Market-Based Green Firms

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Strong demand for greenness measures. What is a green firm?

There is a strong demand for variables measuring the "greenness" of firms.

- Investors use them to invest sustainably.
- Policymakers use them to enact targeted climate policy laws.
- Researchers use them as proxies for exposure to climate change risk (political, transition, physical).

Various measures for the greenness of a company exist

Different papers use different variables to proxy for climate risk exposure:

- Environmental Scores (E-Scores) (Engle et al. [2]).
- Carbon intensities $\frac{CO_2EE}{MV}$ (Ramelli et al. [4], Ilhan, Sautner, and Vilkov [3]).
- Textual analysis measures of earnings conference calls (Sautner et al. [5]).
- Oil betas (Barnett [1])
- Many other carbon ratings, variables and providers...

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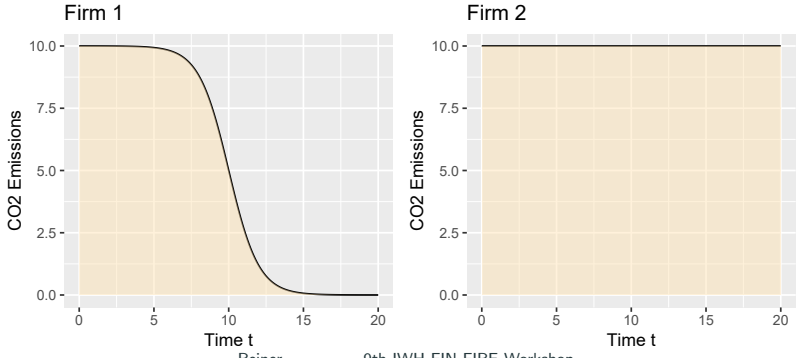
They all have more or less one key problem:
They look at the present or past, not the future.

Problem of traditional backward looking measures

- Not current, but (expected) future emissions matter!
- Two firms might have the same emissions at a certain point in time, but what matters is the area under the curve:

$$CO_2(t=0)^{\text{Firm1}} = CO_2(t=0)^{\text{Firm2}} \quad \text{but} \quad \int_0^{\infty} CO_2(t)^{\text{Firm1}} dt < \int_0^{\infty} CO_2(t)^{\text{Firm2}} dt \quad (1)$$



Financial Markets can provide forward looking measures!

- (Sovereign) bond markets reflect **expected future** interest rates.
- Forwards, futures, derivatives reflect **expected future** prices.
- Stock markets reflect **expected future** profits of firms.

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Our measure attempts to isolate **expected future greenness or climate policy risk exposure** by the reaction of stocks to green news events.

Research questions

Can we create a market-based measure for the greenness of a firm?

- How can we measure the future expected "greenness" of firms in financial markets?
- Can we use firms' abnormal returns around climate change (policy) events to infer firms' exposure to climate policy risk and use them as a measure of greenness?

Why is our measure useful?

Advantages of our measure:

- Our measure is **forward-looking**.
- Our measure **does not rely on self-reported data**.
- Our measure can be computed for any firm listed on a stock exchange.
- Our measure can be computed by anyone anytime and does not come with reporting delay.

Model

The paper includes a rational expectations equilibrium (REE) model of asset prices to show to what extent realized returns provide information about the "greenness" of a stock.

Main ingredients:

- Multiple assets whose fundamentals are driven by a climate risk factor in addition to a market risk factor and idiosyncratic risks.
- Investors with mean-variance preferences choose to allocate their limited attention to learn about these risks.

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Solution: Our method works if climate risk attention and fundamental climate risk uncertainty is large.

- equilibrium abnormal return on stock i:

$$r_i = g_i \gamma(\sigma_c, K_c)\hat{z}_c + \gamma(\sigma_s, K_i)\hat{z}_i, \tag{2}$$

Identification of climate policy shocks

Identification via attention data (Google Trends) ...

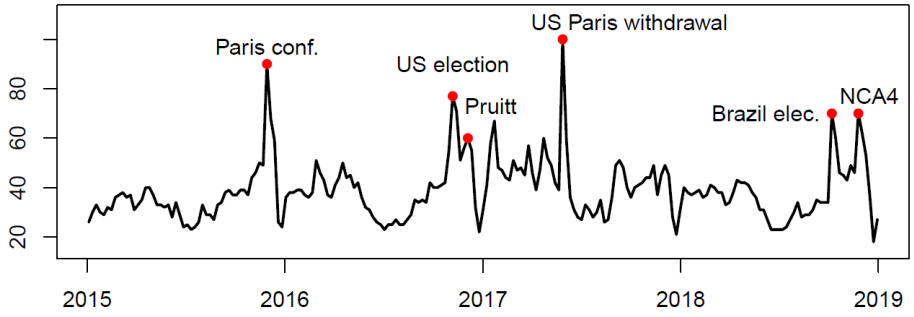


Figure 1: Weekly relative search volume for the term "climate change"

Identification of climate policy shocks

... by browsing the literature ...

Date	Event	Shock Sign	Source
5-Jun-96	Solar Two Plant Demonstrates Low Cost Method of Storing Solar Energy	+	ProCon.org
18-Jul-96	COP 2, Geneva, Switzerland	+	IPCC
9-Oct-96	Hydrogen Future Act of 1996 Is Passed to Further Expand Hydrogen Power Development	+	ProCon.org
29-Oct-96	European Union adopts target of a maximum 2 °C rise in average global temperature	+	Wikipedia
5-Nov-96	Bill Clinton Elected POTUS	+	U.S. Presidential Elections
5-Dec-96	EV1 Electric Car Is Made Available to the Public For Lease; Lease Program and EV1 Later Dismantled by GM	+	ProCon.org
25-Jun-97	US Senate passes Byrd–Hagel Resolution rejecting Kyoto	-	Wikipedia
11-Dec-97	COP 3, The Kyoto Protocol on Climate Change	+	Wikipedia/IPCC
14-Nov-98	COP 4, Buenos Aires, Argentina	+	IPCC
5-Nov-99	COP 5, Bonn, Germany	+	IPCC
7-Nov-00	George W. Bush Elected POTUS	-	U.S. Presidential Elections
25-Nov-00	COP 6, The Hague, Netherlands	+	IPCC
28-Mar-01	President George W. Bush withdraws from the Kyoto negotiations	-	Wikipedia
27-Jul-01	COP 6, Bonn, Germany	+	IPCC
29-Sep-01	IPCC Third assessment report	+	IPCC
10-Nov-01	COP 7, Marrakech, Morocco	+	IPCC
13-May-02	Farm Security and Rural Investment Act	+	Wikipedia

Figure 2: Events identified by Barnett [1]

Identification of climate policy shocks

... or by handpicking certain events by combining sentiment data and our own assessment.

- Paris climate conference 2015 is considered an important milestone.
- Copenhagen climate conference 2009 is considered a surprising disappointment.
- ...

Set of events we consider

Set 1: Paris agreement		
Date	Event	Shock Sign
2015-12-12	UN climate change conference in Paris	+
Set 2: Google Trends events		
2015-12-12	UN climate change conference in Paris	+
2016-11-08	Donald Trump Elected POTUS	-
2016-12-07	Trump's nomination of Scott Pruitt to lead the EPA	-
2017-06-01	Announcement of US withdrawal from the Paris agreement	-
2018-10-08	IPCC special report	+
2018-11-23	Release of NCA4	+
Set 3: Barnett events		
2015-08-03	President Obama Announces Clean Power Plan	+
2015-12-12	UN climate change conference in Paris	+
2016-02-09	Supreme Court issues stay on Clean Power Plan	-
2016-11-08	Donald Trump Elected POTUS	-
2017-06-01	Announcement of US withdrawal from the Paris agreement	-

Table 1: Different sets of climate change events

Construction of our measure

Once we have our events we compute abnormal returns around the events:

- CAPM as benchmark model:

$$\hat{R}_{i,t} = r_{f,t} + \hat{\beta}_i(R_{m,t} - r_{f,t}) \tag{3}$$

- Use 1 year of preceding daily return data to compute $\hat{\beta}$ via OLS regression:

$$R_{i,t} - r_{f,t} = \alpha_i + \beta_i(R_{m,t} - r_{f,t}) + \epsilon_{i,t} \tag{4}$$

- Compute daily abnormal returns around event dates as realized minus expected return:

$$AR_{i,t} = R_{i,t} - \hat{R}_{i,t} \tag{5}$$

- Compute cumulative abnormal returns around each event:

$$CAR_{i,t_1,t_2} = \prod_{t=t_1}^{t_2} (1 + AR_{i,t}) - 1 \tag{6}$$

Definition of our measure

We distinguish between "positive" (1) and "negative" climate shocks (-1). Our greenness measure for firm i at event e_t is

$$GreenMeas_{i,e_t} = \begin{cases} (C)AR_{i,e_t} \text{ , if } \text{sgn}(e_t) = 1 \\ -(C)AR_{i,e_t} \text{ , if } \text{sgn}(e_t) = -1 \end{cases} \tag{7}$$

Alternative: Use return rankings instead of returns (caveat: not information-preserving)

$$RankMeas_{i,e_t} = \begin{cases} \text{rank}\,[(C)AR_{i,e_t}] \text{ , if } \text{sgn}(e_t) = 1 \\ \text{rank}[-(C)AR_{i,e_t}] \text{ , if } \text{sgn}(e_t) = -1 \end{cases} \tag{8}$$

For multiple events our cross-sectional measure is then the average:

$$Greenness_i = \overline{GreenMeas_{i,e_t}} \tag{9}$$

$$Greennessrank_i = \overline{RankMeas_{i,e_t}} \tag{10}$$

Does it work? Abnormal returns following the Paris agreement

BTU: "Peabody Energy is the leading global pure-play coal company".
WPX: "WPX Energy, Inc. was a natural gas and oil exploration and production company".

	date	permno	industry	mktcap	AR	Ticker
1	2015-12-14	88991	Mining	142.35	-0.136	BTU
2	2015-12-14	13141	Mining	1580.08	-0.102	WPX
3	2015-12-14	63765	Mining	2733.65	-0.100	SWN
4	2015-12-14	52337	Services	3019.97	-0.096	THC
5	2015-12-14	90071	Utilities	3697.85	-0.095	NRG
6	2015-12-14	90352	Utilities	1615.42	-0.094	DYN
7	2015-12-14	27422	Mining	242.41	-0.091	CLF
8	2015-12-14	82196	Mining	709.35	-0.085	DNR
9	2015-12-14	12503	Manufacturing	720.86	-0.078	NAV
10	2015-12-14	13919	Finance	634.67	-0.075	AMBC
⋮	⋮	⋮	⋮	⋮	⋮	⋮

Does it work? Abnormal returns following the Paris agreement

At the other end of the table we have e.g. a solar panel company (FSLR), electronic companies and electric vehicle assemblers (ANET, CVG).

	date	permno	industry	mktcap	AR	Ticker
⋮	⋮	⋮	⋮	⋮	⋮	⋮
560	2015-12-14	15401	Manufacturing	26481.39	0.028	BXLT
561	2015-12-14	39538	Manufacturing	9229.65	0.029	MAT
562	2015-12-14	14541	Manufacturing	169308.05	0.03	CVX
563	2015-12-14	92239	Mining	11992.4	0.031	CXO
564	2015-12-14	82298	Mining	2894.05	0.032	DO
565	2015-12-14	75828	Services	21303.2	0.034	EA
566	2015-12-14	86305	Services	2427.6	0.038	CVG
567	2015-12-14	14714	Manufacturing	5274.13	0.04	ANET
568	2015-12-14	91611	Manufacturing	6715.6	0.053	FSLR

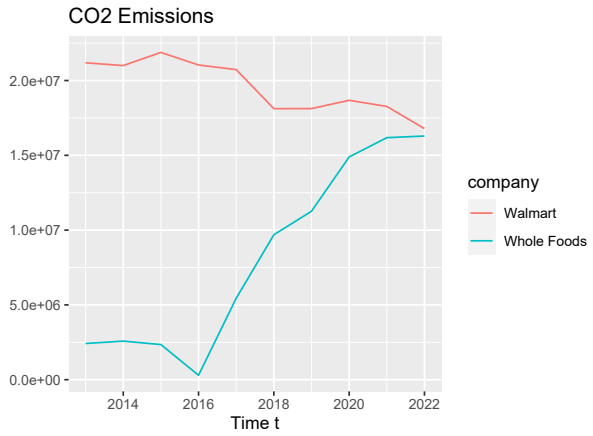
Which firm is "greener"? Our measure says Walmart.

Our market-based measure, e.g. from Paris 2015, says that Walmart is greener (1,52% AR) than Whole Foods Market (-2,16%).

Indeed Walmart could reduce emissions since then whereas Whole Foods Market increased them.

Maybe large scale industrial food production (Walmart) is easier to turn green than local organic food production, which Whole Foods Market is focused on (See Smith et al.[6]).

Other example: Tesla greener than GM.



External consistency: How does our measure relate to other "greenness" measures?

We expect and find a negative correlation with carbon intensities.

Pooled panel regression for different sets of events. Sample: S&P 500 firms. The estimated equation is

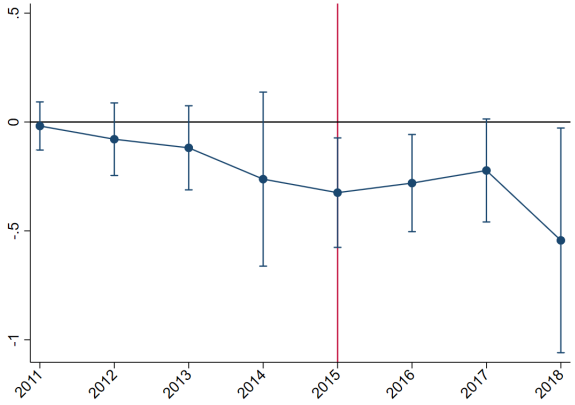
$$\textit{CarbInt}_{it} = \alpha + \textit{GreenMeas}_{it} + \epsilon_{it}$$

We also test correlations with E-scores and textual analysis scores.

	Dependent variable:						
	CarbInt						
	CAR_{00}	CAR_{01}	CAR_{-10}	CAR_{-22}	CAR_{00}	CAR_{01}	CAR_{-10}
Panel A: Paris climate summit							
Greenness	−2.9e+04*	−1.3e+04	−1.8e+04*	−5.3e+03			
	(1.7e+04)	(1e+04)	(9.6e+03)	(5e+03)			
Greenness rank					−2.34*	−0.68	−2.2*
					(1.27)	(1.08)	(1.28)
Panel B: 6 Google Trends Events							
Greenness	−9.6e+03**	−7.9e+03	−4.8e+03	−5e+03			
	(4.9e+03)	(6.1e+03)	(3.3e+03)	(4.1e+03)			
Greenness rank					−1.4**	−0.56	−1.03**
					(0.54)	(0.91)	(0.52)
Panel C: 5 Significant Barnett Events							
Greenness	−4.7e+03	−2.4e+03	−1.8e+03	728.36			
	(7.7e+03)	(7.2e+03)	(4.1e+03)	(1.5e+03)			
Greenness rank					−0.44	−0.39	0.12
					(0.94)	(1.09)	(0.9)
Note:							*p<0.1; **p<0.05; ***p<0.01

Our forward-looking measure correlates "better" with future carbon intensities

Figure 3: Correlation between Paris Climate Agreement CAR (0,0) and carbon intensity over time



Evidence of green-washing?

	Dependent variable:							
					EScore			
	CAR_{00}	CAR_{01}	CAR_{-10}	CAR_{-22}	CAR_{00}	CAR_{01}	CAR_{-10}	CAR_{-22}
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Paris climate summit								
Greenness	25.33	−39.47	40.94	22.99				
	(58.24)	(42.95)	(35.2)	(26.46)				
Greenness rank					8.3e-03	3.6e-03	0.01*	0.01*
					(8.3e-03)	(8.6e-03)	(8.2e-03)	(8.6e-03)
Panel B: 6 Google Trends Events								
Greenness	−120.42	−182.44***	−261.98***	−48.37				
	(122.45)	(64.27)	(100)	(66.45)				
Greenness rank					2.8e-03	−0.03*	−0.04**	−0.01
					(0.02)	(0.02)	(0.02)	(0.02)
Panel C: 5 Significant Barnett Events								
Greenness	16.72	−101.5	−234.86**	−115.07**				
	(119.7)	(81.42)	(111.96)	(48.55)				
Greenness rank					0.02	7.7e-03	−0.05***	−0.03*
					(0.02)	(0.02)	(0.02)	(0.02)

Note: *p<0.1; **p<0.05; ***p<0.01

We can build climate change hedge portfolios based on our measure

- We apply and follow the portfolio-mimicking approach used in Engle et al. [2].
- We gather monthly data of NYSE, AMEX and NASDAQ firms from CRSP and Compustat from 1980-2022 (excluding penny and microcap stocks).
- We compute firm characteristics $\boldsymbol{Z_t}$: Size, Book-to-Market, Greenness (using our methodology) and Market Share.
- We standardize most variables to create a set of characteristic-sorted portfolios $\tilde{\boldsymbol{r}} = \boldsymbol{Z}'_{t-1}\boldsymbol{r_t}$ that span the factor space.

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- We standardize most variables to create a set of characteristic-sorted portfolios $\tilde{\boldsymbol{r}} = \boldsymbol{Z}'_{t-1}\boldsymbol{r_t}$ that span the factor space.
- We then project the climate risk factor $\boldsymbol{CC_t}$ provided by Engle et al. (innovations to the WSJ climate news index) onto these portfolios to obtain the weights for the hedge portfolio:

$$\boldsymbol{CC_t} = \xi + \boldsymbol{w_{SUS}}\boldsymbol{Z^{SUS\prime}}\boldsymbol{r_t} + \boldsymbol{w_{SIZE}}\boldsymbol{Z^{SIZE\prime}_{t-1}}\boldsymbol{r_t} + \boldsymbol{w_{HML}}\boldsymbol{Z^{HML\prime}_{t-1}}\boldsymbol{r_t} + \boldsymbol{w_{MKT}}\boldsymbol{Z^{MKT\prime}_{t-1}}\boldsymbol{r_t} + \boldsymbol{e_t} \tag{11}$$

In-sample results

The sustainability portfolio sorted based on our greenness measures performs better in times of more climate change news ⇒ we can "hedge climate change news".

	Dependent variable:			
	wsj_AR1_Innovation ∗10^4		chneg_AR1_innovation ∗10^4	
Sus_portf_Paris	0.173		0.106*	
	(0.105)		(0.062)	
Sus_portf_GT		0.413***		0.287***
		(0.148)		(0.091)
size_portf	0.044	0.068	−0.068	−0.073
	(0.116)	(0.115)	(0.076)	(0.074)
value_portf	0.131***	0.148***	0.038**	0.047***
	(0.031)	(0.031)	(0.018)	(0.018)
market_portf	21.784	17.356	11.545	12.337
	(33.512)	(33.219)	(27.040)	(26.222)
Observations	401	401	119	119
R^2	0.054	0.066	0.078	0.131
Adjusted R^2	0.045	0.057	0.045	0.100
Note:				*p<0.1; **p<0.05; ***p<0.01

Conclusion

- We propose a new method to measure the "greenness" of firms - by looking at their stocks' reaction following green news events.
- We receive plausible correlations with existing measures.
- We can use our measures to create climate change hedge portfolios.

Next steps:

- Check correlations with forward-looking measures, e.g. Carbon Earnings at Risk (Trucost data).
- Maybe simplify the model.
- Expand set of events and set of firms.

Final slide

Thank you for your attention!

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