\left(1 - \kappa_{rW,pc}\rho_G\right) G_{W,t} - A_{pc,\delta}\left(1 - \kappa_{rW,pc}\rho_\delta\right)\delta_t \\
&\quad + \left(1 - A_{pc,x}\left(1 - \kappa_{rW,pc}\rho_x\right)\right) x_t \\
&\quad + A_{pc,G}\kappa_{rW,pc}\sigma_G\varepsilon_{G,t+1} + A_{pc,\delta}\kappa_{rW,pc}\sigma_\delta\varepsilon_{\delta,t+1} \\
&\quad + A_{pc,x}\kappa_{rW,pc}\sigma_x\varepsilon_{x,t+1} + \sigma_c\varepsilon_{c,t+1} \quad \text{(return on wealth)} \\
m_{t+1} &= m_0 + m_G G_{W,t} + m_\delta\delta_t + m_x x_t \\
&\quad - \lambda_c\varepsilon_{c,t+1} - \lambda_G\varepsilon_{G,t+1} - \lambda_\delta\varepsilon_{\delta,t+1} - \lambda_x\varepsilon_{x,t+1} \quad \text{(SDF)}
\end{aligned}
$$

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:

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

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

Market expected excess return

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

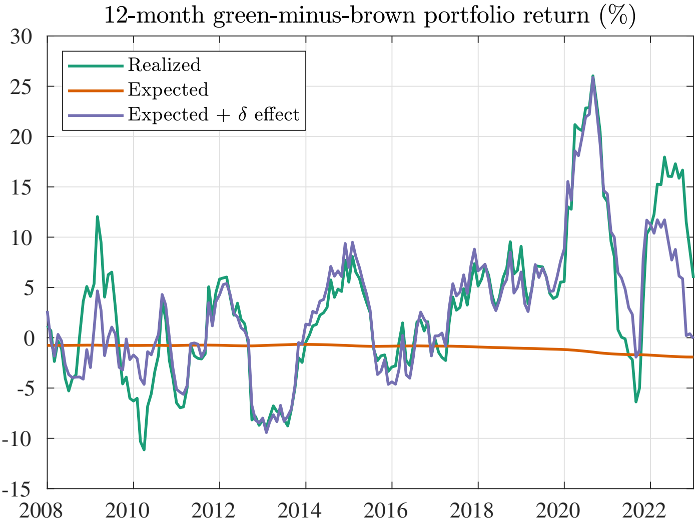
Risky asset price-to-dividend ratio and return

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

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

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

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	0.00126	0.01210	0.00060	0.00482	0.94828	0.01171	0.00010	0.00074	0.00004
(2.14109)	(0.00131)	(0.00061)	(0.00361)	(0.00143)	(0.01539)	(0.00059)	(0.00017)	(0.00020)	(0.00000)
λ_c	λ_G	λ_δ	λ_x						
0.14406	0.00447	0.01966	0.16618						
(0.02711)	(0.00150)	(0.00557)	(0.03100)						

Market portfolio parameters (Θ_M)

μ_{dM}	$\rho_{dM,x}$	$\sigma_{dM,c}$	σ_{dM}
0.00591	3.67321	0.00045	0.00360
(0.00130)	(0.44889)	(0.00351)	(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	3.83717	0.00021	0.01347	0.00243	-0.04111	0.88881	-0.01880	0.01983
(0.00159)	(0.54060)	(0.00390)	(0.01568)	(0.00140)	(0.01032)	(0.02790)	(0.00173)	(0.00098)

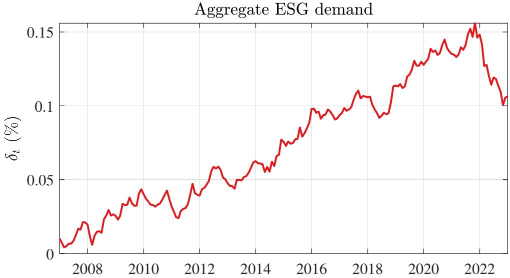
Neutral portfolio parameters (Θ_{neu})

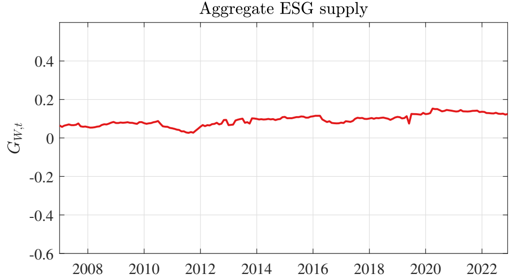
μ_{dneu}	$\rho_{dneu,x}$	$\sigma_{dneu,c}$	$\sigma_{dneu,dM}$	σ_{dneu}	μ_{Gneu}	ρ_{Gneu}	σ_{GneuG}	σ_{Gneu}
0.00645	3.85533	0.00082	-0.00186	0.00002	-0.00747	0.88316	-0.00010	0.01124
(0.00131)	(0.48365)	(0.00373)	(0.01061)	(0.00061)	(0.00225)	(0.03513)	(0.00080)	(0.00057)

Green portfolio parameters (Θ_{gr})

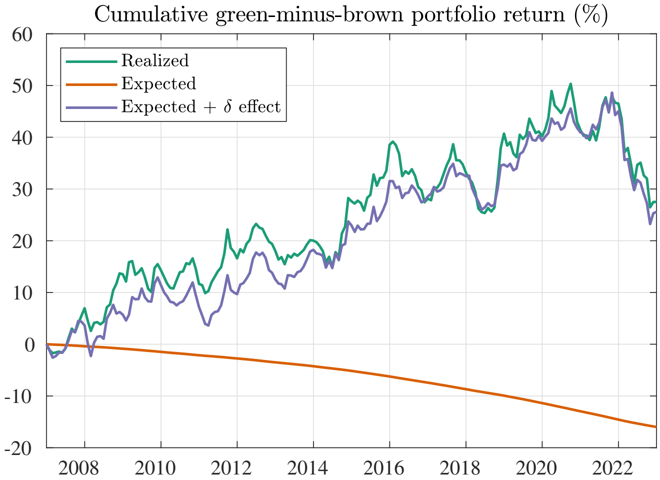
μ_{dgr}	$\rho_{dgr,x}$	$\sigma_{dgr,c}$	$\sigma_{dgr,dM}$	σ_{dgr}	μ_{Ggr}	ρ_{Ggr}	σ_{GgrG}	σ_{Ggr}
0.00537	3.46500	0.00012	0.00488	0.00127	0.03025	0.91331	0.02521	0.01528
(0.00132)	(0.42140)	(0.00332)	(0.00975)	(0.00032)	(0.00772)	(0.02213)	(0.00170)	(0.00073)

Aggregate ESG demand and supply (E scores)

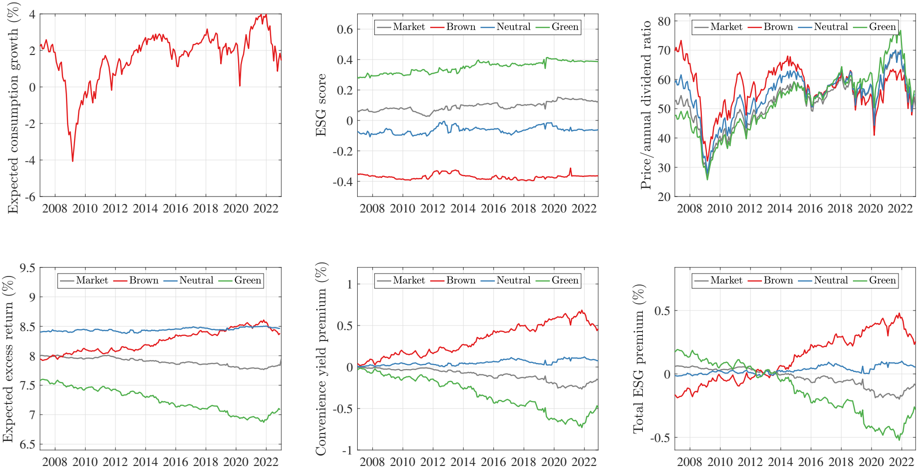




Returns of green-minus-brown portfolio (E scores)



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%