Climate Capitalists

Niels Joachim Gormsen, Kilian Huber, and Simon Oh

Copenhagen Business School, University of Chicago, & Columbia University

Can We Raise Green Investment Through the Cost of Capital?

Challenge: incentivize green investments, despite low carbon taxes

Can We Raise Green Investment Through the Cost of Capital?

Challenge: incentivize green investments, despite low carbon taxes

Cost of capital approach

- Green funding (e.g., buy green stocks) $\Uparrow \rightarrow$ green CoC $\Downarrow \rightarrow$ green investment $\Uparrow$
- Can work like carbon tax (Chitarro et al. 2024)
- Even if returns to brown production are high and taxes low

Can We Raise Green Investment Through the Cost of Capital?

Challenge: incentivize green investments, despite low carbon taxes

Cost of capital approach

- Green funding (e.g., buy green stocks) $\Uparrow \rightarrow$ green CoC $\Downarrow \rightarrow$ green investment $\Uparrow$
- Can work like carbon tax (Chitarro et al. 2024)
- Even if returns to brown production are high and taxes low

Broad interest

- 25% of fin. assets under management in ESG funds in 2024
- Green investors: ECB, government funds, BlackRock, Catholic Church, ...

Can We Raise Green Investment Through the Cost of Capital?

Challenge: incentivize green investments, despite low carbon taxes

Cost of capital approach

- Green funding (e.g., buy green stocks) $\Uparrow \rightarrow$ green CoC $\Downarrow \rightarrow$ green investment $\Uparrow$
- Can work like carbon tax (Chitarro et al. 2024)
- Even if returns to brown production are high and taxes low

Broad interest

- 25% of fin. assets under management in ESG funds in 2024
- Green investors: ECB, government funds, BlackRock, Catholic Church, ...

Real impact unclear

- Depends on how firms set their CoC
- CoC unobserved, no agreed calculation, no quant. analysis
- Hard to measure using fin. prices or surveys
- 21% of academics say green firms have lower CoC; 23% no; 55% unsure

Main Results

1. Hand-collected data on CoC **used by firms**

Main Results

1. Hand-collected data on CoC **used by firms**

2. Across firms: CoC of green firms lower since 2016
   - Greenness 3rd-strongest predictor of CoC
   - Suggests: increased investment by green firms

Main Results

1. Hand-collected data on CoC **used by firms**

2. Across firms: CoC of green firms lower since 2016
   - Greenness 3rd-strongest predictor of CoC
   - Suggests: increased investment by green firms

3. Within firms: Large energy firms use lower CoC for green divisions since 2016
   - Suggests: brown firms become greener

Main Results

1. Hand-collected data on CoC **used by firms**

2. Across firms: CoC of green firms lower since 2016
   - Greenness 3rd-strongest predictor of CoC
   - Suggests: increased investment by green firms

3. Within firms: Large energy firms use lower CoC for green divisions since 2016
   - Suggests: brown firms become greener

4. Magnitude in 2023: 2 ppt.
   - 100$ CO2 tax $\approx$ 6-10 ppt. (Pedersen 2023; Chitarro et al. 2024)
   - Sizable potential of CoC channel

Main Results

1. Hand-collected data on CoC **used by firms**

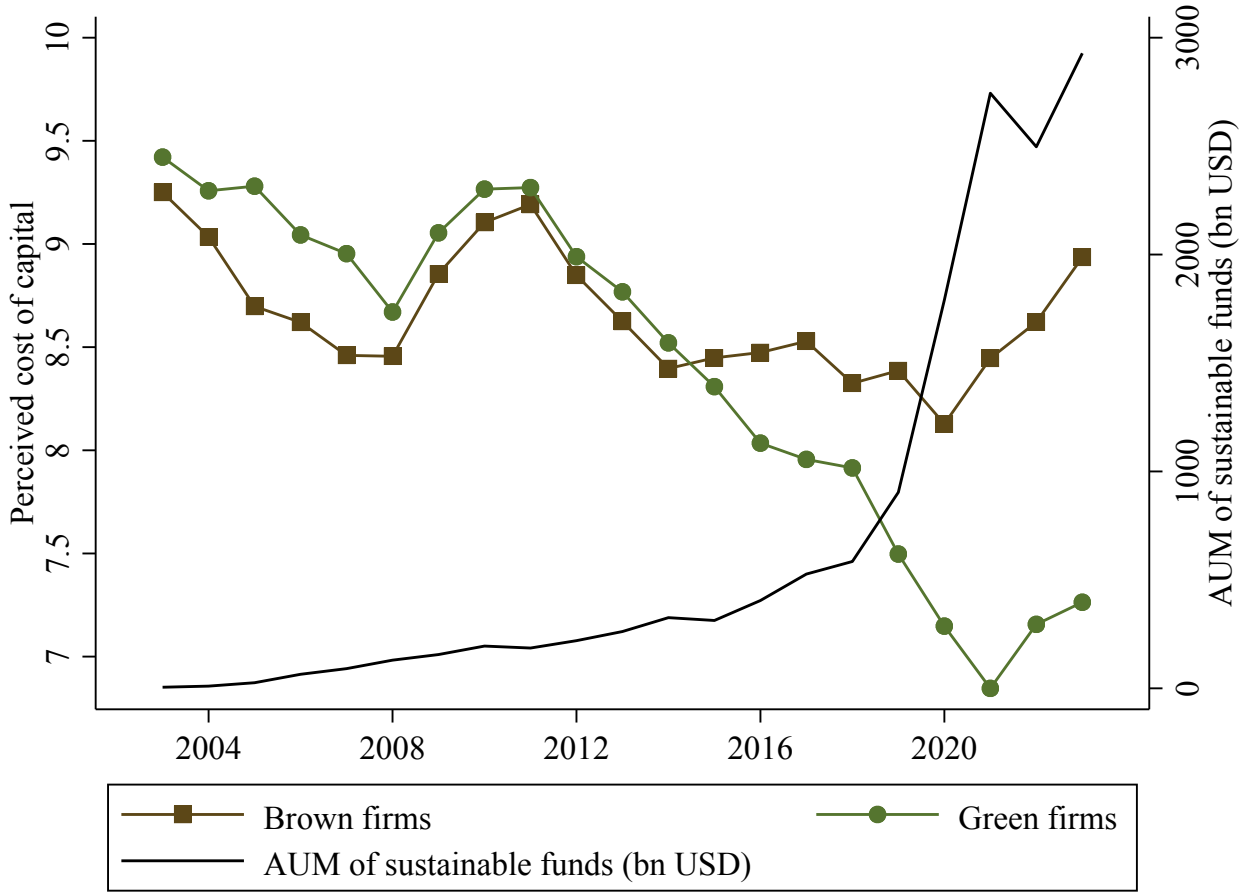
2. Across firms: CoC of green firms lower since 2016
   - Greenness 3rd-strongest predictor of CoC
   - Suggests: increased investment by green firms

3. Within firms: Large energy firms use lower CoC for green divisions since 2016
   - Suggests: brown firms become greener

4. Magnitude in 2023: 2 ppt.
   - 100$ CO2 tax $\approx$ 6-10 ppt. (Pedersen 2023; Chitarro et al. 2024)
   - Sizable potential of CoC channel

5. Implications
   - Changes over time in green CoC, so firms willing to adjust
   - Variation within firms, so some firms are sophisticated
   - Open question on drivers: investor taste, risk, managers' views?

Main Result



Firms sorted into green and brown based on MSCI data

Roadmap

1. Model: two channels for green CoC
    a. Cross-firm allocation
    b. Within-firm allocation
2. Data collection
3. Firm-level cost of capital (cross-firm allocation)
4. Project-level cost of capital (within-firm allocation)
5. CoC and green investment

Model

Framework

- Firms produce output using green and brown capital

- Fall in green CoC leads to reallocation from brown to green capital

  Channel 1: cross-firm reallocation

  Channel 2: within-firm reallocation

- Relative strength of the two channels depends on

  1. Elasticity of substitution in product market
  2. Capital-budgeting practice of firms

Model

- Firms $i \in [0, I]$ produce differentiated products to representative household

Model

- Firms $i \in [0, I]$ produce differentiated products to representative household

Households

Spends W to consume Q_i of each product, with elasticity of substitution σ :

$$U = \left(\int_{i=0}^{I} Q_i^{(\sigma-1)/\sigma} di \right)^{\frac{\sigma}{\sigma-1}}. \tag{1}$$

Model

- Firms $i \in [0, I]$ produce differentiated products to representative household

Households

Spends W to consume Q_i of each product, with elasticity of substitution σ :

$$U = \left(\int_{i=0}^{I} Q_i^{(\sigma-1)/\sigma} di \right)^{\frac{\sigma}{\sigma-1}}. \tag{1}$$

Demand

$$Q_i = P_i^{-\sigma} \frac{W}{\boldsymbol{P}^{1-\sigma}}. \tag{2}$$

where P is price and $\boldsymbol{P}^{1-\sigma} = \left(\int_{i=0}^{I} P_i^{1-\sigma} di \right)^{1/(1-\sigma)}$ is the price index

Model

- Firms $i \in [0, I]$ produce differentiated products to representative household

Households

Spends W to consume Q_i of each product, with elasticity of substitution σ :

$$U = \left(\int_{i=0}^{I} Q_i^{(\sigma-1)/\sigma} di \right)^{\frac{\sigma}{\sigma-1}}. \tag{1}$$

Demand

$$Q_i = P_i^{-\sigma} \frac{W}{\boldsymbol{P}^{1-\sigma}}. \tag{2}$$

where P is price and $\boldsymbol{P}^{1-\sigma} = \left(\int_{i=0}^{I} P_i^{1-\sigma} di \right)^{1/(1-\sigma)}$ is the price index

Firm production

Cobb-Douglas based on brown (K) and green (G) capital

$$Y_i(K_i, G_i) = K_i^{\alpha_i} G_i^{1-\alpha_i}, \tag{3}$$

Brown firms: $\alpha = 0.7$, green firms: $\alpha = 0.3$.

Firm Optimization (I)

Baseline optimization

$$\Pi_i^{\text{Baseline}} = \max_{K_i, G_i} \quad P_i Y_i(K_i, G_i) - r^{\text{Brown}} K_i - r^{\text{Green}} G_i \tag{4}$$

$r^{\text{Brown}} = r$ and $r^{\text{Green}} = r - \zeta$

Firm Optimization (I)

Baseline optimization

$$\Pi_i^{\text{Baseline}} = \max_{K_i, G_i} \quad P_i Y_i(K_i, G_i) - r^{\text{Brown}} K_i - r^{\text{Green}} G_i \tag{4}$$

$r^{\text{Brown}} = r$ and $r^{\text{Green}} = r - \zeta$

Firms' choose optimal mix of capital

$$\frac{K_i^*}{G_i^*} = \frac{\alpha_i}{1 - \alpha_i} \times \frac{r^{\text{Green}}}{r^{\text{Brown}}} \tag{5}$$

Firm Optimization (I)

Baseline optimization

$$\Pi_i^{\text{Baseline}} = \max_{K_i, G_i} \quad P_i Y_i(K_i, G_i) - r^{\text{Brown}} K_i - r^{\text{Green}} G_i \tag{4}$$

$r^{\text{Brown}} = r$ and $r^{\text{Green}} = r - \zeta$

Firms' choose optimal mix of capital

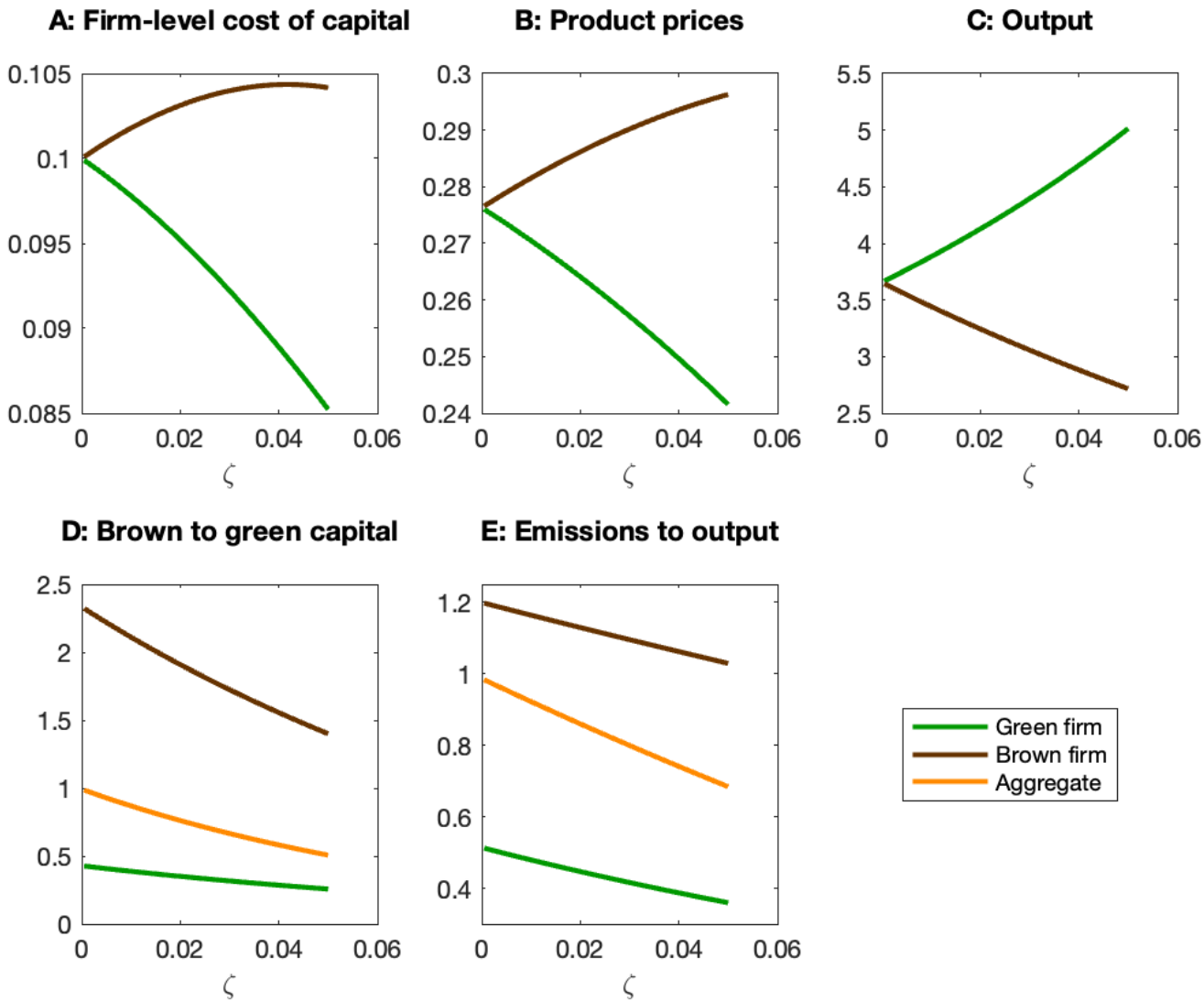
$$\frac{K_i^*}{G_i^*} = \frac{\alpha_i}{1-\alpha_i} \times \frac{r^{\text{Green}}}{r^{\text{Brown}}} \tag{5}$$

and quantities such that

$$P_i^* = \frac{\sigma}{\sigma - 1} \left(\frac{r^{\text{Brown}}}{\alpha_i} \right)^{\alpha_i} \left(\frac{r^{\text{Green}}}{1-\alpha_i} \right)^{1-\alpha_i} \tag{6}$$

Results of Baseline Model

Effects of increasing discount on green capital ζ (and r)



Firm Optimization (II)

Optimization with one cost of capital

$$\Pi_i^{\text{WACC}} = \max_{K_i, G_i} \quad P_i Y_i(K_i, G_i) - \text{WACC}_i(K_i + G_i), \tag{7}$$

$$\text{WACC}_i = r - \zeta(1 - \alpha_i)$$

Firm Optimization (II)

Optimization with one cost of capital

$$\Pi_i^{\text{WACC}} = \max_{K_i, G_i} \quad P_i Y_i(K_i, G_i) - \text{WACC}_i(K_i + G_i), \tag{7}$$

$$\text{WACC}_i = r - \zeta(1 - \alpha_i)$$

Firms' choose optimal mix of capital

$$\frac{K_i^{'}}{G_i^{'}} = \frac{\alpha_i}{1 - \alpha_i}, \tag{8}$$

Firm Optimization (II)

Optimization with one cost of capital

$$\Pi_i^{\text{WACC}} = \max_{K_i, G_i} \quad P_i Y_i(K_i, G_i) - \text{WACC}_i(K_i + G_i), \tag{7}$$

$$\text{WACC}_i = r - \zeta(1 - \alpha_i)$$

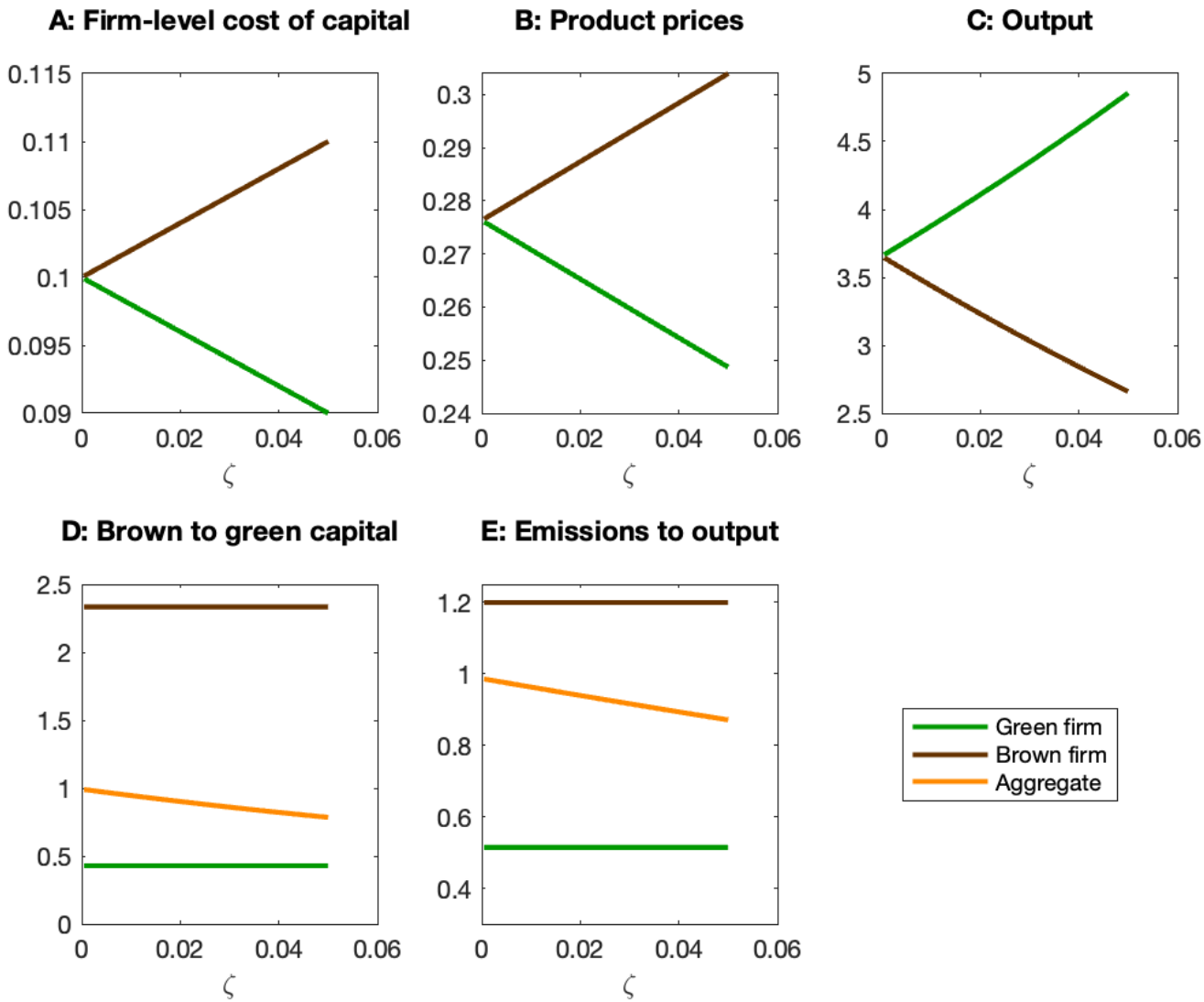
Firms' choose optimal mix of capital

$$\frac{K_i^{'}}{G_i^{'}} = \frac{\alpha_i}{1 - \alpha_i}, \tag{8}$$

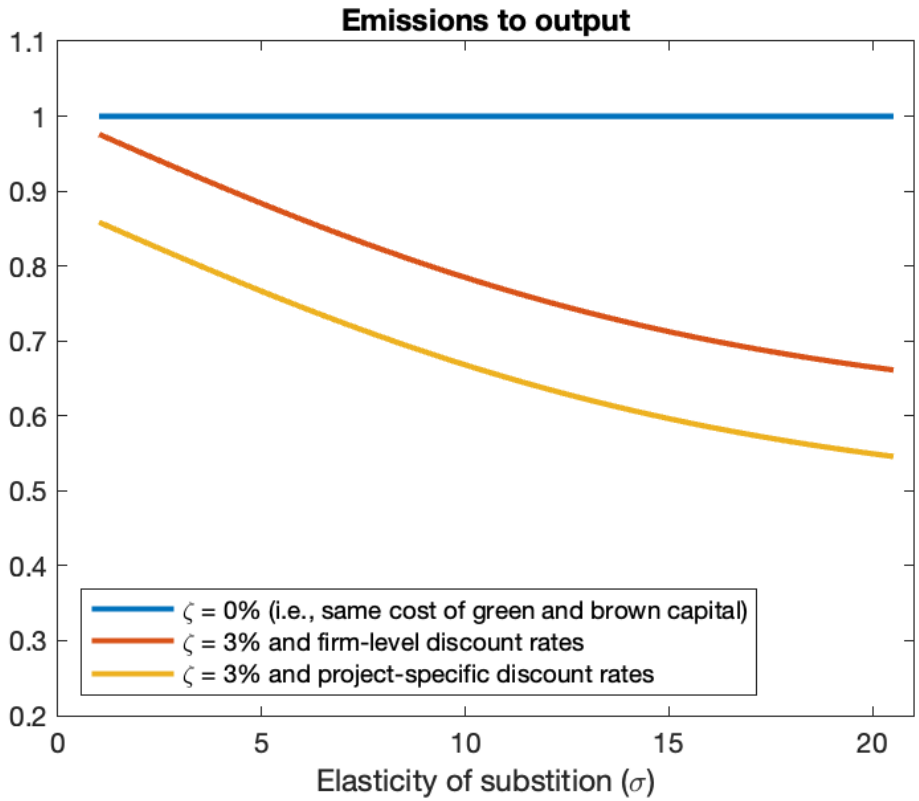
and quantities such that

$$P_i^{'} = \frac{\sigma}{\sigma - 1} \frac{\text{WACC}_i}{\alpha_i^{\alpha_i}(1 - \alpha_i)^{1-\alpha_i}}. \tag{9}$$

Results with Single Cost of Capital



Comparison of the Two Channels



Data and Framework

Data from Corporate Conference Calls

Data from Corporate Conference Calls

Nestlé, Q4-2006: *"We use an average cost of capital of 7.5%."*

Air Canada, Q3-2017: *"... our weighted average cost of capital of 7.6%."*

Phillips 66, Q2-2022: *"... our weighted average cost of capital of 10%."*

Data from Corporate Conference Calls

Nestlé, Q4-2006: *"We use an average cost of capital of 7.5%."*

Air Canada, Q3-2017: *"... our weighted average cost of capital of 7.6%."*

Phillips 66, Q2-2022: *"... our weighted average cost of capital of 10%."*

Our approach

- Identify 110k paragraphs containing keywords from 2002-2022
- Manually read and enter numbers with RA team
- Collect numbers related to:
  - Perceived CoC, CoE, and CoD
  - Required returns (discount rates or "hurdle rates")
  - Realized returns
- Separately collect "project-specific" variables from firm-level CoC

Data from Corporate Conference Calls

Nestlé, Q4-2006: *"We use an average cost of capital of 7.5%."*

Air Canada, Q3-2017: *"... our weighted average cost of capital of 7.6%."*

Phillips 66, Q2-2022: *"... our weighted average cost of capital of 10%."*

Our approach

Overview of data

- 3,200 observation of perc. CoC for 1,200 firms in 20 countries
- Representative, except larger firms (more on next slide)
- Firms with perc. CoC account for 40% of assets in developed countries
- Data under costofcapital.org

Data from Corporate Conference Calls

Nestlé, Q4-2006: *"We use an average cost of capital of 7.5%."*

Air Canada, Q3-2017: *"... our weighted average cost of capital of 7.6%."*

Phillips 66, Q2-2022: *"... our weighted average cost of capital of 10%."*

Our approach

Overview of data

Verifiable data

- Calls are repeated high-stakes interactions (Hassan et al. 2019)
- Information from conference calls used in security lawsuits
- Extensive data validation in paper

Predicting Duke-CFO Data

- We estimate predicted value of perc. CoC and discount rates using machine learning
- Predicted values are unbiased estimates of Duke-CFO variables:

	(1) Duke CoC	(2) Duke CoC	(3) Duke discount rate	(4) Duke discount rate
Predicted CoC	0.74***	0.90***		
	(0.17)	(0.21)		
Predicted discount rate			1.02***	0.98**
			(0.38)	(0.38)
Constant	0.034**	0.021	0.027	0.031
	(0.014)	(0.018)	(0.036)	(0.037)
Observations	319	319	92	92
R-squared	0.057	0.067	0.118	0.136
FE	None	Year	None	None
Within R^2	0.057	0.057	0.12	0.11

Go back

Perceived Cost of Capital Related to Real Outcomes

Standard theory: CoC should influence real decisions

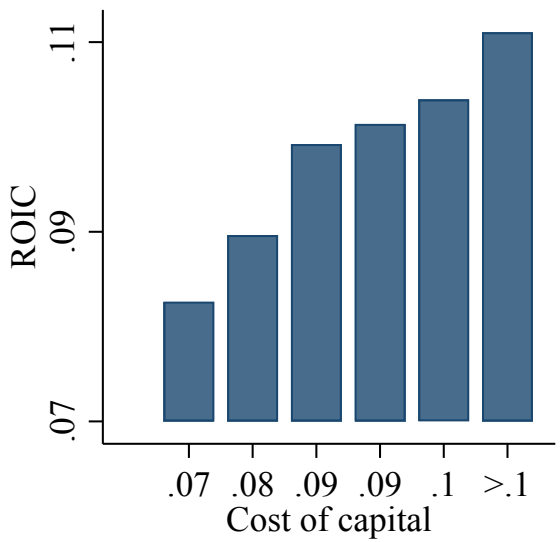
- Higher CoC $\Rightarrow$ higher returns
- Higher CoC $\Rightarrow$ less investment
- Higher CoC $\Rightarrow$ less capital deployed

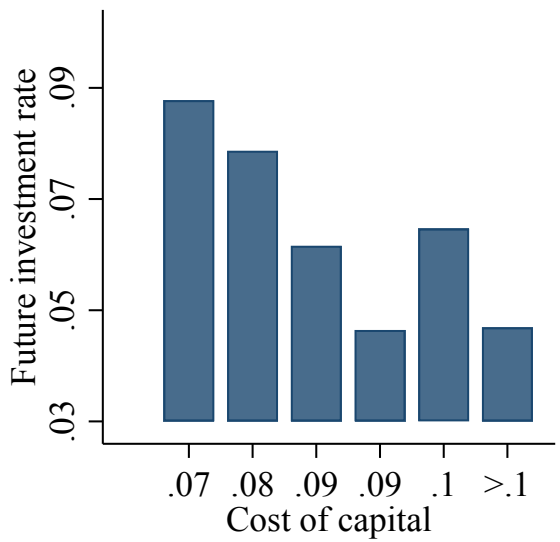
Perceived Cost of Capital Related to Real Outcomes

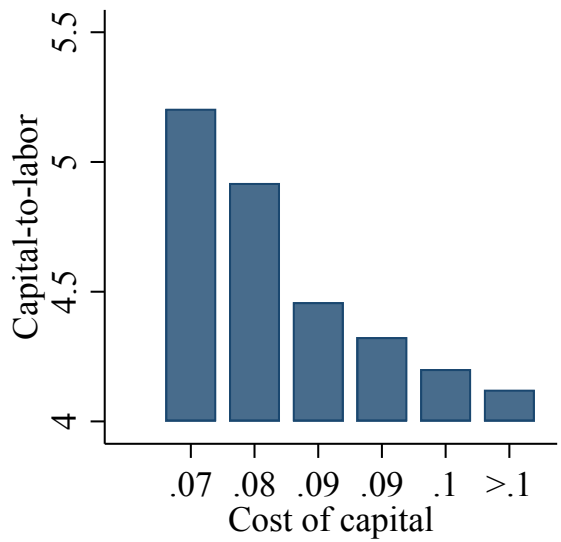
Standard theory: CoC should influence real decisions

- Higher CoC ⇒ higher returns
- Higher CoC ⇒ less investment
- Higher CoC ⇒ less capital deployed

We find consistent evidence:







Perceived CoC, Hurdle Rates, and Investment

Previous work focuses on real effects of hurdle rates:

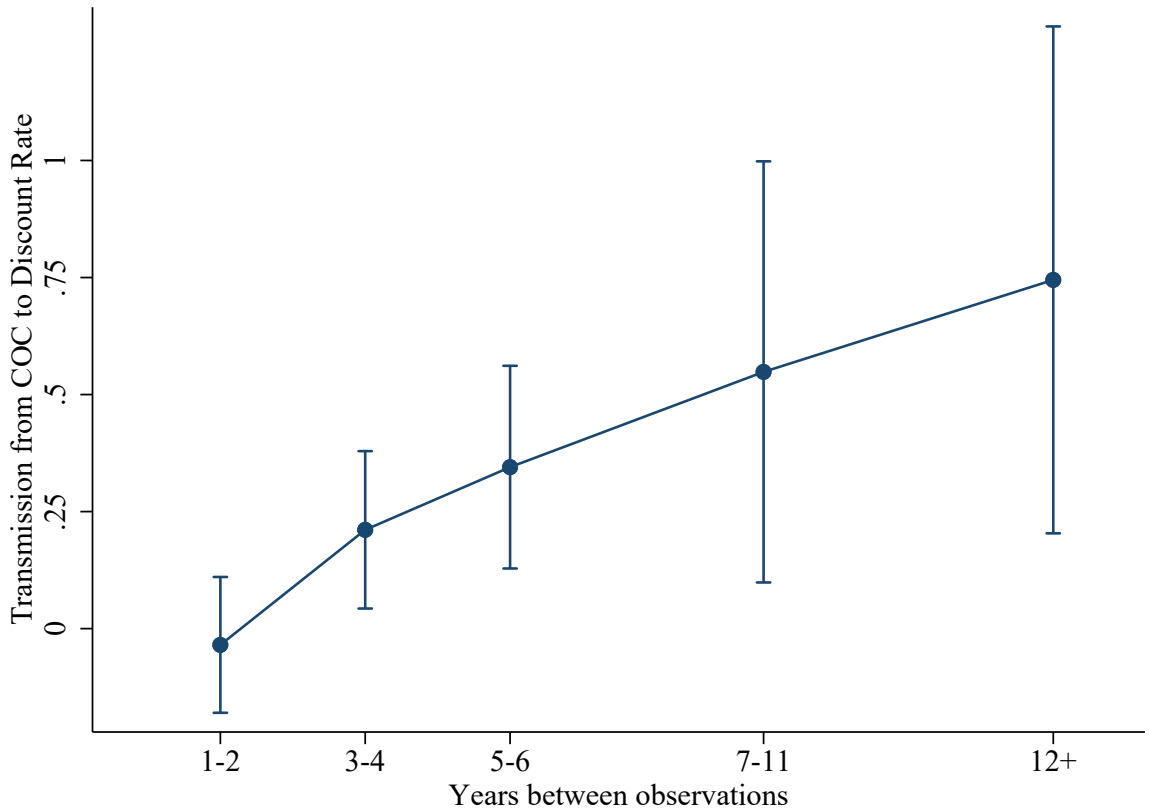
- Gormsen and Huber (2024) & Barry et al. (2024): hurdle rates predict investment and returns

Perceived CoC, Hurdle Rates, and Investment

Previous work focuses on real effects of hurdle rates:

- Gormsen and Huber (2024) & Barry et al. (2024): hurdle rates predict investment and returns

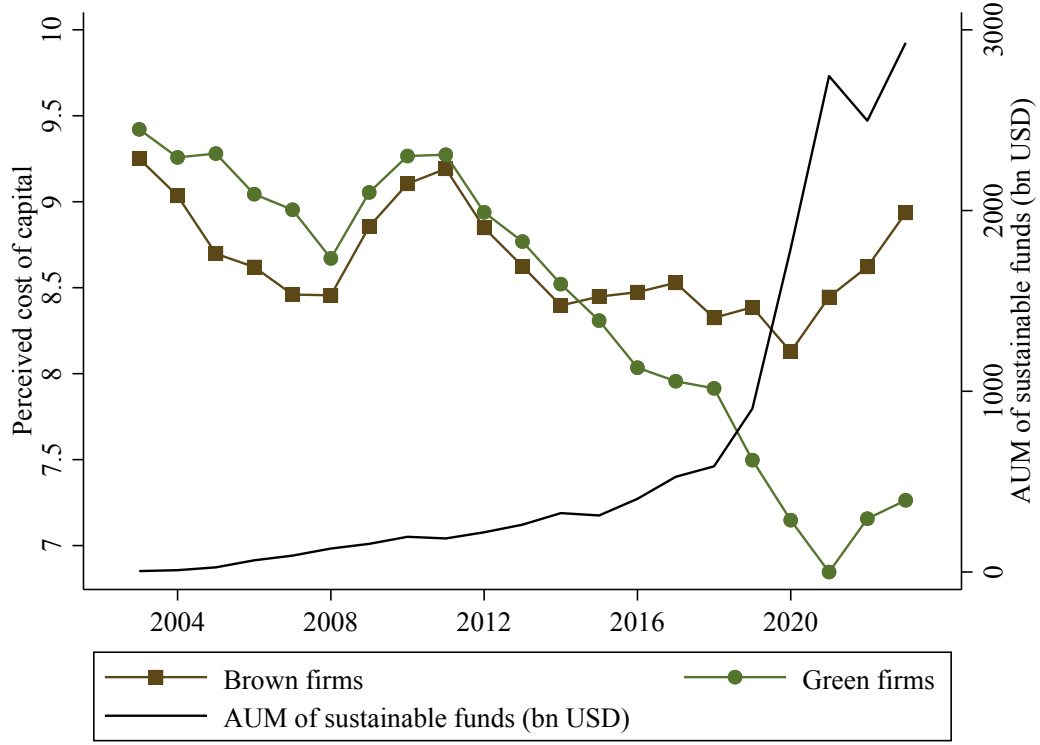
Persistent variation in CoC influence hurdle rates and hence investment:



Firm-Level Differences in the Perceived Cost of Capital

Firm-Level Differences in Perc. CoC

Measure firm-level greenness based on MSCI data



Firm-Level Differences in Perc. CoC

- Measure firm-level greenness based on MSCI data
- E-score (from MSCI) ranges from 0 to 1

	Perceived cost of capital					
	US sample			Global sample		
E-score	-0.53	0.22	0.94	-1.38***	-0.74	-0.10
	(0.40)	(0.52)	(0.61)	(0.38)	(0.45)	(0.49)
E-score × Post-2016		-1.90**	-2.12**		-1.46**	-1.71***
		(0.87)	(0.84)		(0.65)	(0.60)
Controls:	No	No	Yes	No	No	Yes
Observations	1,026	1,026	885	1,606	1,606	1,384
Within R^2	0.0029	0.012	0.15	0.021	0.027	0.19

Controls: Leverage, beta, market value, and book-to-market

Firm-Level Differences in Perc. CoC

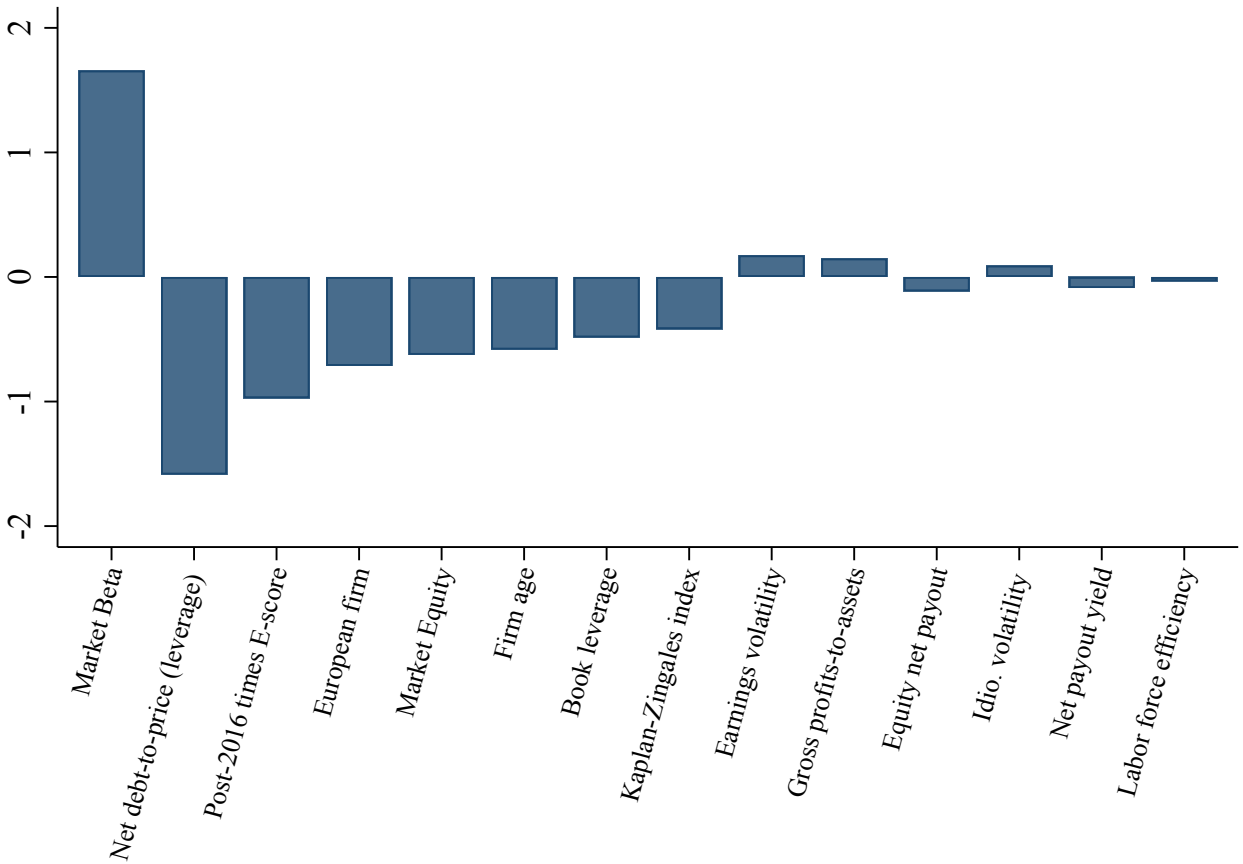
E-score is not explained by other factors

- Estimate optimal model for perc. CoC using Lasso
- Candidate factors: factor zoo from Jensen et al. (2021)
- Include E-score interacted with post-2016 dummy

Firm-Level Differences in Perc. CoC

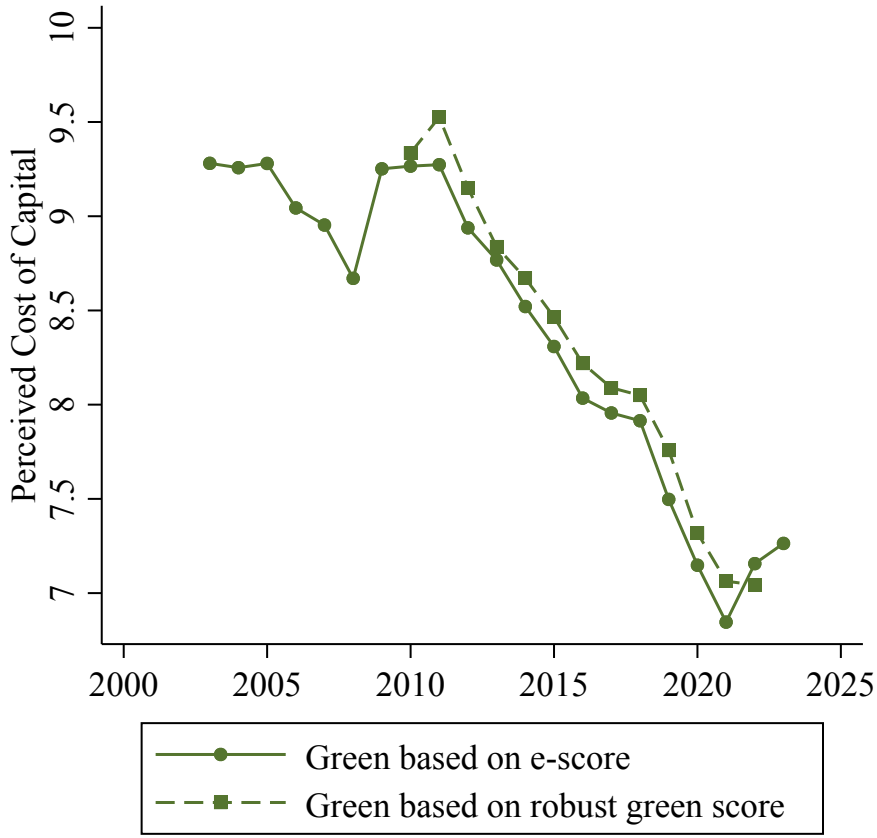
E-score is not explained by other factors

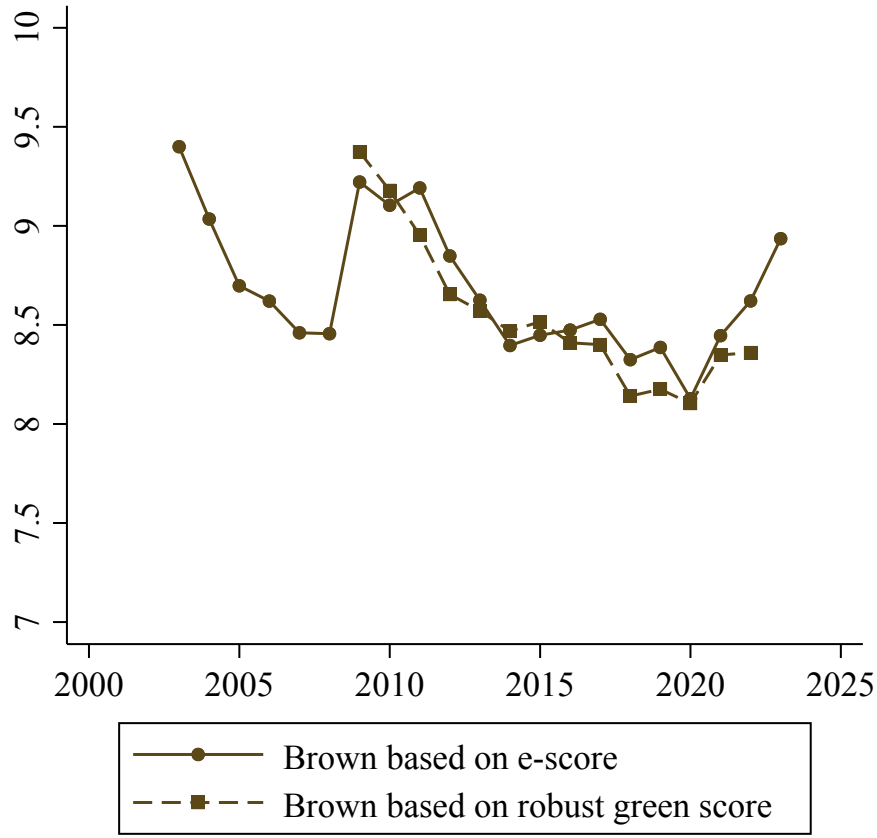
- Estimate optimal model for perc. CoC using Lasso
- Candidate factors: factor zoo from Jensen et al. (2021)
- Include E-score interacted with post-2016 dummy



Firm-Level Differences in Perc. CoC: Robustness

Similar results if we greenness based on Robust Green Score (Eskildsen et al. 2024)





Firm-Level Differences in Perc. CoC: Robustness

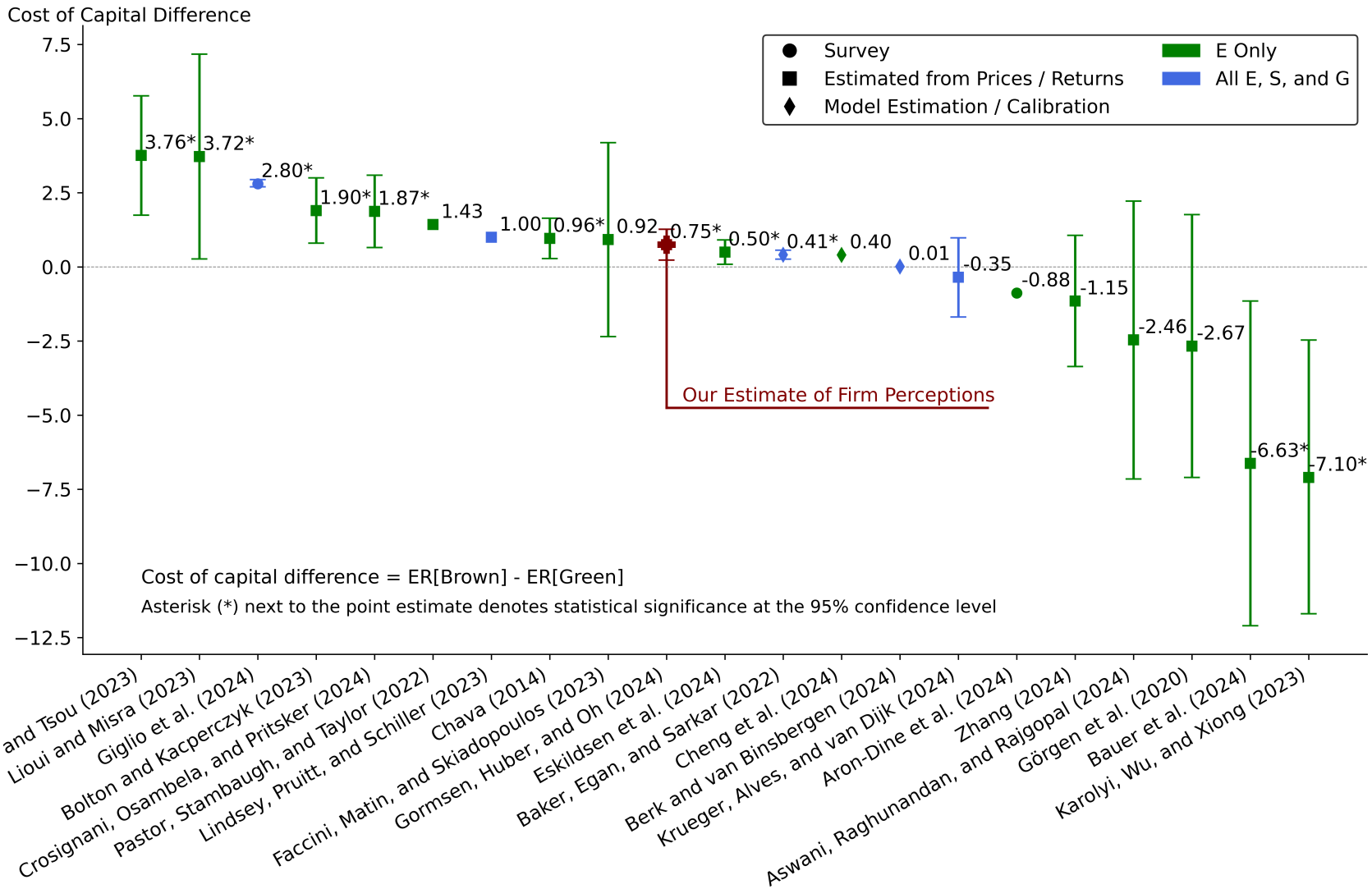
- Measure firm-level greenness based on "Robust Green Score" (Eskildsen et al. 2024)
- Robust Green Score ranges from 0 to 1

	(1)	(2)	(3)	(4)	(5)	(6)
	Perceived cost of capital					
	US sample			Global sample		
"Robust green score"	0.56	1.19*	1.17**	-0.69	0.18	0.35
	(0.48)	(0.61)	(0.54)	(0.58)	(0.63)	(0.44)
"Robust green score" × post 2016		-1.82**	-1.31*		-2.08**	-1.62*
		(0.84)	(0.77)		(1.04)	(0.94)
Controls:	No	No	Yes	No	No	Yes
Observations	835	835	821	1,348	1,348	1,259
Within R^2	0.0039	0.013	0.18	0.0054	0.017	0.22

Controls: Leverage, beta, market value, and book-to-market

Comparison to Estimates in the Literature

- Measure premium associated with two σ spread in green score



Within-Firm Variation in the Cost of Green and Brown Capital

Within-Firm Variation in the Cost of Capital

- Within-firm reallocation towards green capital requires capital-specific cost of capital
- Some large firms indeed have different cost of capital for different projects/investments

Within-Firm Variation in the Cost of Capital

- Within-firm reallocation towards green capital requires capital-specific cost of capital
- Some large firms indeed have different cost of capital for different projects/investments

Example on green vs. brown variation

Disciplined, value-focused capital allocation

		Cash Capex				Cash Capex after power dilutions	FCF	IRR hurdle rates
	$ billion	2022	2023	24-25	Power dilutions	24-25	2025[1]	
Integrated Gas	IG	4	~5	~5		~5	~8	11%
Upstream	UP	8	~8	~8		~8	~10	15%
Integrated Gas and Upstream	IGU	12	~13	~13		~13	17-18	
Marketing (gas stations)	MKT	5	~6[2]	~3		~3	~4	MKT ex. LCF/EV 15% LCF 12% EV 12%
Chemicals & Products	C&P	4	3-4	3-4		3-4	~5	12%
Renewables & Energy Solutions	R&ES	3	2-4	4-5	(1-2)	~3	~(2)	R&ES excl. power 10% Power generation 6-8%
Downstream and Renewables & Energy Solutions	DSR	12	11-14	10-12		9-10	7-8	
	Total	**25**	**23-27**	**22-25**		**21-23**	**24-26**	

[1] For price assumptions see appendix [2] Includes acquisition of Nature Energy (nearly $2 billion)

Capital Markets Day 2023 | June 14

43

Project Specific Cost of Capital

- We collect project specific discount rates for the 100 largest energy and utility firms
  $\sim 1,000$ rates classified as green, brown, neutral
  ~ 50 firms (including Shell, BP, Total, EDF = 4% of global emissions)

Project Specific Cost of Capital

- We collect project specific discount rates for the 100 largest energy and utility firms
  $\sim 1,000$ rates classified as green, brown, neutral
  ~ 50 firms (including Shell, BP, Total, EDF = 4% of global emissions)

	(1) Regulated CoC	(2) Perceived CoC	(3) Hurdle
Green division	0.50	-0.67***	-4.01***
	(0.37)	(0.15)	(1.55)
Brown division	0.25	0.11*	-0.054
	(0.29)	(0.053)	(0.57)
Observations	443	193	248

Project Specific Cost of Capital

- We collect project specific discount rates for the 100 largest energy and utility firms
  $\sim 1,000$ rates classified as green, brown, neutral
  ~ 50 firms (including Shell, BP, Total, EDF = 4% of global emissions)

	(1) Regulated CoC	(2) Perceived CoC	(3) Hurdle
Green division	0.49	-0.84***	-4.06**
× Post-2016	(0.36)	(0.20)	(1.57)
Green division	-3.07	0.043	2.65
× Pre-2016	(2.57)	(0.74)	(1.57)
Brown division	0.21	0.16**	-0.0096
	(0.25)	(0.063)	(0.57)
Observations	443	193	248

Impact on Pledged Reductions in Emissions

Impact on Pledged Reductions in Emissions

Ideal data

- Green vs. brown CoC for all firms
- Actual changes in emissions over long horizons

What we have

- Green and brown cost of capital in different sectors
- Pledged reduction in future emissions

Impact on Pledged Reductions in Emissions

	Firm-level CO2 change (pct)		Firm-level CO2 change per year (pct)	
Brown CoC in sector	-15.5**	-17.0**	-2.38***	-2.08***
	(4.89)	(5.37)	(0.67)	(0.57)
Green CoC in sector	6.88**	2.91	1.41**	-0.067
	(2.79)	(4.63)	(0.51)	(0.48)
Fin. CoC (CAPM)		7.01		1.31*
		(5.13)		(0.63)
Return on equity		1.25		0.45***
		(1.02)		(0.13)
Tobin's Q		-0.78		-2.19*
		(7.40)		(1.00)
Observations	615	615	520	520
R^2	0.49	0.50	0.12	0.13

Conclusions

Main results

- Substantial cross-firm in the perceived cost of capital between green and brown firms
- Some within-firm variation across green and brown divisions
- Differences arose concurrently with the rise of SI

Incentives for green transition

- Cross-firm reallocation towards green firms (even with singe CoC)
- Within-firm reallocation for the firms that use multiple CoC

Thank You!

References

Barry, John W, Bruce I Carlin, Alan D Crane, and John Graham, "Project development with delegated bargaining: The role of elevated hurdle rates," Technical Report, National Bureau of Economic Research 2024.

Chitarro, Lautaro, Monika Piazzesi, Martin Schneider, and Marcelo Sena, "Asset Returns as Carbon Taxes," 2024.

Eskildsen, Marc, Markus Ibert, Theis Ingerslev Jensen, and Lasse Heje Pedersen, "In search of the true greenium," 2024.

Gormsen, Niels Joachim and Kilian Huber, "Corporate Discount Rates," *University of Chicago Working Paper*, 2024.

Graham, J. R. and C. R. Harvey, "The theory and practice of corporate finance: Evidence from the field," *Journal of Financial Economics*, 2001, *60* (2-3), 187–243.

Hassan, Tarek A., Stephan Hollander, Laurence Van Lent, and Ahmed Tahoun, "Firm-Level Political Risk: Measurement and Effects," *Quarterly Journal of Economics*, 2019, *134* (4), 2135–2202.

Jagannathan, R., D.A. Matsa, I. Meier, and V. Tarhan, "Why do firms use high discount rates?," *Journal of Financial Economics*, 2016, *120* (3), 445–463.

Jensen, Theis Ingerslev, Bryan T Kelly, and Lasse Heje Pedersen, "Is there a replication crisis in finance?," 2021.

Pedersen, Lasse Heje, "Carbon pricing versus green finance," 2023.

Poterba, James M and Lawrence H Summers, "A CEO survey of US companies' time horizons and hurdle rates," *MIT Sloan Management Review*, 1995, *37* (1), 43.

Levels of Discount Rates

Puzzle in literature: high level of reported discount rates (Poterba and Summers 1995; Graham and Harvey 2001; Jagannathan et al. 2016)

Conference calls provide context

- Many discount rates do not account for all overhead
- Discount rates accounting for overhead are lower

1	Discount rate (mean of full sample)	15.7
2	Discount rate (mean of observations accounting for all overhead)	11.4
3	Return on invested capital (Compustat)	13.5
4	Total overhead over invested capital (Compustat)	30.7
5	Perceived cost of capital (mean of full sample)	8.4

Today: focus on within-firm analyses, where levels are largely irrelevant

We control for levels when relevant

Firms Included in the Sample

Dataset has larger firms

Similar w.r.t. bankruptcy risk (Z-score), investment, and value

Characteristics of included firms in cross-sectional percentiles

	Discount rates			Perceived cost of capital		
	mean	min	max	mean	min	max
Market value	83.1	3.0	100.0	79.4	8.5	100.0
Return on equity	59.8	0.8	100.0	58.3	0.2	100.0
Book-to-market	49.4	0.2	100.0	47.3	0.2	100.0
Investment rate	53.6	0.3	100.0	54.0	1.4	100.0
Physical capital to assets	59.0	2.2	100.0	59.7	2.4	100.0
Z-score (bankruptcy risk)	47.6	0.8	99.0	48.8	2.3	99.0
Financial constraints	20.5	0.0	100.0	23.0	0.0	90.7
Leverage	60.4	1.2	100.0	59.3	0.5	100.0

Average percentile relative to all firms in Compustat in same year and country