

In Search of the True Greenium

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Research question: How big is the greenium?

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Reward or cost of ESG investing?



- Doing well by doing good: $\text{greenium} > 0$
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Cost of capital for green vs. brown firms?



- Cheap funding for green, e.g., wind
- Expensive funding for brown, e.g., coal

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Environmental perspective

Does ESG investing help?



- Pedersen (2025): is greenium large enough to save the climate?

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Empirical perspective: So how big is the greenium?

Conflicting results in the literature

Large literature, mainly focused on realized returns in the US

- Mixed results and large confidence intervals
- Many data providers and sub-measures, some with biases
- Different and short time periods (mostly since mid/late 2000s)

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Empirical examples:

- Hsu et al. (2023): Green stocks underperform brown by 440 bps/yr
- Pastor et al. (2022): Green stocks outperform brown by 780 bps/yr

Related results in Bolton and Kacperczyk (2021, 2022), Aswani et al. (2024), and Zhang (2024)

Paper part I: Large-scale global greenium replication

What we do

- Realized returns of green-minus-brown (GMB) portfolios
 - across 23 greenness measures
 - in US + 48 countries

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What we find

- Globally, GMB returns are centered around zero
- Multiple testing $\rightarrow$ all estimates become insignificant
- Problems: short time series, noisy realized returns, repricing

Paper part II: Searching for the true greenium

What we do

- Propose asset pricing theory with many greenness measures
- Based on this theory, estimate the greenium using
 - An aggregate green score
 - Forward-looking expected returns
- In equities, corporate bonds, WACC, and sovereign bonds

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What we find

- Equity greenium: -39bps per $\sigma(\text{green score})$, implying
$$E(r^{\text{green}} - r^{\text{brown}}) = -82\text{bps}$$
- Magnitude larger in greener countries and recent sample
- Smaller greeniums for corporate bonds, WACC, and sovereigns
- Can greenium address global warming?

Part I: Replicating the literature

Replicating the literature: green-minus-brown portfolios

Existing literature

- US-centric
- 1 greenness measure per paper
- Different sample periods
- Different industry/risk adj.
- No multiple-testing adjustment

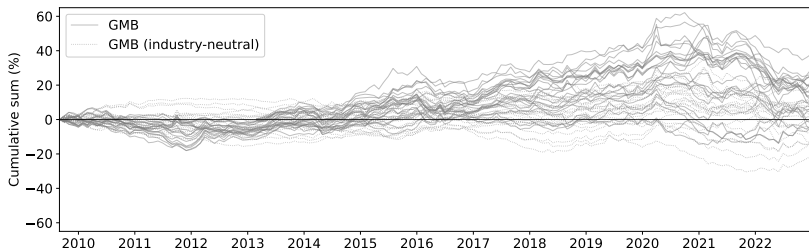
Our scientific replication

- US + 48 countries
- 23 greenness measures
- Extended sample period
- All combinations
- Benjamini-Hochberg adj.

Greenness measures

Name	Time period	Avg. <i>N</i> (US)	Avg. <i>N</i> (Global ex-US)	Source
Aggregate Green Score	2009-08 to 2022-12	1966	6002	Several
LOG(S1TOT)	2009-05 to 2022-12	1337	5933	Trucost
LOG(S1+2TOT)	2009-05 to 2022-12	1337	5933	Trucost
LOG(S1+2+3TOT)	2009-05 to 2022-12	1337	5933	Trucost
S1INT (Sales)	2009-05 to 2022-12	1337	5932	Trucost
S1+2INT (Sales)	2009-05 to 2022-12	1337	5932	Trucost
S1+2+3INT (Sales)	2009-05 to 2022-12	1337	5932	Trucost
S1INT (Assets)	2009-05 to 2022-12	1337	5933	Trucost
S1+2INT (Assets)	2009-05 to 2022-12	1337	5933	Trucost
S1+2+3INT (Assets)	2009-05 to 2022-12	1337	5933	Trucost
Ind.-adj. ESG score	2007-01 to 2022-12	1529	3333	MSCI
Weighted ESG score	2007-01 to 2022-12	1529	3332	MSCI
Environment score	2007-01 to 2022-12	1529	3333	MSCI
Greenness (PST)	2007-01 to 2022-12	1528	3333	MSCI
E climate score	2013-01 to 2022-12	2043	4384	MSCI
E nat. res. score	2013-01 to 2022-12	1449	3285	MSCI
E waste score	2013-01 to 2022-12	1374	2685	MSCI
E env. opps. score	2013-01 to 2022-12	718	1840	MSCI
Total ESG score	2009-08 to 2022-12	788	2717	Sustainalytics
Environmental score	2009-08 to 2022-12	788	2718	Sustainalytics

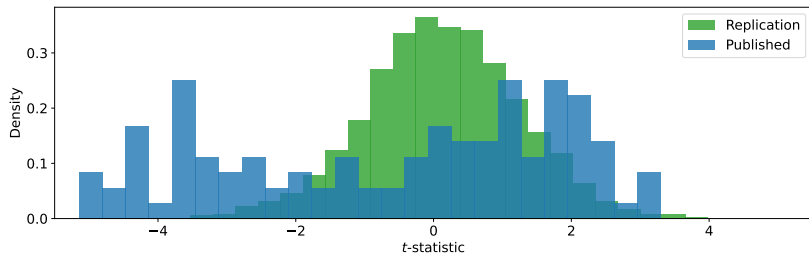
Replicating the literature: US green-minus-brown portfolios



Cumulative returns of 46 US GMB portfolios:

- 23 greenness measures
- Industry-neutral or agnostic

GMB Performance: Replicated vs. Published



Why can greenium not be estimated with realized returns?

- We estimate

$$SR^{GMB} = -0.82\% / 5.4\% = -0.15$$

- The Sharpe ratio of a strategy is linked to its t -statistic:

$$t = \sqrt{T} \times \frac{E[r]}{\sigma} = \sqrt{T} \times SR = -0.55$$

- How many years T needed for significance (i.e., $t = -1.96$):

$$T = \left(\frac{1.96}{SR} \right)^2 = \left(\frac{1.96}{0.1} \right)^2 = 167 \text{ years}$$

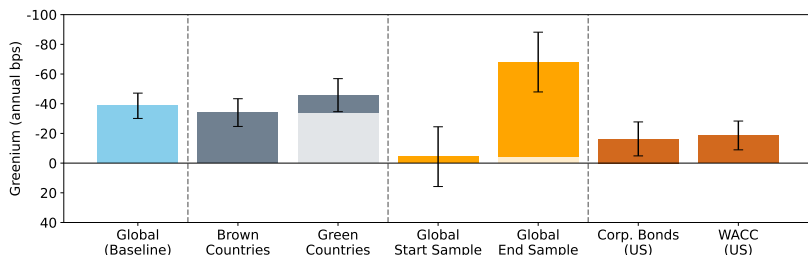
Our Greenium Estimates

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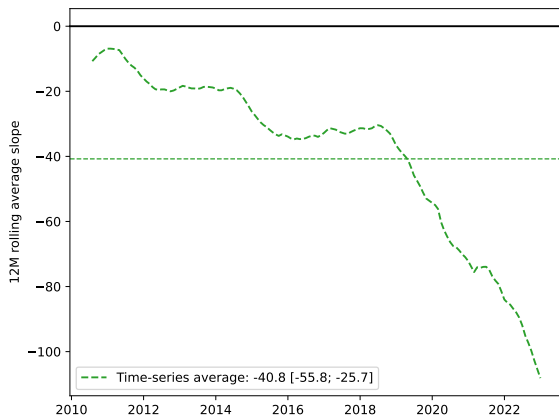
New estimate of greenium, g , based on

- forward-looking exp. returns, $\hat{E}_t(r_{t+1}^n)$: implied cost of capital
- aggregate green score, s_t^n

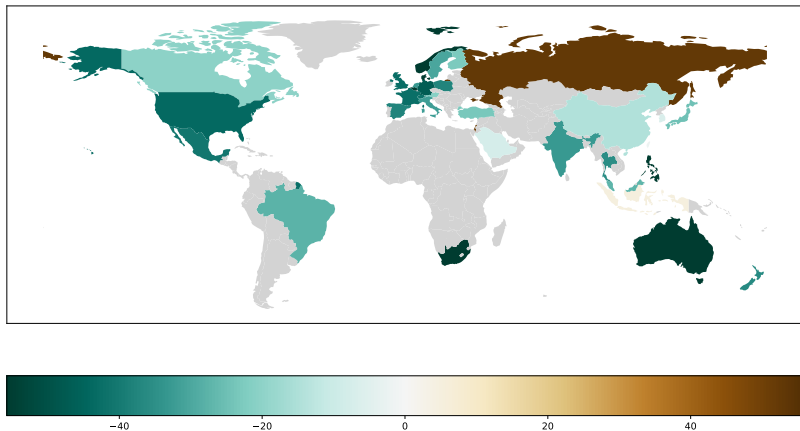
$$\hat{E}_t(r_{t+1}^n) = g \times s_t^n + \text{controls} + \varepsilon_{t+1}^n$$



Global equity greenium over time

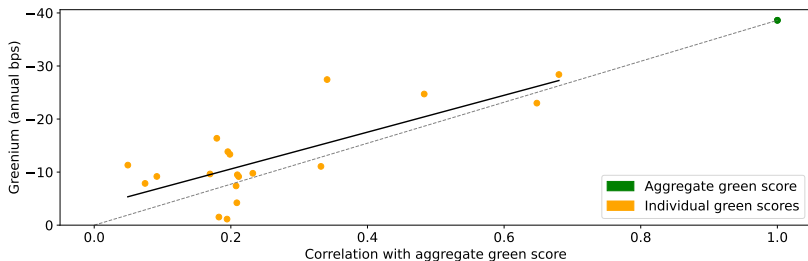


Global greenium map



Individual greenium estimates

Individual greeniums vs correlation with aggregate green score



Larger greeniums for more popular green scores

Can the greenium solve global warming?

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- **Problem:**

- Externality: emission
- Social cost of carbon, S

- **Solution based on:**

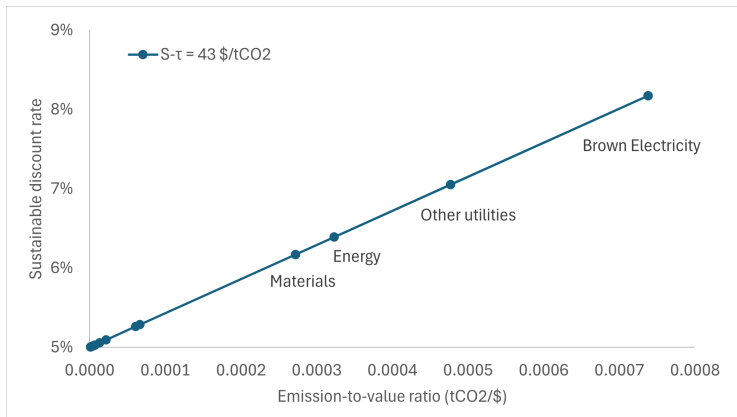
- Economics: firm pays tax of $S \times \text{emission}$
- Sustainable finance: translate tax into a higher cost of capital

$$\text{CoC} = r + (\text{Desired carbon tax} - \text{Actual tax}) \times \frac{\text{Emission}}{\text{Firm value}}$$

Pedersen (2025), "Carbon Pricing versus Green Finance,"
Journal of Finance, forthcoming

Sustainable discount rates to save the climate

$$\begin{aligned}\text{CoC} &= r + (\text{Desired carbon tax} - \text{Actual tax}) \times \frac{\text{Emission}}{\text{Firm value}} \\ &= 5\% + 43\$/\text{tCO}_2 \times \frac{\text{Emission}}{\text{Firm value}}\end{aligned}$$



Empirical results for CO₂: Implied cost of capital

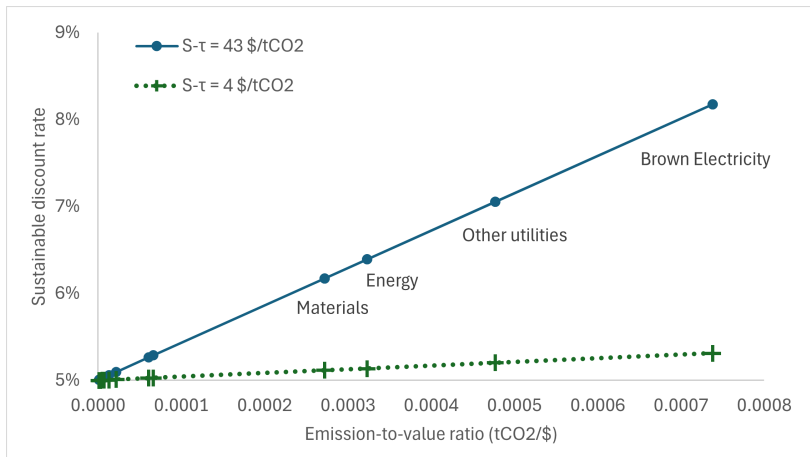
- Empirical counterpart with regression coefficient b :

$$\hat{E}_t(r_{it+1}) = b \times \frac{\text{Emission}}{\text{Firm value}} + \text{controls} + \varepsilon_{it+1}$$

- EJIP estimate this relation

- $\hat{E}_t(r_{it+1})$: implied cost of capital (ICC)
- Controls: country-time FE, beta, log book eq., net debt-to-assets, ebit-to-assets
- $\hat{b} = 4.2$ is the “tax” on externality due to climate finance
- t -statistic 2.13

Empirical results for CO₂: Implied cost of capital



- Greenest firms: $\frac{it+1}{v_{it}}$ close to zero
- Dirty: $\frac{it+1}{v_{it}} = 0.00074$ for brown electricity
- Return spread: $GMB = 4.2 \times (0 - 0.00074) = -0.31\%$

Conclusion

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- Greenium central to ESG investors for their
 - financial performance
 - impact on the environment via cost of capital
- Magnitude of greenium
 - not trivial in size
 - but not enough to drive green transition

