Dissecting green returns

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(JFE ， 2022)

1.Introduction

Past performance is a popular marketing tool, and indeed a number of studies report **superior historical returns** to **sustainable strategies** (e.g., Edmans, 2011; Nagy et al., 2016; In et al., 2019).

- **Warning:** past performance does not necessarily predict future performance.

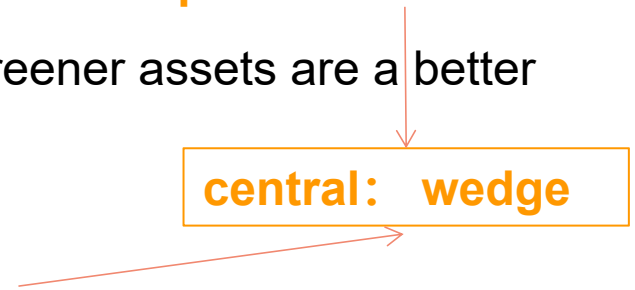
➡ **Q:** Should green stocks′ recent outperformance lead one to expect high green returns going forward?

- No, likely reflects an unanticipated increase in environmental concerns： bad news about climate change→green stocks >brown←hedges against climate shocks.

1.Introduction

Address this question empirically, guided by the equilibrium model of Pástor et al. (2021, henceforth PST).

- PST model predicts that green assets have **lower expected returns** than brown： investors have **green tastes**, and greener assets are a better hedge against climate **risk**.



- green assets can have **higher realized returns** while agents' demands shift unexpectedly in the green direction： investors' **demand for green assets** can increase, directly driving up green asset prices； consumers' demand for **green products can strengthen**—driving up green firms'profits and thus their stock prices.

2.Research design

stock expected returns hard to estimate→bond: yield to maturity

- highlights the gap between expected and realized returns in the context of **German twin bonds**.
- describes how we measure greenness for U.S. stocks ESG→GMB factor
- compares the **realized performance** of green versus brown stocks.
- implements two approaches to estimating the **expected return** on the green-minus-brown stock portfolio.
- documents the delayed reaction of stock prices to **climate news**.
- construct the green factor and explore its role in pricing **value and momentum.**

2.Research design

2.1. measure greenness for U.S. stocks

Stock-level environmental scores--**MSCI ESG Ratings** data：

- world′ s largest provider
- covers more firms than other ESG raters
- the least noisy among the eight ESG data vendors

- MSCI′ s composite ESG rating is **industry-adjusted**--choose granular data

E_score（0-10）：firm′ s weighted-average score across 13 environmental issues related to climate change, natural resources, pollution and waste, and environmental opportunities --resilience to longterm environmental risks.

E_weight（0-100）：firms in the same industry, importance of environmental issues relative to social and governance issues.

$$G_{i,t-1} = -(10 - E\_score_{i,t-1}) \times E\_weight_{i,t-1}/100, \qquad (1)$$

2.Research design

2.1. measure greenness for U.S. stocks

greenness score of firm i at the beginning of month t as:

i′ s most recent MSCI ratings date before month t

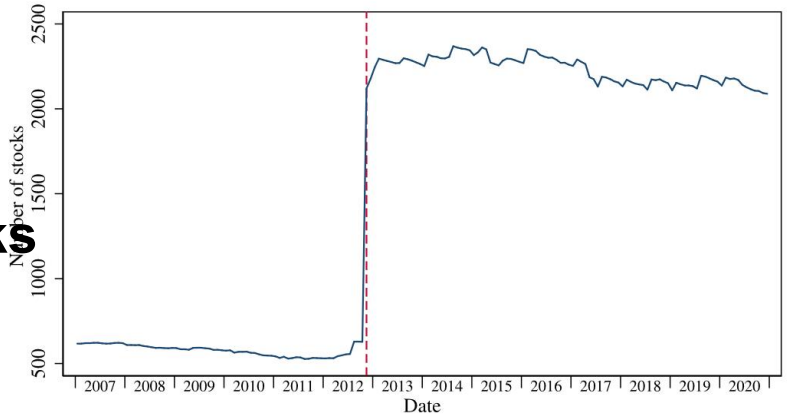
$$G_{i,t-1} = -(10 - E\_score_{i,t-1}) \times E\_weight_{i,t-1}/100, \qquad (1)$$

- $10 - E\_score_{i,t-1}$ measures how far the company is from a perfect environment score of 10.
- $(10 - E\_score_{i,t-1}) \times E\_weight_{i,t-1}$ measures how brown the firm is
- Interaction of how badly the firm scores on environmental issues and how large the environmental impacts are for the industry′ s typical firm

eg: oil and gas companies have larger environmental impacts than consumer retail companies.

2.Research design

2.1. measure greenness for U.S. stocks



Environmental score：

$$g_{i,t} = G_{i,t} - \overline{G}_t,$$

- $\overline{G}_t$: value-weighted average of $G_{i,t}$ across all firms i.
- measures the company′ s greenness relative to the market portfolio

$$w_t^{'} g_t = 0$$

- w_t and g_t denote the vectors containing stocks' market weights and $g_{i,t}$ values

GMB: monthly return diff greenness scores in the top third-bottom third.

2. Research design

2.2. estimating the **expected return**

Define the equity greenium as the **expected return on the GMB spread**:

- uses ex ante data: **implied cost of capital (ICC)**, which is the discount rate that equates the **stock's current price** to the present value of **expected future cash flows**

- uses ex post data: purged of unanticipated shocks to quantities affecting the return--**PST green demand**--increased concerns about climate change--**climate concern shocks and earnings news shocks**

2.Research design

2.2. estimating the **expected return**

uses ex ante data: **implied cost of capital (ICC)**-Hou(2012)

- r_e : the internal rate of return that equates the **present value of future dividends** to the **current stock price**:

$$P_{i,t} = B_{i,t} + \sum_{\tau=1}^{\infty} \frac{E_t[EPS_{i,t+\tau}] - r_e E_t[B_{i,t+\tau}]}{(1+r_e)^{\tau}},$$

$$P_t = B_t + \sum_{\tau=1}^{11} \frac{E_t[(ROE_{t+\tau} - r_e)B_{t+\tau-1}]}{(1+r_e)^{\tau}} + \frac{E_t[(ROE_{t+12} - r_e)B_{t+11}]}{r_e(1+r_e)^{11}}.$$

$EPS_{i,t+\tau}$ is the forecast of earnings per share in year $t+\tau$, and $B_{i,t+\tau}$ is the book value per share; earnings equal ROE times book equity

2.Research design

2.2. estimating the **expected return**

Inferring expected return from past realizations-**PST green demand**:

- addresses the general problem of inferring an asset's unconditional expected return, $\mu = E\{r_t\}$, using ex post data.

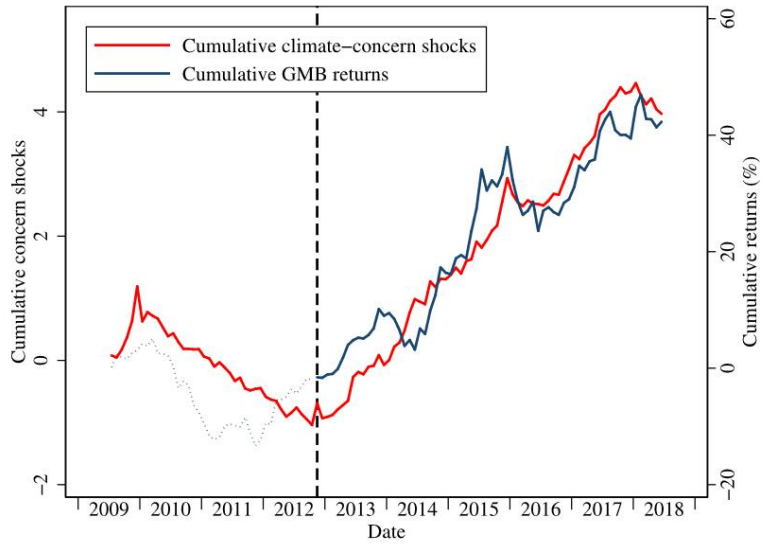
  - use the asset's sample average return, $\bar{r}$ as the estimate of μ.
  - exploit the additional information in the contemporaneous history of another variable, x_t , that is correlated with the return and for which $E\{x_t\} = 0$ --x_t: unanticipated change in climate concerns.

$$r_t = a + bx_t + \epsilon_t$$

$a = \mu$ because x_t has zero mean ex ante. Therefore, we can estimate μ by the sample estimate of a.

2.Research design

2.2. estimating the **expected return**



$$r_t = a + bx_t + \epsilon_t$$

Estimator 1: $\bar{r}$ Estimator 2: $\hat{a} = \bar{r} - b\bar{x}$.

- signed $\hat{b} > 0$,suppose the realizations of x_t exceed their expectation on average,so that $\bar{x} > 0$.→ $\bar{r}$ overstates μ by $b\bar{x}$ on average.

- x_t--Measuring shocks to **climate concerns** and earnings
  - concerns about climate change with the **Media Climate Change Concerns index (MCCC)** of Ardia et al. (2021).(2003.1 - 2018.6), constructed by using data from eight major U.S. newspapers.

  → measure shocks to climate concerns as **prediction errors from AR(1)** (36 months)models applied to the underlying MCCC index.

  → $x_t : \Delta C_t, \Delta C_{t-1}$

2.Research design

2.2. estimating the **expected return**

- x_t--Measuring shocks to climate concerns and **earnings**
  - a large portion of earnings news occurs on days when firms make earnings related **announcements** (Beyer et al., 2010)： quarterly earnings & voluntary forward guidance regarding future earnings.

  → compute stock returns in excess of the market during the three-trading-day windows

  → add the excess returns within a given stock-quarter→explains 20%var

  - captures news about **long-term earnings**： analysts' forecasts of each firm's long-run earnings growth rate.

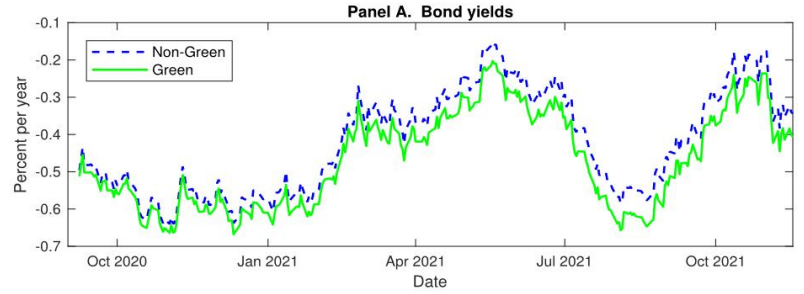
  → i,t: earliest mean analyst forecast in quarter $t+1$ minus latest in $t-1$

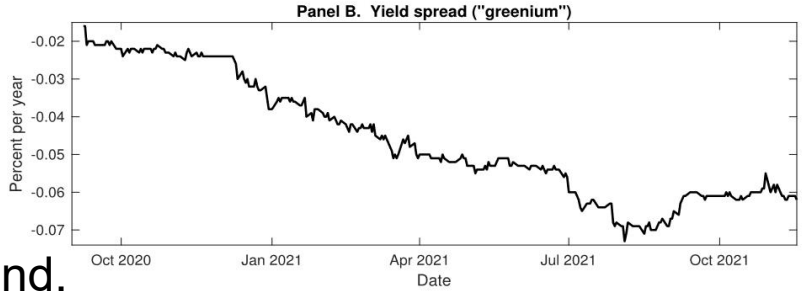
  → significantly related to quarterly stock-level returns but explains <1%var

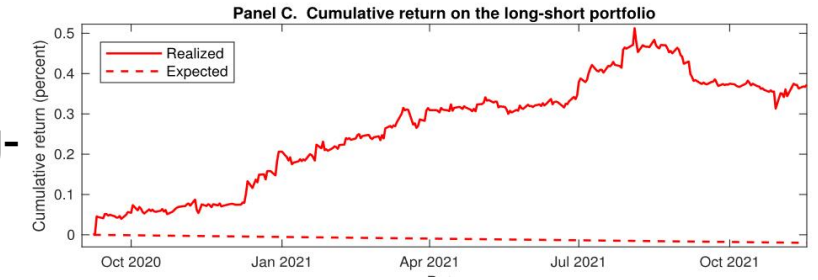
3. Empirical results

3.1. German government bond yields and returns:

	Green bond	Non-green bond	Difference
Panel A. Yields to maturity (basis points per year)			
Average	-46.72	-42.09	-4.63
	(-13.53)	(-10.90)	(-6.19)
First day	-51.20	-49.60	-1.60
Last day	-40.60	-34.40	-6.20
Panel B. Realized returns			
Average	-0.47	-0.59	0.12
	(-0.35)	(-0.44)	(2.19)
Cumulative	-1.53	-1.90	0.37





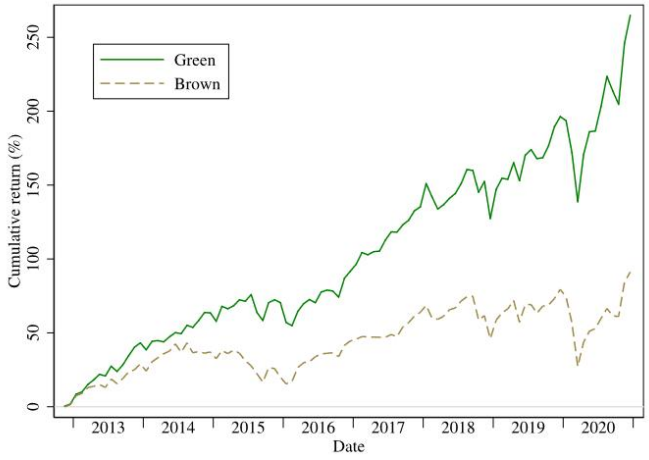


- green bond always has a lower expected return than the non-green bond. **greenium**
- the positive average return of the long-short portfolio

3. Empirical results

3.2. Realized green stock returns:

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	0.65	0.71	0.50	0.47	0.50	0.50	0.55	0.49
	(3.23)	(2.91)	(2.23)	(2.14)	(2.25)	(2.38)	(2.28)	(1.99)
Mkt-RF		-0.05	0.02	0.05	0.01	0.04	-0.00	0.01
		(-0.78)	(0.32)	(0.87)	(0.21)	(0.77)	(-0.05)	(0.23)
SMB			-0.14	-0.11	-0.16	-0.26		
			(-1.49)	(-1.23)	(-1.56)	(-2.59)		
HML			-0.26	-0.18	-0.26	-0.21		
			(-3.36)	(-1.99)	(-3.26)	(-2.60)		
UMD				0.13				
				(2.00)				
LIQ					0.04			
					(0.60)			
RMW						-0.39		
						(-2.90)		
CMA						-0.10		
						(-0.60)		
ME							-0.15	-0.13
							(-1.48)	(-1.28)
I/A							-0.30	-0.25
							(-2.21)	(-1.59)
Roe							0.09	0.02
							(0.99)	(0.20)
Eg								0.12
								(0.67)
Observations	98	98	98	98	98	98	98	98
R^2	0.00	0.01	0.19	0.22	0.19	0.26	0.13	0.14

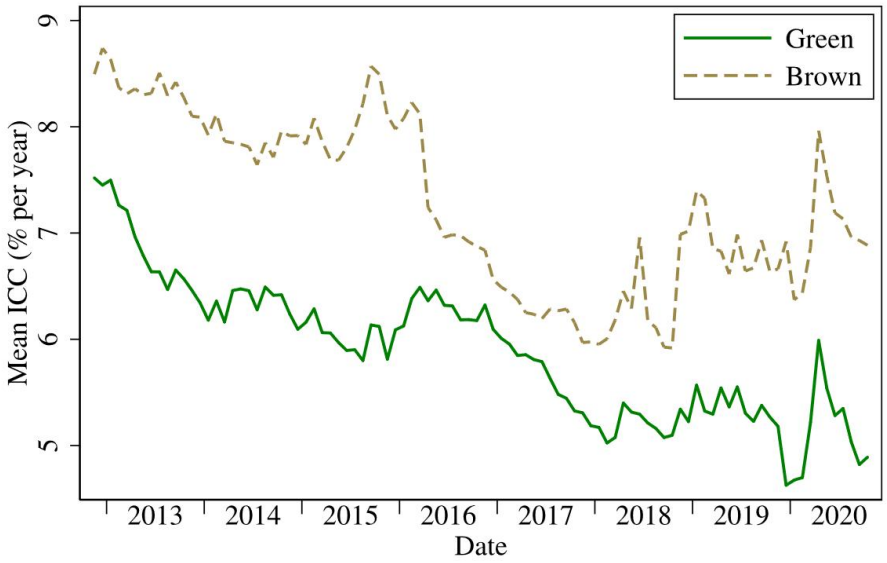


- This strong performance of GMB cannot be explained by exposures to return factors prominent in the asset pricing literature.
- Its exposures to SMB, HML, and UMD indicate that GMB tilts toward large stocks, growth stocks, and recent winners.

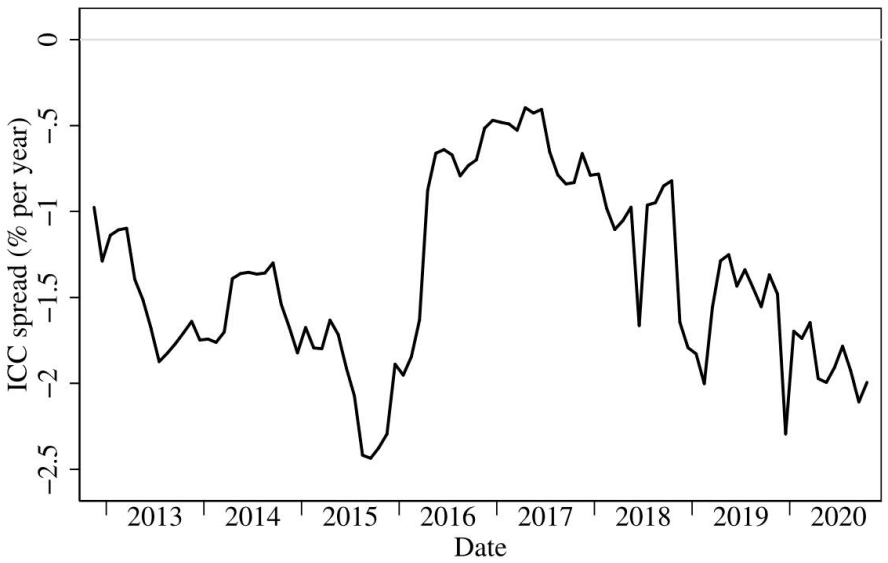
3. Empirical results

3.3. ICC estimates of the equity greenium

Panel A: ICCs of green and brown portfolios



Panel B: ICC spread (equity greenium)



- consistently negative equity greenium→−12 bps per month.

3. Empirical results

$$r_t = a + bx_t + \epsilon_t$$

3.4. Estimates of the equity greenium using past realizations

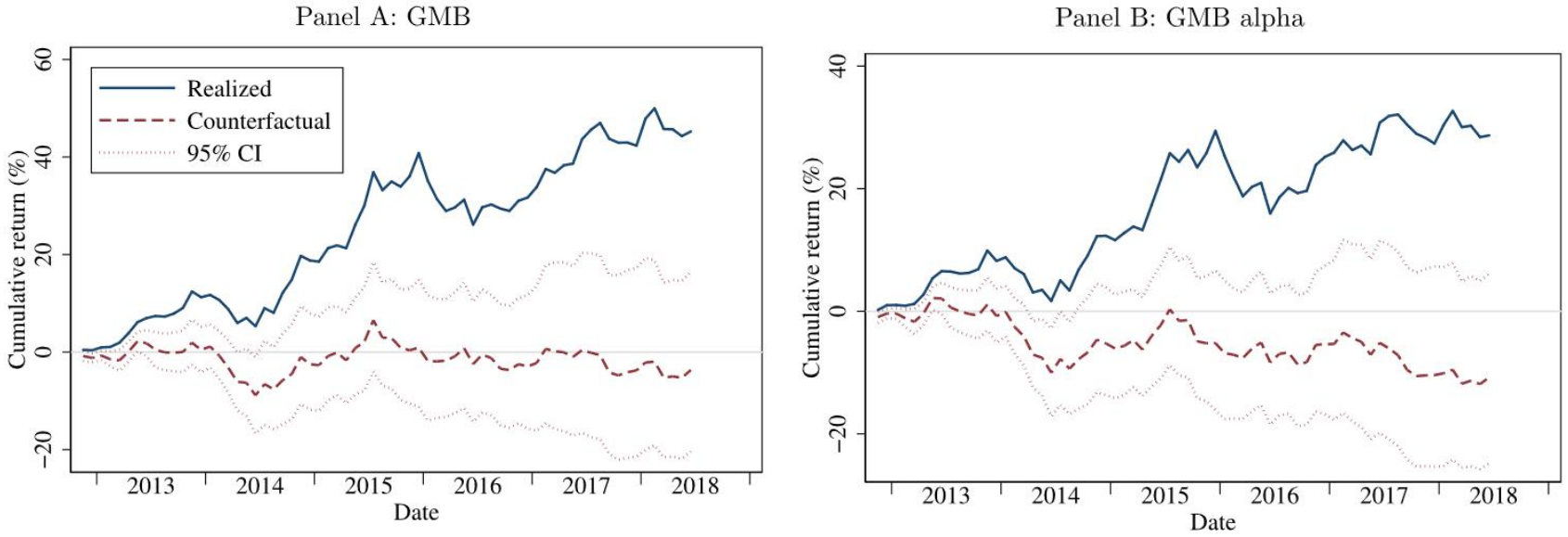
	Dependent variable			
Independent variable	GMB return		GMB alpha	
Δ Climate concerns (same month)	4.08	3.75	3.95	3.44
	(2.70)	(2.69)	(2.79)	(2.70)
Δ Climate concerns (prev. month)	2.98	2.86	2.64	2.33
	(1.86)	(1.77)	(1.97)	(1.82)
Earnings announcement returns		0.77		0.63
		(2.64)		(2.31)
Δ Earnings forecasts		6.93		14.16
		(0.44)		(0.96)
Constant	0.05	-0.04	-0.10	-0.15
	(0.20)	(-0.15)	(-0.41)	(-0.66)
Observations	68	68	68	68
R^2	0.14	0.25	0.14	0.26

- an increase in climate concerns is worse news for brown stocks than green stocks
- the equity greenium, intercept $\hat{\alpha}$, −4 bps per month.

3. Empirical results

3.4. Estimates of the equity greenium using past realizations

Counterfactual GMB performance.



- absent shocks to climate concerns and earnings, GMB′ s performance is slightly downward-trending,

3. Empirical results

3.5. Greenness and individual stock returns

	(1)	(2)	(3)	(4)
$g_{i,t-1}$	0.21	0.00	-0.02	-0.04
	(2.24)	(0.02)	(-0.23)	(-0.41)
$g_{i,t-1} \times \Delta C_t$		0.83	0.81	0.72
		(1.42)	(1.59)	(1.28)
$g_{i,t-1} \times \Delta C_{t-1}$		1.70	1.54	1.65
		(2.66)	(2.78)	(2.68)
$[\text{Earnings announcement ret.}]_{i,t}$			0.32	0.32
			(13.28)	(12.38)
$[\Delta \text{ Earnings forecast}]_{i,t}$			5.89	5.91
			(5.02)	(4.58)
Observations	218,208	153,884	133,290	114,355
R^2	0.18	0.11	0.18	0.19
Additional controls	No	No	No	Yes

- absent shocks to climate concerns and earnings, GMB′ s performance is slightly downward-trending,

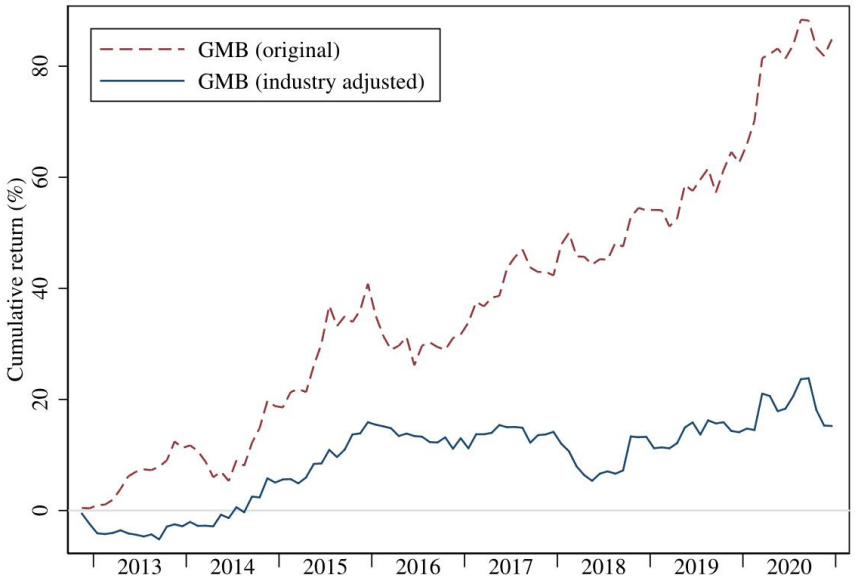
3.Empirical results

3.6. Industry greenness

the greenness of the firm′ s industry and the relative greenness of the firm within its industry.

$$g_{i,t} = gAcross_{i,t} + gWithin_{i,t},$$

- $gAcross_{i,t}$ equal to the average $g_{i,t}$ of all firms within the **same industry** as stock i in month t



3. Empirical results

3.6. Industry greenness

$$g_{i,t} = gAcross_{i,t} + gWithin_{i,t},$$

	(1)	(2)	(3)	(4)
$gAcross_{i,t-1}$	0.25	-0.00	-0.02	-0.05
	(2.14)	(-0.01)	(-0.18)	(-0.39)
$gWithin_{i,t-1}$	0.07	0.02	-0.02	-0.01
	(1.11)	(0.28)	(-0.27)	(-0.11)
$gAcross_{i,t-1} \times \Delta C_t$		1.08	1.05	0.94
		(1.49)	(1.66)	(1.33)
$gWithin_{i,t-1} \times \Delta C_t$		-0.13	-0.08	-0.09
		(-0.28)	(-0.17)	(-0.16)
$gAcross_{i,t-1} \times \Delta C_{t-1}$		2.01	1.86	1.94
		(2.58)	(2.74)	(2.57)
$gWithin_{i,t-1} \times \Delta C_{t-1}$		0.49	0.34	0.56
		(1.05)	(0.70)	(1.00)
$[\text{Earnings announcement ret.}]_{i,t}$			0.32	0.32
			(13.28)	(12.38)
$[\Delta \text{ Earnings forecast}]_{i,t}$			5.85	5.88
			(5.01)	(4.57)
Observations	218,208	153,884	133,290	114,355
R^2	0.18	0.11	0.18	0.19
Additional contrls	No	No	No	Yes

- **industry greenness** is the key component of a firm′ s greenness, capturing both the superior past performance of green stocks as well as the climate-shock source of that performance.

3. Empirical results

3.7. Delayed stock price reaction to climate news

	ΔC (same month)			ΔC (prev. month)		
Portfolio	Small	Large	Lg. - Sm.	Small	Large	Lg. - Sm.
GMB	2.83	3.91	1.08	7.49	2.79	-4.70
	(1.23)	(2.46)	(0.56)	(2.99)	(1.74)	(-2.35)
Green	0.03	2.27	2.24	-0.14	0.62	0.75
	(0.01)	(3.19)	(0.75)	(-0.06)	(0.83)	(0.28)
Brown	-1.81	-1.39	0.42	-8.49	-2.35	6.14
	(-0.61)	(-1.26)	(0.15)	(-2.71)	(-2.10)	(2.29)

- the reaction is significantly more delayed in the small-cap segment.
- the effect of climate news on small stocks is limited to brown stocks.

3. Empirical results

3.8. The green factor-PST

factor′ s realizations can be estimated month by month by running cross-sectional regressions of market-adjusted excess stock returns on the stocks′ greenness, with no intercept.

$$\hat{f}_{gt} = \frac{g_{t-1}^{'} \tilde{r}_t^e}{g_{t-1}^{'} g_{t-1}}$$

- where $\tilde{r}_t^e \equiv \tilde{r}_t - \beta_{m,t-1}\tilde{r}_{mt}$ is the vector of stocks′ market adjusted excess returns.

	Value		Momentum	
Constant	-0.71	-0.15	0.66	-0.06
	(-1.93)	(-0.50)	(1.92)	(-0.22)
Mkt-RF	0.14	0.07	-0.37	-0.27
	(1.18)	(0.70)	(-3.75)	(-3.14)
Green factor		-0.80		1.05
		(-4.55)		(6.18)
Observations	98	98	98	98
R^2	0.04	0.35	0.17	0.49

- While exposure to the green factor explains most or all of HML and UMD, the reverse is not true--brown nature of value stocks

5. Conclusion

- the portfolio's recent outperformance **vanishes** after removing the effects of unexpected increases in **climate concerns;** the reaction is significantly more delayed in the small-cap segment.

- A two-factor asset pricing model featuring a theoretically motivated **green factor** absorbs much of the **historic underperformance of value stocks** in the 2010s.

- **Key** : new approach to estimate expected return: **removes unanticipated shocks** from the realized average return→ Future research can apply to estimate expected returns in other settings.