Carbon Beta: A Market-Based Measure of Climate Risk

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Abstract

We estimate asset-level climate risk exposure by regressing stock returns on a pollutive-minus-clean portfolio. This measure, **'carbon beta'**, has relatively high levels of availability, coverage, and informativeness. We study the interaction of carbon betas with several proxies for realisations in climate risk. Returns to stocks with high carbon betas are lower during months in which climate change is more frequently discussed in the news, during months in which temperatures are abnormally high, and during exceptionally dry months. Variation in carbon betas correlates with green patent issuance and forward-looking measures of climate risk.

Background & Motivation

Despite rising investments in sustainable assets, adressing climate transition risks remains challenging

- Krüger, Sautner & Starks (2020) survey 439 investment professionals: *"... integrating climate risks into the investment process can prove to be challenging, with investment tools and best practices not yet well established."* (p. 1068).
- Giglio, Kelly & Stroebel (2020) propose a research agenda for Climate Finance: *"On the empirical side, there is substantial scope for improvements of the measures of climate risk exposure in different asset classes, and in particular for equity assets."* (p. 24).

Data

(1) **Stock market and accounting variables** from merging CRSP and S&P Capital IQ Compustat: ±570k firm-month observations on 6,900+ unique firms.

(2) **Corporate emissions** from S&P Trucost: Merge 199k+ firm-month observations to 2,700+ unique firms.

(3) **Climate Policy Uncertainty (CPU)**: Daily Wall Street Journal archives, IPCC Assessment Reports, and articles in Wikipedia Climate Change category

(4) **Temperature anomalies and droughts** data (Palmer, 1965) from NOAA

(5) **Green Innovation**: Patent issues from the U.S. Patent Office Bulk Data Storage System + Green Patent classification from the OECD (Haščič and Migotto; 2015) and the WIPO Green Inventory + Patent-Company mapping by own algorithm & WRDS U.S. Patents (Bèta) product.

Methodology

Pollutive-Minus-Clean is a portfolio that goes long in 30% of highest emitters, while going short in 30% of lowest emitters.

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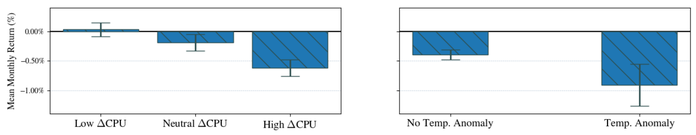
Methodology (cont'd)

Performance of the PMC Portfolio

Performance of the PMC Portfolio Conditional on ΔCPU and Temperature Anomalies



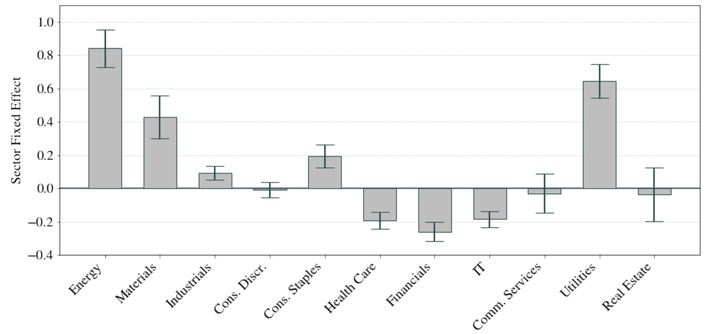
Estimation of **carbon betas** (3-year rolling window, daily returns):

$$R^e_{i,t} = \alpha_i + \beta_i^{PMC} PMC_t + \boldsymbol{\beta}_\mathbf{i}^{\mathbf{4F}} \mathbf{X}_{\mathbf{4F,t}} + \epsilon_{i,t},$$

where β_i^{PMC} denotes firm i's carbon beta and $\boldsymbol{\beta}_\mathbf{i}^{\mathbf{4F}}$ holds sensitivities towards the Fama & French (1993) and the Carhart (1997) factors.

Validation

Industry Sector Variation in Climate Risk Exposure



Firm Characteristics and Climate Risk Exposure

Smaller, lower-valued, more capital-intensive, and less innovative firms have higher carbon betas. So do firms with higher emissions, emission intensities and lower "E"-scores.

Main results

When CPU increases, stocks with higher carbon betas have lower returns. For each standard deviation with which the CPU index increases, a 1 standard deviation higher carbon beta tends to be associated with a 42 bps lower return, *ceteris paribus*.

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Main results (cont'd)

A similar effect occurs in months with abnormally high temperatures and droughts.

Carbon Beta × CPU and Stock Returns

		$\Delta CPU \geq 0$	$\Delta CPU < 0$
	(1)	(2)	(3)
Carbon Beta† × ΔCPU†	-0.103***	-0.420***	-0.176**
	(0.025)	(0.069)	(0.068)
Carbon Beta†	0.098***	0.425***	-0.042
	(0.037)	(0.075)	(0.076)
Controls	Yes	Yes	Yes
Year - Month FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
N.o. Obs.	207,727	105,506	102,221
R^2-Adj.	0.261	0.279	0.240

†Indicates a standardised variable. Firm-level variables are cross-sectionally standardised.

Firms with higher shares of green patents have lower carbon betas. The effect is most pronounced for firms in emission-intense sectors which are drivers of green innovation (Cohen, Gurun, & Nguyen, 2020), such as the Energies sector.

Green Patent Share and Climate Risk Exposure

	Carbon Beta†	Carbon Beta†	Emission Intensity†	log Emissions†
Green Share (%)	-0.098**	-0.458*	-0.201	0.223
	(0.043)	(0.257)	(0.419)	(0.279)
Controls	Yes	Yes	Yes	Yes
Year-Month	Yes	Yes	Yes	Yes
Industry FE	Yes	No	No	No
Sectors	All	Energy	Energy	Energy
N.o. Obs.	183,707	7,899	4,205	4,205
R^2-Adj.	0.351	0.284	0.261	0.704

†Indicates a cross-sectionally standardised variable.

Conclusion

- We propose a complementary measure of climate risk determined by the extent to which an asset's return correlates with a carbon risk factor.
- Carbon Betas can be estimated for a wide variety of assets, have high cross-sectional coverage, help in identifying both climate "winners" and "losers", and capture forward-looking information such as green innovation.
- Stocks with higher Carbon Betas have lower returns in months when CPU increases, when temperatures are abnormally high, or during extreme droughts.
- "Carbon premium" amounts to ±26 bps per month.

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