Carbon Pricing versus Green Finance

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The views expressed are those of the author and not necessarily those of AQR

"Ultimate Challenge for Economics" (Nordhaus 2018)

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- Economics: carbon tax=social cost of carbon=43$/tCO2
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Research questions:

- How does 43$/tCO2 translate into green finance?
- When can green finance work?
- What is the interaction of carbon pricing and green finance?
- Who should be targeting – scope 1, 2, or 3?

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What I do:

- Simple unified model: carbon pricing meets green finance
- Calibration: how large is the required effect?

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Two separate literatures on climate change:

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Research questions:

- How does 43$/tCO2 translate into green finance? 4%
- When can green finance work? no stranded assets
- What is interaction of carbon pricing/ green fin? substitutes
- Who should be targeting – scope 1, 2, or 3? either

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Main Findings: More Detail

	Carbon pricing (Cost of emission)	**Green finance** (Cost of capital, CoC)
Optimum:		
Pure carbon pricing	Tax=SCC	Zero
Green finance	Tax<SCC	CoC(SCC$-$tax$_i$,i,action$_i$)
Problems		Stranded assets
		CoC unmanageable

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Implemention:		
Scope	1, 2, or 3	1, 2, or 3
Calibration	43\$/tCO2	4%
	279\$/CO2	27%

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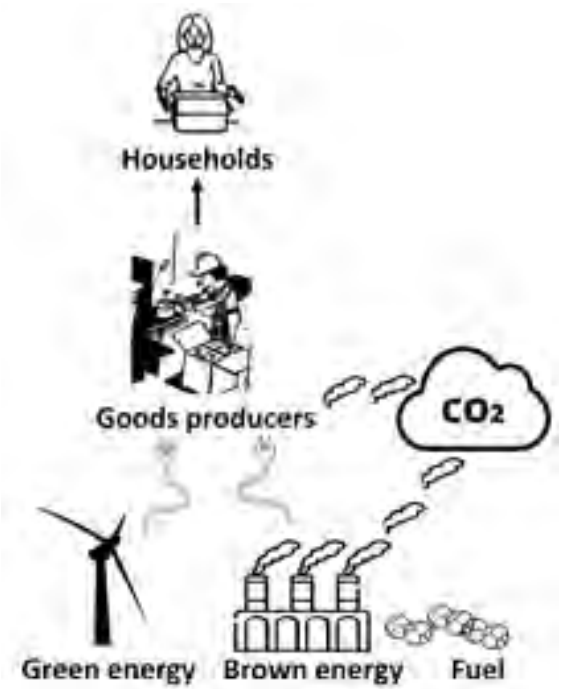
Data:		
Effect	6\$/tCO2	50 bps green-vs-brown*

** *In Search of the True Greenium*, Eskildsen, Ibert, Jensen, and Pedersen (2024)*

A Model of Carbon Pricing and Green Finance

Model Overview

- Time: $t = 1, 2, ..., T$
- Firms: max(discounted value)
  - Choose: investment, labor, energy use $\rightarrow$ pollution
- Carbon pricing: tax (or allowance or offsets)
- Green finance: cost of capital



Translating Carbon Taxes to Green Finance: Simple Case

- Brown energy zero-profit condition (no stranded assets):

$$0 = (p_b - \pi - \tau_b f_b) a_b K_b - (r_b + \delta_b) K_b$$

- Energy price with *no* green finance, but carbon tax:

$$p_b^* = \frac{r + \delta_b}{a_b} + \pi + S f_b$$

- Energy price with green finance, but *no* carbon tax:

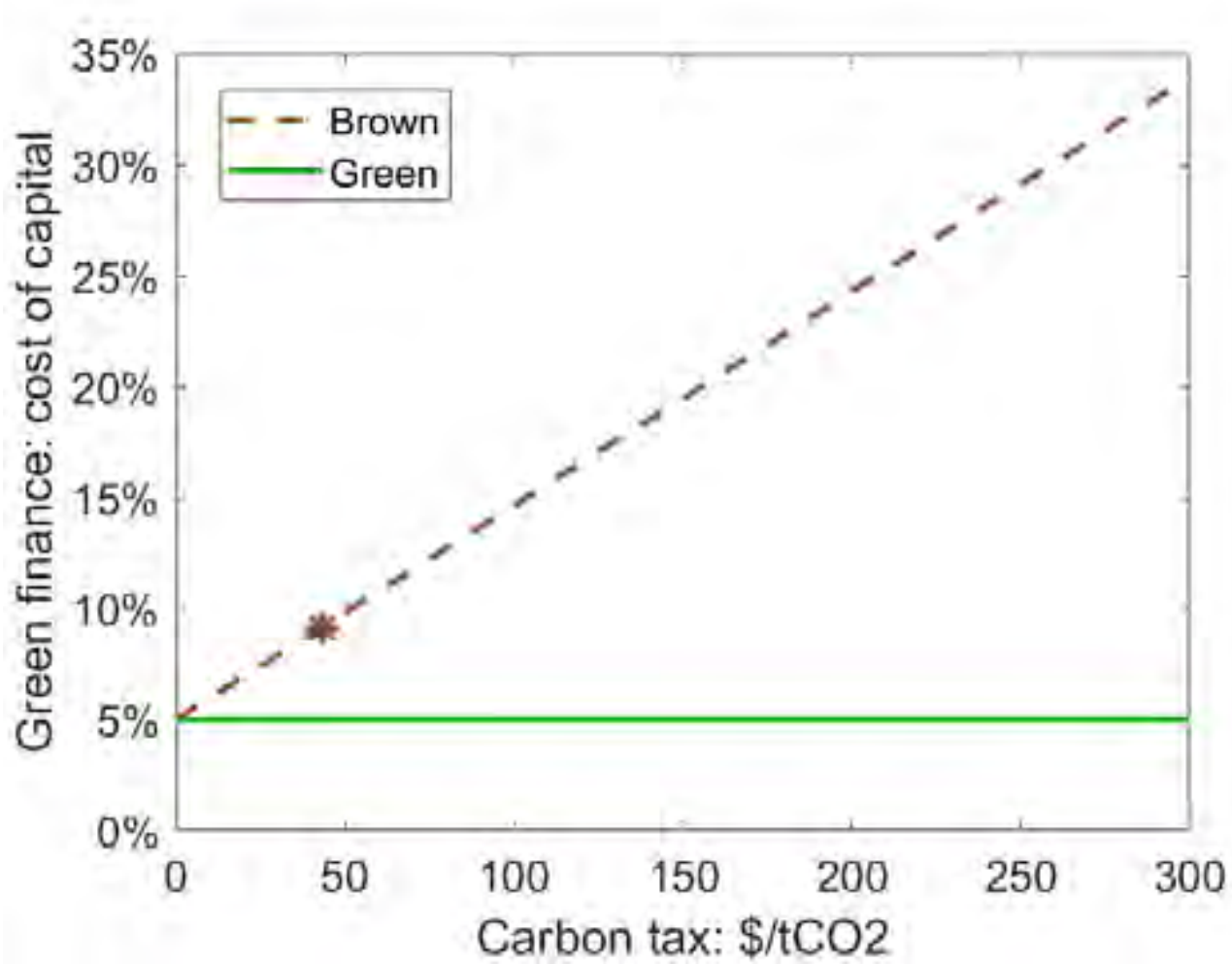
$$p_b = \frac{r_b + \delta_b}{a_b} + \pi$$

- Choose r_b to equalize:

$$r_b = r + S f_b a_b = r + \frac{S f_b}{(r + \delta_b)/a_b}(r + \delta_b)$$

$$= 5\% + \frac{43 \frac{\$}{tCO2} \times 0.00082 \frac{tCO2}{kWh}}{0.5 \times 0.17 \frac{\$}{kWh}} \times (5\% + 5\%) = 9.1\%$$

Translating Carbon Taxes to Green Finance: In a Figure



Social Optimum

Proposition (Scope-1 Carbon Pricing, No Green Finance)

The market equilibrium is socially optimal when each firm faces a carbon tax equal to the social cost of carbon, S_t, levied on their scope 1 emissions, no green finance ($r_{it} = r$), and $\tau_w = 0$.

Simple Green Finance

Proposition (Simple Green Finance)

If carbon tax$<T$, then simple green finance may raise welfare, but cannot implement the socially optimal outcome except in certain special cases

Problem:

- Green finance can fix investment, but not necessarily what firms do with the capital, ϵ_i, L_i

Green Finance with Commitment

Proposition (Green Finance with Commitment)

If firms can commit to their future actions, the social optimum can be implemented with green finance, except in the case of "stranded assets."

Problem with stranded assets:

- Social optimum: brown energy should not be used
- Market equilibrium: chooses I_{bt-1} and use $\in \{0, 1\}$ to max:

$$\frac{(p_{bt} - \pi - \tau_{bt} f_b) a_b K_{bt} 1_{\text{use}_t} + (1 - \delta_{bt}) K_{bt}}{1 + r_{bt-1}} - I_{bt-1}$$

- Carbon tax$\rightarrow$unprofitable to use brown energy, $\text{use}_t = 0$
- Green finance$\rightarrow$no investment, but $\text{use}_t > 0$

Scope of Green Finance

No stranded assets: optimum can be implemented in several ways:

(I) CoC_i(scope-1 emissions) for all firms

(II) $\text{CoC}_{\text{goods-producers}}$(scope-2 emissions), $\text{CoC}_{\text{green energy}}$ subsidized

(III) $\text{CoC}_{\text{energy-producers}}$(scope-3 emissions)

Calibration: Low Estimate of Social Cost of Carbon

Panel A. Social cost of carbon 43\$/CO2

		I	II	III
Energy producers:				
Green: zero emission	r_g	5%	1.4%	6.2%
Brown: fossil intensity f_b	r_b	8.6%	5%	9.8%
Goods producers:				
No electricity, $s_{i_1} = 0$; no emission, $f_{i_1} = 0$	$\bar{r}_{i_1}$	5%	5%	
Electricity, $s_{i_2} = 0.3$; no emission, $f_{i_2} = 0$	$\bar{r}_{i_2}$	5%	5.4%	5%
Electricity, $s_{i_3} = 0.3$; and emission, $f_{i_3} = f_b$	$\bar{r}_{i_3}$	5.4%	5.8%	

$f_b = 820 \times 10^{-6}$tCO2/kWh, $\tau_{it} = \tau_{bt}$ =6\$/tCO2

$r = 5\%$, all depreciation rates of 5%

$a_b = a_g$ chosen s.t. $(r + \delta_b)/a_b + \pi = 0.17$\$/kWh and $\pi = 0.5[(r + \delta_b)/a_b + \pi]$

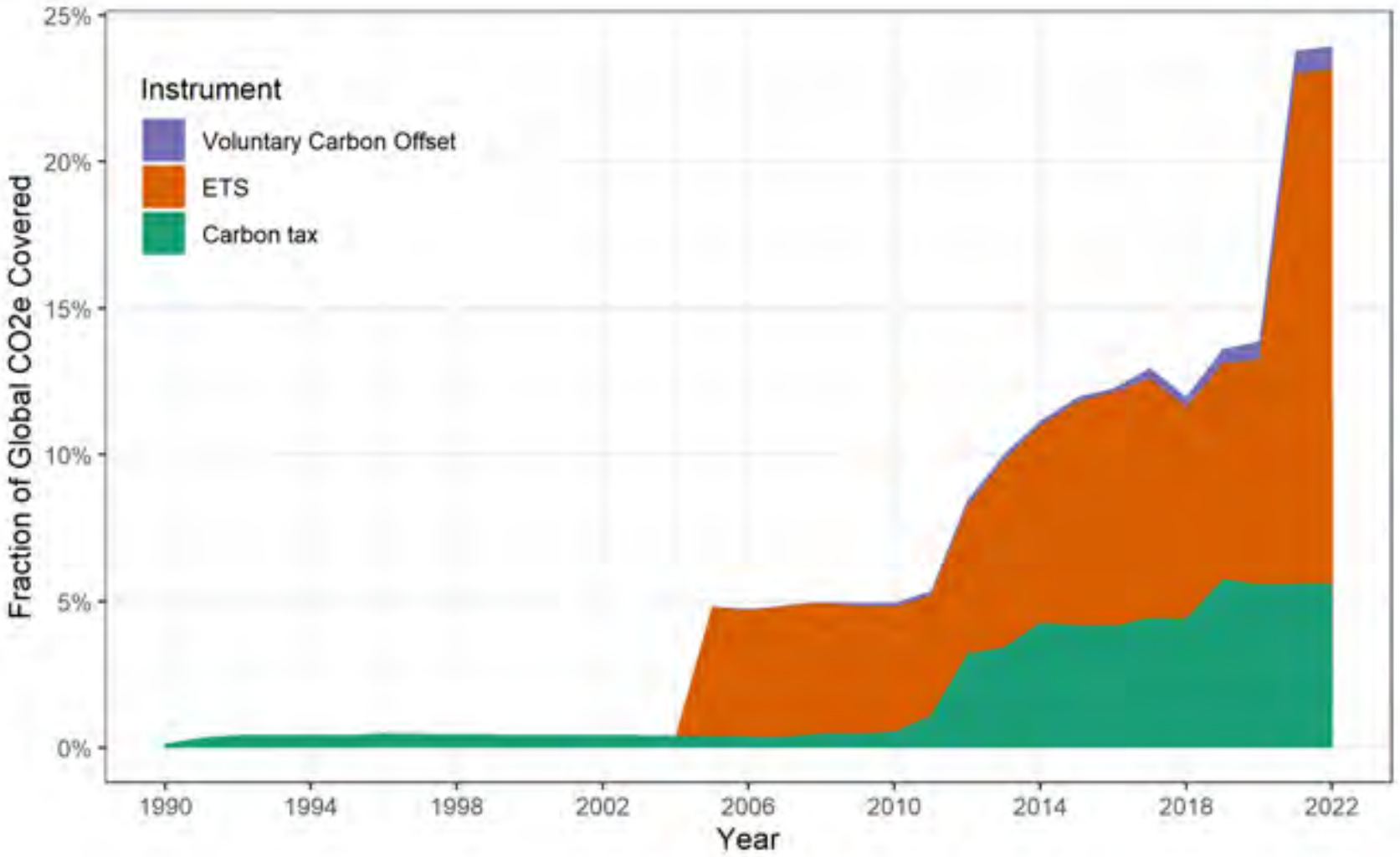
Calibration: High Estimate of Social Cost of Carbon

Panel B. Social cost of carbon 279\$/CO2

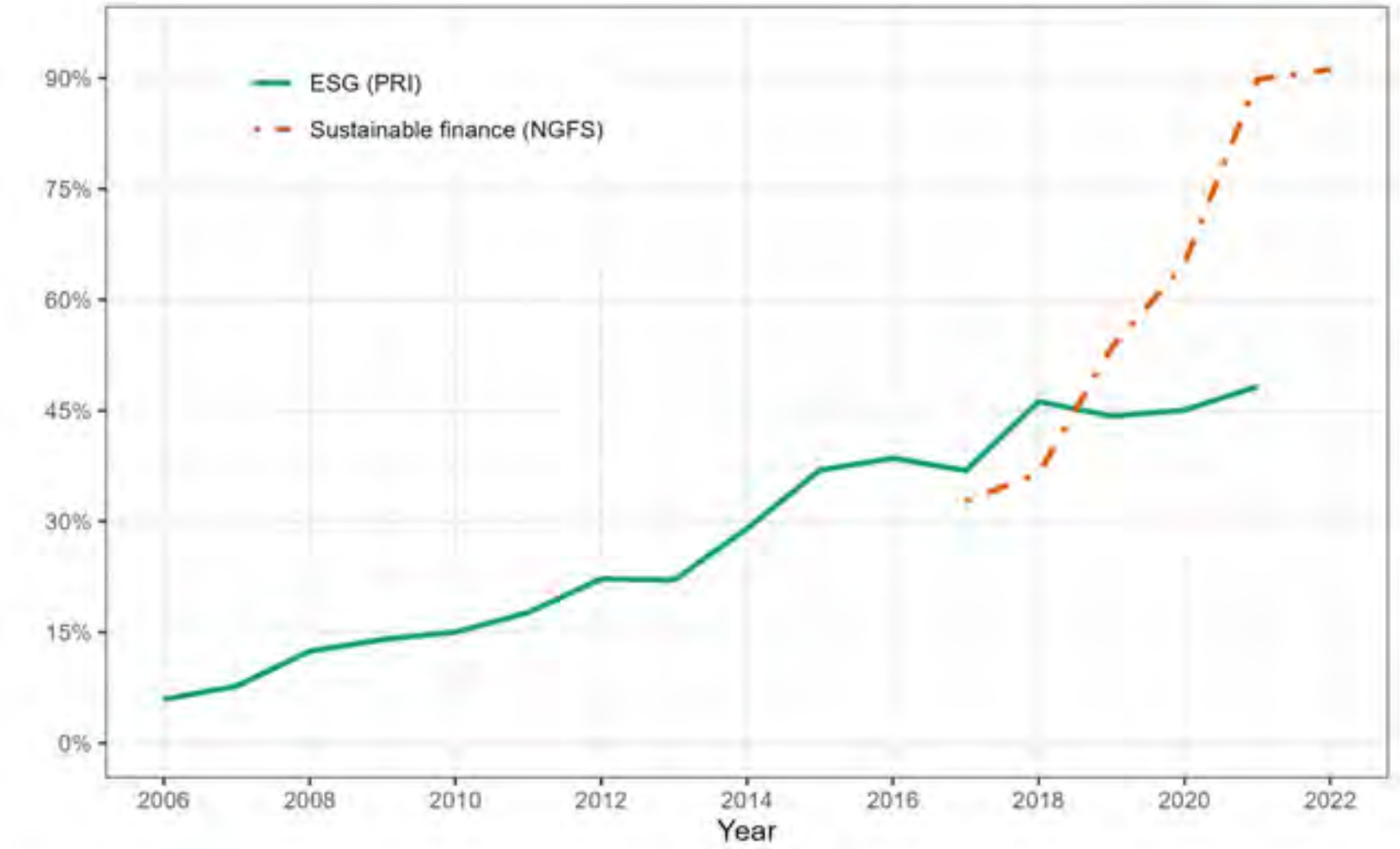
		I	II	III
Energy producers:				
Green: zero emission	r_g	5%	−21.3%	13.8%
Brown: fossil intensity f_b	r_b	31.3%	5%	40.1%
Goods producers:				
No electricity, $s_{i_1} = 0$; no emission, $f_{i_1} = 0$	$\bar{r}_{i_1}$	5%	5%	
Electricity, $s_{i_2} = 0.3$; no emission, $f_{i_2} = 0$	$\bar{r}_{i_2}$	5%	6.7%	5%
Electricity, $s_{i_3} = 0.3$; and emission, $f_{i_3} = f_b$	$\bar{r}_{i_3}$	6.1%	7.1%	

Global Use of
Carbon Pricing versus Green Finance

Global Use: Carbon Taxes, Allowances, and Offsets



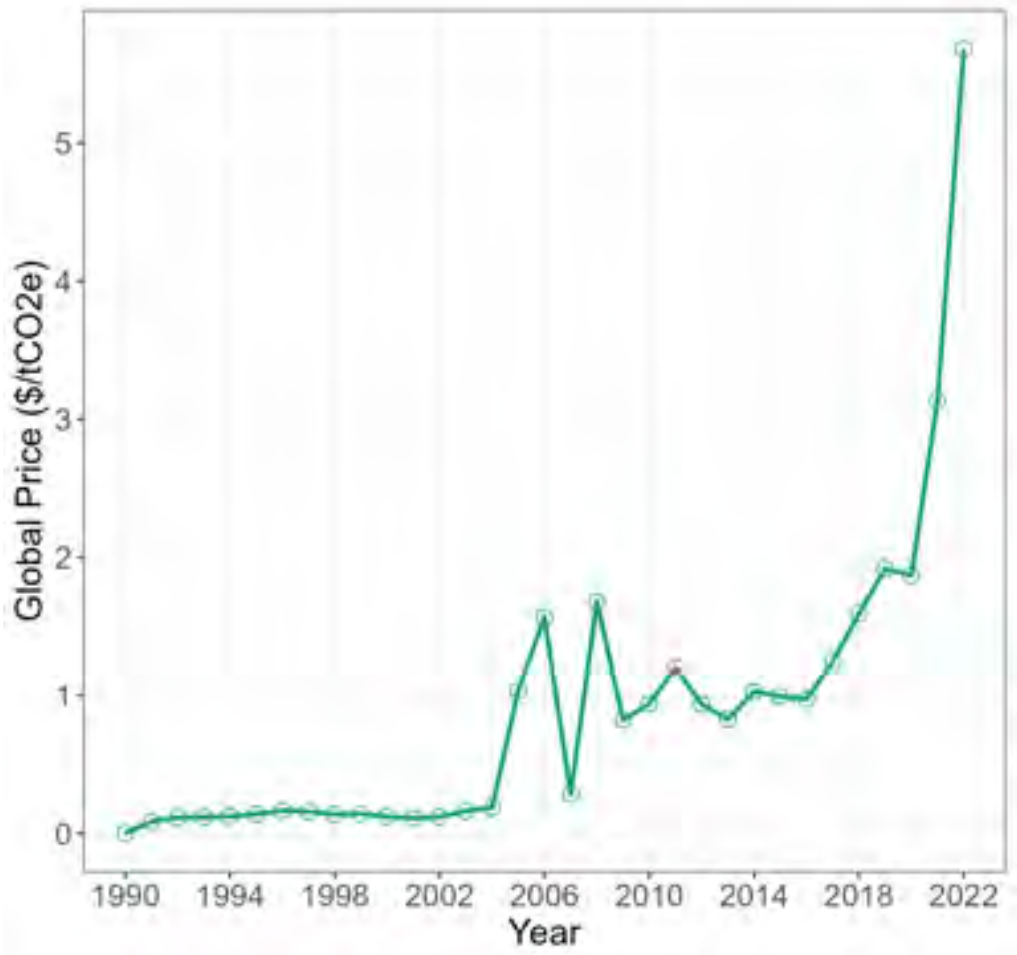
Global Use: ESG Investing and Sustainable Finance Reg.



Magnitude of
Carbon Pricing versus Green Finance

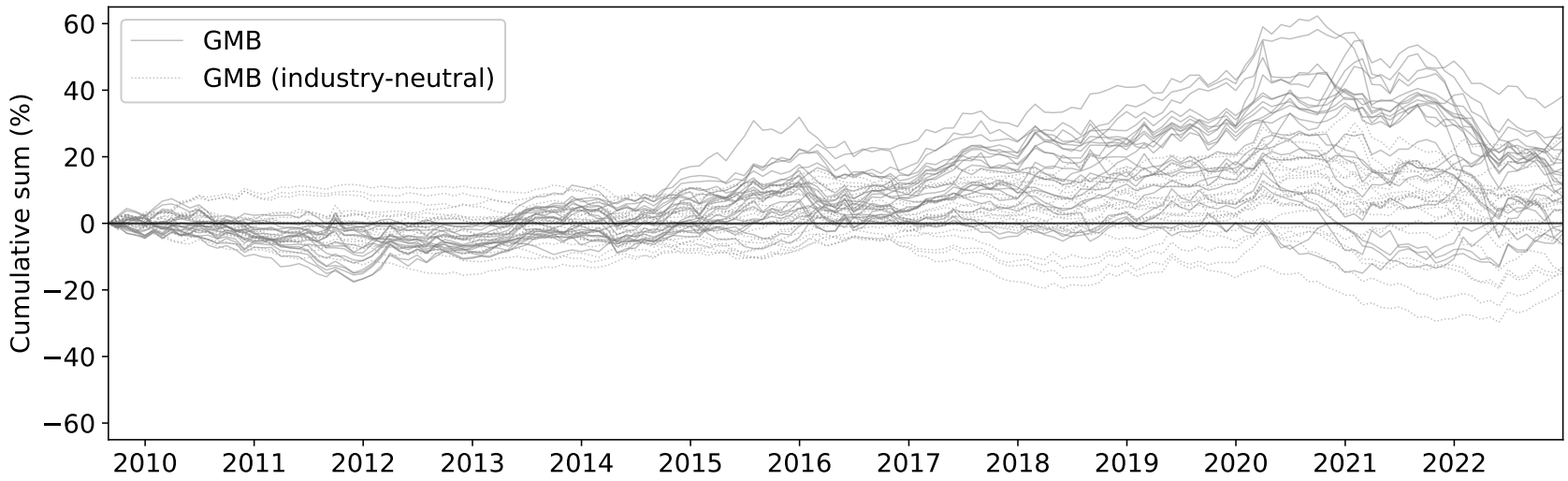
Global Carbon Price

$$\bar{p}_c = \tau_c^{tax} \frac{\text{CO2 covered}_c^{tax}}{\text{Total CO2 in country}_c} + \tau_c^{ETS} \frac{\text{CO2 covered}_c^{ETS}}{\text{Total CO2 in country}_c}$$



Magnitude of Green Finance: Estimates from New Paper

"In Search of the True Greenium," Eskildsen, Ibert, Jensen, and Pedersen ('24)



Literature: Realized return of GMB (green-minus-brown)

Our replication:

- 23 measures
- 48 countries
- Industry neutral: yes/no.
- Alpha vs. 1/CAPM/FF3/FF6

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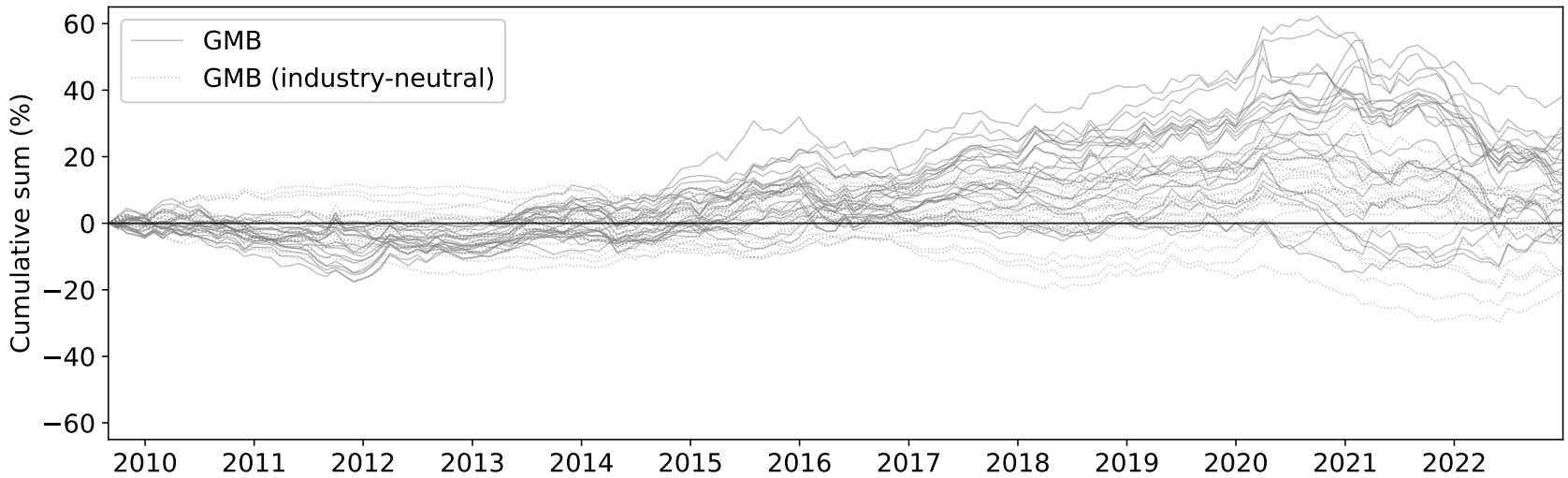

Literature: Realized return of GMB (green-minus-brown)

Our replication:

- 23 measures
- 48 countries
- Industry neutral: yes/no.
- Alpha vs. 1/CAPM/FF3/FF6

Result: everything insignificant with multiple-testing adjustment

Reason: need 300+ years of realized returns, only have 13 years

Effect of Green Finance: Estimates from New Paper

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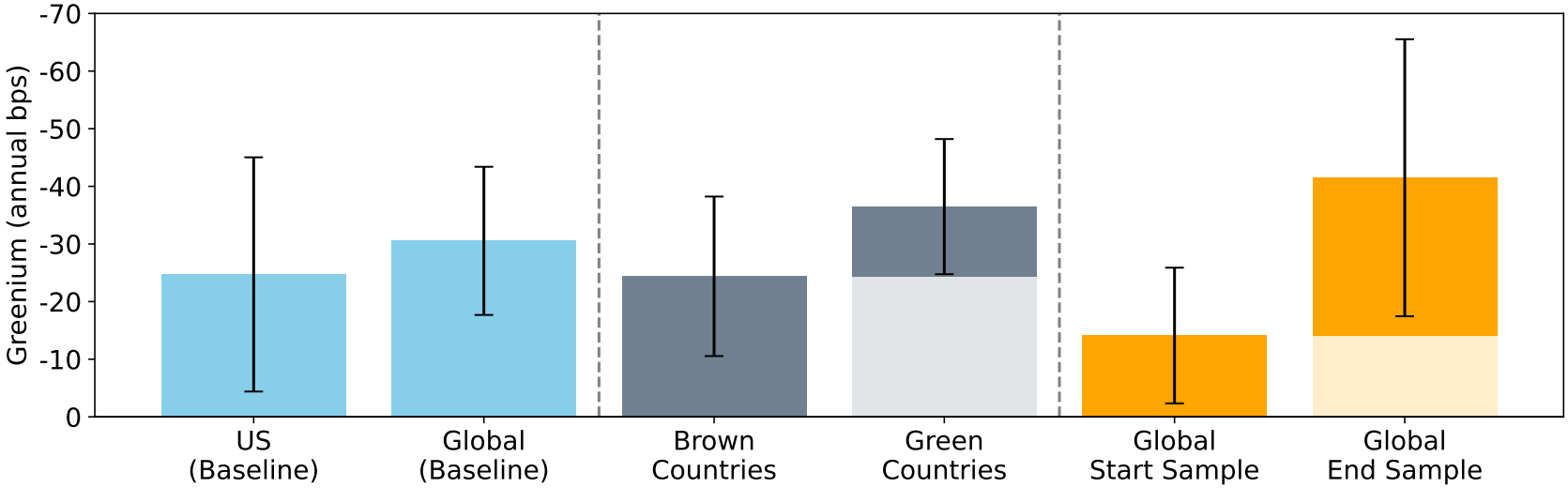


New estimate of greenium, g, based on

- forward-looking expected returns, $\hat{E}(r_t^i)$
- robust green score, s_t^i

$$\hat{E}(r_t^i) = g \times s_t^i + \text{controls} + \varepsilon_t^i$$

Conclusion: Everything, Everywhere, All at Once?

- The UN secretary general, António Guterres: *"our world needs climate action on all fronts — everything, everywhere, all at once"*
- My unified model of carbon pricing and green finance:
  - Only need one tool everywhere at once—carbon tax
  - But, if all tools are limited, many small steps
  - Carbon tax will be needed
    - Hard to move cost of capital enough
    - Stranded assets

Appendix

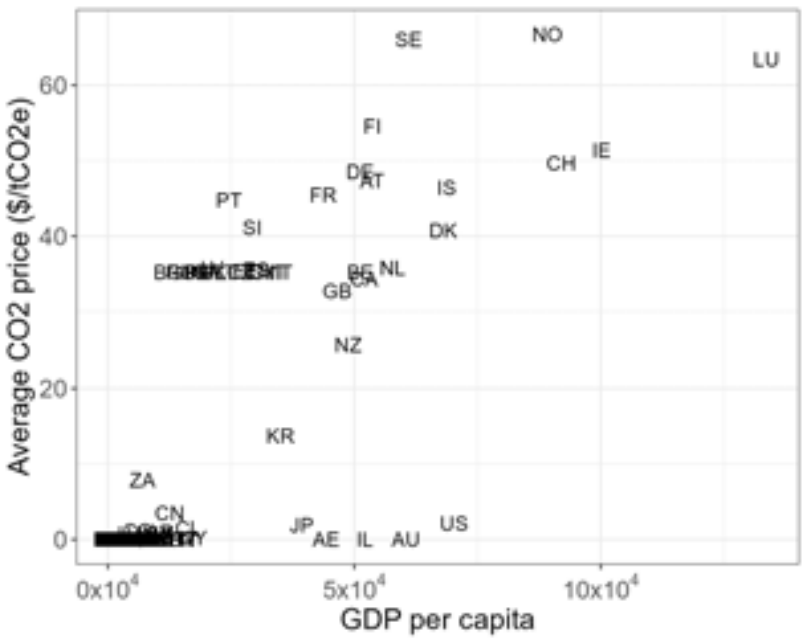
Global Economic Conditions and Carbon Pricing versus Green Finance

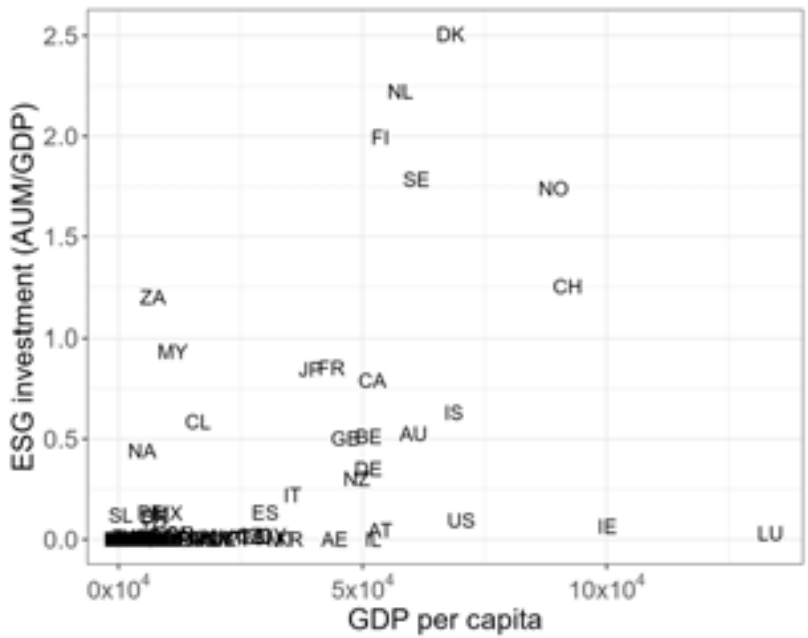
Carbon Offset Prices vs. Quality of Offset

	Dependent variable: Est. Retirement Price	
	(1)	(2)
Constant	5.97***	2.44***
	(0.08)	(0.26)
Registry dummies		
Example: CDM	-3.94***	
	(0.03)	
Registry Quality Score		0.51***
		(0.002)
Sector dummies		
Chemical Processes/Industrial Manufacturing	0.75***	0.14
	(0.08)	(0.26)
Energy Efficiency/Fuel Switching	3.83***	2.79***
	(0.08)	(0.26)
Forestry and Land Use	4.10***	3.03***
	(0.07)	(0.26)
Household Devices	3.78***	2.74***
	(0.08)	(0.26)
Renewable Energy	-0.07	-1.10***
	(0.07)	(0.26)
Transportation	-1.12***	-0.34
	(0.11)	(0.32)
Waste Disposal	0.59***	0.29
	(0.07)	(0.26)
Other	8.19***	7.14***
	(0.08)	(0.26)
R^2	0.70	0.70
Observations	288,046	269,536

Emission Price and ESG vs. Wealth

$$\bar{p}_c = \tau_c^{tax} \frac{\text{CO2 covered}_c^{tax}}{\text{Total CO2 in country}_c} + \tau_c^{ETS} \frac{\text{CO2 covered}_c^{ETS}}{\text{Total CO2 in country}_c}$$





Carbon Price and Green Finance vs. Societal Conditions

	CO2 price		ESG		NGFS	
Constant	5.93	2.93	−0.13	−0.18	−0.01	0.05
	(5.98)	(5.65)	(0.22)	(0.19)	(0.23)	(0.23)
GDP/capita	5.35***	4.79***	0.11***	0.05**	−0.01	−0.01
	(0.68)	(0.68)	(0.03)	(0.02)	(0.03)	(0.03)
Democracy	1.42***	1.49***	0.03*	0.03**	0.10***	0.11***
	(0.50)	(0.50)	(0.02)	(0.02)	(0.02)	(0.02)
Knowl. of global warming	10.44*	3.35	0.09	−0.01	0.21	0.08
	(5.80)	(5.68)	(0.22)	(0.19)	(0.23)	(0.23)
Inequality (Gini)	−0.42***	−0.25**	−0.00	0.00	−0.01	−0.01
	(0.12)	(0.11)	(0.00)	(0.00)	(0.00)	(0.00)
Emission/capita in 2000	−0.89***	−0.59*	−0.02*	0.00	0.02**	0.03**
	(0.30)	(0.30)	(0.01)	(0.01)	(0.01)	(0.01)
Legal origin						
English		−4.08**		−0.03		−0.21**
		(1.97)		(0.07)		(0.08)
German		9.18***		−0.10		−0.15
		(2.58)		(0.09)		(0.11)
Scandinavian		14.01***		1.19***		−0.20
		(5.03)		(0.17)		(0.21)
Socialist		1.22		0.12		0.01
		(9.63)		(0.33)		(0.40)
R^2	0.69	0.74	0.36	0.54	0.41	0.44
Num. obs.	148	148	148	148	148	148

Do Countries Have Carbon Pricing or Green Fi or Both?

Panel A: Correlations

	CO2-price	NGFS	ESG
CO2 price	1		
NGFS	0.47	1	
ESG	0.50	0.34	1

Panel B: *t*-statistics

	CO2-price	NGFS	ESG
CO2 price			
NGFS	7.31		
ESG	7.99	4.93	

Carbon Allowance Prices and Economic Conditions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Brentoil	0.27***							0.10**
	(0.02)							(0.03)
Gasoil		0.30***						0.15***
		(0.02)						(0.04)
EuroStoxx			0.42***					0.24***
			(0.04)					(0.05)
SP500				0.35***				0.06
				(0.04)				(0.05)
EuroBund					−1.78***			−0.50
					(0.28)			(0.30)
Aluminium						0.22***		0.01
						(0.04)		(0.04)
Corn							0.13***	0.02
							(0.03)	(0.03)
Adj. R^2	0.03	0.03	0.03	0.02	0.01	0.01	0.00	0.05
Observations	4508	4508	4508	4508	4508	4508	4508	4508

Carbon Allowances

Proposition (Cap-and-Trade)

There exists a level $\bar{C}$ of total carbon allowances such that the market equilibrium is socially optimal when all firms are required to buy carbon allowance or high-quality offsets, $\bar{q}_i = 1$, required returns are competitive, $r_i = r$, and $\tau_w = 0$.

References Cited in Slides (see paper for further references)