Carbon Returns across the Globe

Shaojun Zhang

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Present by: Zhen Long

Research background

- The pricing of carbon transition risk is a central question as investors consider climate-aware investments.
- Carbon transition risk: the financial and operational risks that companies face as the global economy transitions toward net-zero carbon emissions.
  - → brown firms should earn higher expected return (premium)
  - ← Green firms can outperform when policy shocks kick in
- Empirically: mixed evidence
- Practice: Blackrock and vanguard retain brown firms despite net-zero pledges.

Research motivation

- Revisit and explain this important debate empirically
- A key empirical challenge:
  - Emission data are released with significant lags (Median lags are 10-12 m)
  - Carbon emissions are estimated using economic activity
  - → emission contains substantial info about firm performance
  - → should be lagged to avoid look-ahead bias

- This paper provides new evidence by accounting for the emission lags and explains existing literature findings and a novel explanation for carbon returns

Research question

- Are carbon returns (brown-minus-green) truly a risk premium?
  - reflect firm performance
- How do carbon returns vary across countries with different climate policies and investor preferences?

Contribution

- Literature on the pricing of carbon risks
- Prior literature provides conflicting findings
  - Bolton and Kacperczyk (2021, 2023) : positive brown-minus-green
  - In et al. (2017), Garvey et al. (2018), Duan et al. (2023),…: negative premium

- This paper examines a critical methodological choice and reconcile conflicting findings

Contribution

- Literature to international climate evidence
- Prior literature interpret cross-country carbon return variation as expected return variation (BK, 2023)

- This paper shows that the variation reflect climate concern shifts

Contribution

- Literature of institutional investors and ESG investing
- Prior literature shows evidence about carbon transition and price impact of institutional investors in US
  - Pastor, Stambaugh, and Taylor (2022)
  - Berk and van Binsbergen (2021), van der Beck (2021), Ardia et al. (2023), and Alekseev et al. (2022)

- This paper extends to international markets and examines cross-country implications

Research design

- Data
  - Firm-level annual carbon emission: S&P Trucost
    - Scope 1: direct emissions from sources owned or controlled by the firm
    - Scope 2: indirect emissions from the generation of purchased electricity, steam, heating, and cooling consumed by the reporting company.
    - Trucost provide the data available date (use the most recently available)
  - Stock market and accounting info: CRSP, Compustat
  - Market level: natural gas price, Brent oil price, and commodity index from FRED at the St. Louis Fed and by country-level information extracted from World Bank, World Risk Poll, and Climate Change Performance Index.
- 2009 June – 2021 Dec
- 22 developed markets + 58 developing markets

Research design

- Main measure of carbon transition risk
  - Carbon intensity: emissions scaled by sales

	U.S.			Global		
	AR	Mean	*SD*	AR	Mean	*SD*
Scope 1 Intensity	0.99	2.71	2.19	0.99	3.04	2.27
Scope 2 Intensity	0.94	2.71	1.40	0.94	2.92	1.49
Scope 1 ΔEmissions	−0.05	0.04	0.48	−0.06	0.02	0.53
Scope 2 ΔEmissions	−0.10	0.06	0.56	−0.09	0.04	0.54
Scope 1 Log Emissions	0.98	10.08	3.06	0.98	10.14	2.93
Scope 2 Log Emissions	0.97	10.08	2.53	0.97	10.02	2.29
Log Sales	0.98	7.47	1.97	0.98	6.33	2.01
Beta	0.87	1.23	0.63	0.87	1.06	0.48
Size	1.01	7.97	1.68	0.98	6.45	1.78
Book-to-Market	0.85	−0.88	0.94	0.82	−0.52	0.9
ROA	0.72	0.00	0.15	0.7	0.02	0.13
Asset Growth	0.10	0.12	0.36	0.08	0.14	0.4
Momentum	0.00	0.16	0.50	0.10	0.15	0.53
Log PPE	0.06	4.84	3.81	0.74	3.47	4.01
Leverage	0.74	3.90	4.05	0.14	1.67	4.98
IVol (×100)	0.68	1.97	1.51	0.49	2.08	1.36
ΔSales	−0.04	0.05	0.36	−0.08	0.08	0.42
ΔEPS	−0.28	0.10	2.37	−0.29	0.03	1.58
Natural Gas Exposure	0.75	0.02	0.09	0.75	0.16	0.29
Oil Exposure	0.78	0.22	0.24	0.78	0.01	0.11
Commodity Exposure	0.75	2.63	2.88	0.75	1.67	2.48

Empirical results

- Financial information contained in emissions data

$$\log Emission_{it} = \alpha + \beta \log Sales_{it} + \varepsilon_{it},$$

$$\Delta Emission_{it} = \alpha + \beta \Delta Sales_{it} + \varepsilon_{it},$$

Panel A: Emissions and Sales

	U.S.				Global			
	Log Emissions		ΔEmissions		Log Emissions		ΔEmissions	
	Scope 1	2	1	2	1	2	1	2
Log Sales	1.04***	1.04***			1.01***	0.97***		
	(44.51)	(78.79)			(55.21)	(74.03)		
ΔSales			0.86***	0.89***			0.74***	0.72***
			(29.56)	(35.73)			(29.12)	(27.59)
Industry FE	N	N	N	N	N	N	N	N
Time FE	Y	Y	Y	Y	Y	Y	Y	Y
Country FE	N	N	N	N	Y	Y	Y	Y
R^2	0.50	0.71	0.34	0.35	0.49	0.66	0.18	0.18
Observations	21,783	21,783	19,219	19,219	92,790	92,790	84,247	84,247

Empirical results

- Baseline analysis: return ~ carbon intensity (US)

	Scope 1				Scope 2			
	L	M	H	H-L	L	M	H	H-L
Panel A: Intensity								
Raw Return	1.44***	1.51***	1.04***	−0.39**	1.51***	1.31***	1.24***	−0.27*
	(4.03)	(4.51)	(3.00)	(−2.47)	(4.26)	(3.88)	(3.62)	(−1.87)
α	0.15**	0.11	−0.24**	−0.40**	0.21***	0.01	−0.13	−0.34**
	(2.16)	(1.39)	(−2.34)	(−2.51)	(2.68)	(0.11)	(−1.57)	(−2.40)
Panel B: ΔEmissions								
Raw Return	1.29***	1.26***	1.49***	0.20	1.31***	1.31***	1.41***	0.10
	(3.95)	(3.65)	(4.04)	(1.37)	(3.80)	(3.89)	(3.90)	(0.68)
α	0.06	−0.02	0.04	−0.02	0.07	0.03	−0.01	−0.08
	(0.91)	(−0.34)	(0.44)	(−0.17)	(0.89)	(0.46)	(−0.16)	(−0.57)
Panel C: Emissions								
Raw Return	1.62***	1.41***	1.28***	−0.34*	1.39***	1.50***	1.30***	−0.09
	(4.03)	(3.70)	(4.02)	(−1.77)	(3.61)	(4.14)	(3.86)	(−0.42)
α	0.36***	0.11	−0.06	−0.42***	0.28**	0.23**	−0.05	−0.33**
	(3.74)	(1.34)	(−1.13)	(−3.30)	(2.07)	(2.39)	(−1.30)	(−2.17)

Empirical results

- Baseline analysis: return ~ carbon intensity (Global)

	Scope 1				Scope 2			
	L	M	H	H-L	L	M	H	H-L
Panel A: Intensity								
Raw Return	0.90***	0.84***	0.90***	−0.01	0.90***	0.82***	0.93***	0.01
	(10.61)	(9.70)	(10.58)	(−0.20)	(10.66)	(9.60)	(10.74)	(0.08)
α	0.06	−0.07	−0.05	−0.06	0.05	−0.06	−0.03	−0.03
	(0.74)	(−0.88)	(−0.61)	(−0.74)	(0.62)	(−0.75)	(−0.41)	(−0.43)
Panel B: ΔEmissions								
Raw Return	0.90***	0.88***	0.84***	−0.07	0.85***	0.90***	0.88***	0.02
	(10.46)	(10.35)	(9.86)	(−1.13)	(10.11)	(10.39)	(10.29)	(0.25)
α	0.01	0.00	−0.10	−0.08	−0.02	0.00	−0.06	0.00
	(0.16)	(0.03)	(−1.25)	(−1.22)	(−0.25)	(0.02)	(−0.74)	(0.00)
Panel C: Emissions								
Raw Return	0.93***	0.88***	0.84***	−0.12*	0.95***	0.91***	0.78***	−0.20***
	(10.82)	(10.42)	(10.04)	(−1.77)	(10.98)	(10.60)	(9.61)	(−3.06)
α	0.07	0.01	−0.09	−0.11	0.06	0.00	−0.11	−0.15**
	(0.83)	(0.11)	(−1.16)	(−1.44)	(0.76)	(0.03)	(−1.51)	(−2.07)

Empirical results

- Replicate existing findings: contemporaneous portfolio sort
  - Follow BK (2021, 2023): investors can develop expectations regarding carbon emissions as the fiscal year progresses
  - Positive premium for ΔEmission

Panel A: Contemporaneous Return								
	Scope 1				Scope 2			
	L	M	H	H-L	L	M	H	H-L
Intensity	1.03***	1.01***	0.98***	−0.05	1.08***	0.95***	1.03***	−0.04
	(3.15)	(3.71)	(3.20)	(−0.29)	(3.43)	(3.24)	(3.40)	(−0.28)
ΔEmissions	0.82***	0.93***	1.30***	0.47***	0.74**	0.97***	1.32***	0.58***
	(2.61)	(3.37)	(4.11)	(3.25)	(2.36)	(3.53)	(4.18)	(4.34)
Emissions	1.13***	1.01***	0.99***	−0.14	1.10***	1.16***	0.95***	−0.16
	(3.10)	(2.99)	(3.69)	(−0.75)	(3.37)	(3.56)	(3.31)	(−1.13)

Empirical results

- Replicate existing findings: contemporaneous portfolio sort

$$r_{it} = \alpha + \beta Carbon_{i\tau} + \beta \mathbf{Sales}_{i\tau} + \gamma Controls_{it-1} + \nu_t + \varepsilon_{it},$$

Panel B: Controlling for Future Sales Growth

	Scope 1				Scope 2			
	L	M	H	H-L	L	M	H	H-L
				B.1 Intensity				
ΔSales L	−0.04	0.13	−0.11	−0.07	−0.01	−0.07	−0.13	−0.12
	(−0.10)	(0.36)	(−0.31)	(−0.42)	(−0.01)	(−0.17)	(−0.37)	(−0.71)
2	0.95***	0.91***	0.74**	−0.21	0.80***	0.97***	0.87***	0.07
	(3.20)	(3.15)	(2.57)	(−1.43)	(2.75)	(3.37)	(3.02)	(0.50)
H	1.71***	1.49***	1.72***	0.01	1.63***	1.47***	1.80***	0.18
	(5.52)	(4.54)	(4.31)	(0.04)	(5.26)	(4.04)	(4.64)	(0.81)
				B.2 ΔEmissions				
ΔSales L	0.04	−0.05	0.01	−0.03	0.17	−0.00	−0.08	−0.25
	(0.10)	(−0.12)	(0.04)	(−0.11)	(0.45)	(−0.01)	(−0.24)	(−1.31)
2	0.75**	0.75**	0.99***	0.24	0.80**	0.81***	0.91***	0.12
	(2.15)	(2.36)	(3.70)	(1.25)	(2.58)	(2.64)	(3.24)	(0.81)
H	1.56***	1.72***	1.66***	0.10	1.52***	1.84***	1.62***	0.10
	(4.05)	(4.71)	(5.00)	(0.42)	(4.08)	(4.95)	(4.91)	(0.46)

Empirical results

- Cross-country variation
  - Negative in developed markets
  - Positive in emerging markets

Panel A: Value-Weighted Sorting						
	Scope 1			Scope 2		
	G7 + AUS	DM	EM	G7 + AUS	DM	EM
Raw Return	−0.38***	−0.32***	0.23***	−0.25***	−0.22***	0.12**
	(−5.84)	(−6.95)	(3.94)	(−4.11)	(−5.16)	(1.97)
α	−0.44***	−0.40***	0.20***	−0.34***	−0.33***	0.06
	(−7.24)	(−9.52)	(3.55)	(−6.10)	(−8.36)	(0.99)

Empirical results

- How to explain:
  - climate concern or climate tastes
    - Country-level Investors' demand: sustainable investor flows each quarter scaled by end-of-quarter market capitalization
    - The level of climate concerns from the Lloyd's Register Foundation
  - Current policy tightness
    - the policy score in the Climate Change Performance Index
    - the fraction of renewable energy
    - civil law dummy
  - Cash flow shock
    - carbon returns on earnings days
    - long-short spread in consensus analyst revisions
    - long-short spread in sales growth next year

Empirical results

- Explain cross-country variation

$$r^s_{it} = a + b \cdot X_{it-1} + \kappa \cdot Y_{it} + \nu_t + e_{it},$$

	Scope 1			Scope 2		
	(1)	(2)	(3)	(4)	(5)	(6)
GDP Per Capita	−0.18**			−0.17**		
	(−2.41)			(−2.35)		
Sustainable Flow		−0.10			−0.15**	
		(−1.37)			(−2.11)	
Climate Concern			−0.11*			−0.15**
			(−1.68)			(−2.26)
Earnings Day Ret	0.79***	0.77***	0.78***	0.71***	0.69***	0.71***
	(8.62)	(8.53)	(8.46)	(6.42)	(6.41)	(6.39)
$E_t[\Delta \text{EPS}_{t+1}]$	3.87***	3.65***	3.98***	4.68***	3.94***	4.71***
	(3.10)	(2.88)	(3.15)	(3.56)	(3.15)	(3.45)
$E_t[\Delta \text{LTG}]$	0.16	0.15	0.17	0.14	0.12	0.22
	(0.71)	(0.66)	(0.73)	(0.51)	(0.41)	(0.76)
$\Delta \text{Sales}_{t+1}$	0.49	0.27	0.53	0.44	0.24	0.47
	(1.41)	(0.80)	(1.47)	(1.23)	(0.68)	(1.28)
Oil Exposure	−0.01	−0.01	−0.01	−0.01	−0.01	−0.01
	(−1.29)	(−1.24)	(−1.41)	(−1.47)	(−1.51)	(−1.48)

- The transition to the equilibrium with carbon-aware investment is underway.

Empirical results

- Explain cross-country variation

$$r^s_{it} = a + b \cdot X_{it-1} + \kappa \cdot Y_{it} + \nu_t + e_{it},$$

	Panel B: Additional Country Characteristics					
Policy	0.13**			0.10		
	(2.12)			(1.33)		
%Renewable Energy		0.20**			0.16**	
		(2.60)			(2.08)	
1(Civil Law)			0.55***			0.41**
			(3.38)			(2.52)
Controls	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y
R^2	0.12	0.08	0.08	0.09	0.06	0.07
Observations	4,376	6,033	6,033	4,376	6,033	6,033

- Countries with more stringent climate policies, more renewable energy, and civil law yield higher carbon returns

Conclusion

- After accounting for the data release lag, more carbon-intensive firms underperform relative to less carbon intensive firms in the
- International evidence on carbon or green premium is largely absent.
- The carbon premium documented in previous studies stems from forward-looking bias instead of a true risk premium.
- Shifts in investor preferences, policy tightness, and cash flow shocks are factors driving the cross-country carbon return variation.

Possible extension

- Carbon return on fund, fixed income, or private market
- Social media and carbon return
- Climate events and carbon return
- Cross country analysis on greenwashing and carbon return