Is "Being Green" Rewarded in the Market? An Empirical Investigation of Decarbonization Risk and Stock Returns

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Main Findings

This study empirically examines the relationship among firm-level carbon intensity, firm characteristics, and stock returns.

- Based on 75,638 observations of U.S. firms from 2005 to 2015, we construct EMI ("[carbon] efficient-minus-inefficient") portfolio based on firm-level carbon intensity.
- We find that EMI portfolio exhibits a large positive cumulative return since 2009.
- Using multi-factor asset pricing models, we find that EMI portfolio is not well priced by well-known risk factors (market, size, value, operating profitability, investment, and momentum)

Main Findings (cont'd)

- By estimating factor-loadings of industry portfolios, we find that EMI portfolio has explanatory power that is independent from well-known risk factors.

- Carbon-efficient firms tend to be those with lower book-to-market ratios, higher ROA, higher Tobin's q, higher free cash flows and cash holdings, higher coverage ratios, lower leverage ratios, and higher dividend payout ratios.

Road Map

1. Motivation
2. Related Literature
3. Data and Methodology
4. Empirical Findings and Discussion
5. Conclusion and Future Directions

Motivation

- investors lack understanding of market evaluation of firm's decarbonization actions → investment barrier
- What kinds of firms are efficient or inefficient in terms of carbon emission?
- What does it mean to invest in carbon-efficient firms?

Literature Review

How EP (environmental performance) and FP (financial performance) are related?

- "Traditionalist" view: corporate EP is not compatible with profit maximization → (-) relationship
- "Revisionist" view: EP can be a source of a firm's competitiveness → (+) relationship
- "Neo-classical" view: The relationship can be (+) or (-) depending other factors (regulation, governance, etc)
- Thus, it can be an empirical question and is important to address endogeneity problem

Empirical Approaches

- Event studies
  - Events include oil spills, law violation, etc
  - Not easy to generalize the results

- Typical regression analysis
  - Effect of ESG-related effort on cost of capital, firm value, etc
  - Need to address endogenity issues

- Asset pricing models
  - Cohen et al. (1995): “environmental leaders” outperform “environmental laggards”
  - Puopolo et al. (2015): no linear relationship between green standard and stock returns
  - ET Index Research (2015): EMI (“efficient-minus-intensive”) portfolio exhibits a large positive cumulative return from 2009

Distinct Value of this Study

Different from previous studies,

- we measure carbon intensity based on the actual amount of GHG emissions, not self-reported ESG ratings.
- we apply multi-factor asset pricing models with a broader set of factors
- we examine the firm-level characteristics that earns extra returns in stock market (ongoing subject)

Data Description

- Sample:
  - 75,638 observations of 739 U.S. firms during January 2005 – December 2015

- Data:
  - Trucost for carbon intensity
  - KLD (Kinder, Lydenberg, Domini and Company) for ESG ratings
  - Compustat for financial variables
  - CRSP for stock prices/returns
  - Fama-French website

Key Variables

- Measures of firm's carbon intensity:

- Absolute GHG emissions: direct emissions from operations (Scope 1), indirect emission from purchased electricity (Scope 2) and other supply chain emissions (Scope 3)

- Carbon intensity: absolute GHG emissions divided by revenue

- External cost: sum of direct and indirect external cost of carbon emission

- Impact ratio: external cost/revenue

Summary Statistics, by Industry

GICS industry sectors	(1) Scope 1 (CO2e)	(2) Scope 1 (CO2e/$mil)	(3) Scope 2 (CO2e/$mil)	(4) Scope 3 (CO2e/$mil)	(5) External cost	(6) Impact ratio	N
Consumer Discretionary	23,654	19.83	36.68	142.98	84.88	0.70	1,303
Consumer Staples	22,106	42.57	41.39	446.69	428.11	1.86	410
Energy	22,266	444.38	59.58	215.24	598.96	2.53	544
Financials	22,739	2.94	7.41	37.93	18.22	0.17	1,029
Health Care	22,338	16.69	18.47	101.50	61.07	0.48	685
Industrials	22,024	157.58	22.70	213.25	139.11	1.40	1,193
Information Tech	22,452	14.84	22.79	99.53	39.37	0.48	1,041
Materials	22,362	498.39	174.11	424.63	326.56	4.01	561
Real Estate	22,732	30.16	59.72	54.85	13.38	0.51	422
Telecommunication	19,123	7.45	29.69	54.54	91.11	0.32	132
Utilities	22,680	3,780.87	96.37	319.19	1,096.75	14.73	472
Total	22,550	331.21	43.71	176.12	205.08	1.95	7,792

Research Design

EMI Portfolio & its Market Performance	• Sort stocks into 10 market capitalization groups and 3 carbon intensity groups at the end of each month, and construct the EMI portfolio
Pricing EMI Portfolio with Risk Factors	• Perform GRS test to see if well-known risk factors can price the EMI portfolio. • Models of consideration: CAPM model, Fama-French 3-factor model, Fama-French 4-factor model, and Fama-French 5-factor model
Industry Portfolios & Bivariate-Sorted Portfolios	• Estimate the factor loadings of 12 industry portfolios to see if EMI portfolio can explain industry portfolio
Carbon Intensity & Firm Characteristics	• Examine the average values of firm-level characteristics (e.g. financial, managerial) by quartiles defined by four decarbonization variables

Constructing EMI Portfolio

- We define carbon intensity as (GHG emission/revenue) to adjust for a firm's size → low carbon intensity implies 'efficient' firms

- We sort stocks into 10 market capitalization groups and 3 carbon intensity groups at the end of each month, and construct the EMI portfolio:

  EMI = 0.5*(small efficient + big efficient)
  – 0.5*(small inefficient + big inefficient)

- By double-sorting on size and carbon intensity, we attempt to address the industry-specific carbon intensity

- We also use different definitions of EMI portfolio

Performance of EMI Portfolio

- With varying definitions of EMI portfolios, they exhibit large positive cumulative returns, especially from 2009

GRS Test

- Is it alpha? Or compensation for bearing additional risk?

- We use market excess return, SMB, HML, RMW, CMA, WML to capture the risk (or styles) related to beta, size, value, operating profitability, investment, and momentum → CAPM, Fama-French 3-factor, FF3 + momentum, FF 5-factor model

$$EMI_t - r_{ft} = \alpha + b(r_{Mt} - r_{ft}) + e_t$$

$$EMI_t - r_{ft} = \alpha + b(r_{Mt} - r_{ft}) + sSMB_t + hHML_t + e_t$$

$$EMI_t - r_{ft} = \alpha + b(r_{Mt} - r_{ft}) + sSMB_t + hHML_t + mWML_t + e_t$$

$$EMI_t - r_{ft} = \alpha + b(r_{Mt} - r_{ft}) + sSMB_t + hHML_t + rRMW_t + cCMA_t + e_t$$

GRS Test

- From 2009, an investment strategy that purchases shares of efficient firms and sells shares of inefficient firms earns abnormal returns of 7.7~8.9 percent per year.

	Sample period: 2009m1-2015m12			
Market excess return	0.076	0.135	0.108	0.099
	(0.90)	(1.42)	(1.22)	(1.08)
SMB (size)		-0.075	-0.072	-0.118
		(0.62)	(0.58)	(0.98)
HML (B/M)		-0.142	-0.220*	-0.054
		(1.17)	(1.75)	(0.29)
WML (momentum)			-0.120*	
			(1.71)	
RMW (profitability)				-0.276*
				(1.71)
CMA (investment)				-0.341
				(0.88)
Alpha	0.736**	0.643**	0.628**	0.743**
	(2.67)	(2.29)	(2.27)	(2.56)
R^2	0.014	0.035	0.078	0.076
N	84	84	84	84

Can EMI Price Other Portfolio Returns?

- EMI portfolio prices industry portfolios even in the presence of well-known risk factors

- For carbon-intensive industries such as utilities, energy, and manufacturing, we obtain negative factor loadings on EMI portfolio.

	nodur	durbl	manuf	enrgy	chms	busq
Mktrf	0.76***	1.44***	1.28***	1.21***	0.99***	1.12***
	(17.26)	(12.66)	(26.70)	(12.86)	(21.09)	(26.99)
SMB	-0.23***	0.72***	0.29***	0.00	-0.13	0.12
	(2.98)	(3.10)	(3.66)	0.00	(1.58)	(1.58)
HML	-0.06	0.18	0.01	-0.02	0.01	-0.38***
	(0.71)	(0.94)	(0.15)	(0.08)	(0.12)	(4.79)
RMW	0.25**	0.2	0.12	0.27	0.19	-0.01
	(2.15)	(0.54)	(0.96)	(1.17)	(1.56)	(0.06)
CMA	0.24*	0.14	-0.12	-0.52**	0.08	-0.14
	(1.67)	(0.49)	(0.98)	(2.00)	(0.47)	(1.08)
EMI	0.06	0.09	-0.16***	-0.95***	-0.08	0.21***
	(1.14)	(0.87)	(3.71)	(7.88)	(1.30)	(4.76)
alpha	0.28*	-0.45	0.02	0.17	0.08	-0.04
	(1.80)	(-1.42)	(0.10)	(0.48)	(0.48)	(0.23)
R^2	0.77	0.78	0.92	0.68	0.85	0.91
	tlcm	utils	shops	health	money	othr
Mktrf	1.04***	0.68***	0.83***	0.71***	1.02***	1.11***
	(20.30)	(8.15)	(16.94)	(10.53)	(20.54)	(28.82)
SMB	-0.06	-0.15	0.26***	-0.16	-0.16*	0.08
	(0.76)	(1.13)	(2.77)	(1.38)	(1.95)	(1.14)
HML	-0.15	-0.28**	-0.07	-0.24*	0.83***	0.14**
	(1.55)	(1.98)	(0.88)	(1.96)	(8.41)	(2.00)
RMW	0.37***	0.14	0.46***	-0.35**	-0.44***	0.08
	(2.79)	(0.72)	(3.48)	(2.39)	(3.62)	(0.82)
CMA	0.46***	0.31*	0.23	0.21	-0.32**	0.22**
	(3.11)	(1.68)	(1.55)	(1.25)	(2.16)	(2.16)
EMI	0.06	-0.26***	0.21***	0.06	0.19***	0.06
	(0.86)	(3.39)	(3.39)	(0.90)	(3.07)	(1.53)
alpha	-0.05	0.26	0.08	0.46**	-0.2	-0.24*
	(0.28)	(0.94)	(0.44)	(2.19)	(1.21)	(1.94)
R^2	0.83	0.44	0.81	0.65	0.92	0.93

What Drives Positive Alphas?

- Are carbon-efficient firms better firms? Or riskier firms?
- In what senses?
- Carbon-efficient firms tend to be those with lower book-to-market ratios, higher ROA, higher Tobin's q, higher free cash flows and cash holdings, higher coverage ratios, lower leverage ratios, and higher dividend payout ratios.

Carbon Intensity and Firm Characteristics

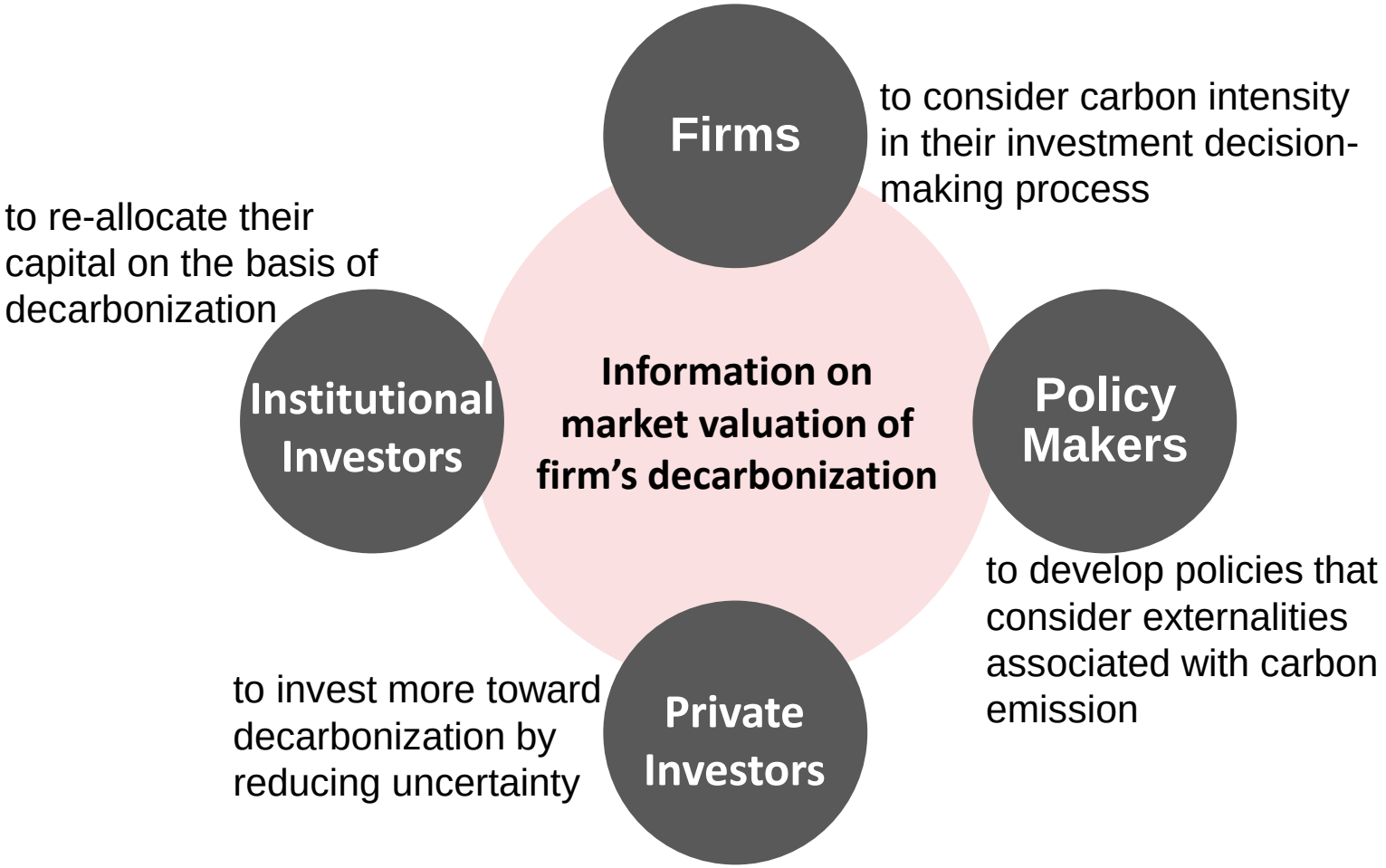
	Scope (sum of scope 1, 2, & 3, divided by revenue)				
	Q1 (lowest)	Q2	Q3	Q4 (highest)	Average
Size (market capitalization)	15,754.4	15,264.7	11,657.4	20,000.9	15,670.1
Book-to-market ratio	0.375	0.382	0.418	0.542	0.430
ROA	0.069	0.062	0.062	0.049	0.060
ROE	0.038	0.029	0.033	0.048	0.037
ROI	0.113	0.099	0.102	0.078	0.098
Tobin's q	2.376	2.338	2.059	1.562	2.084
Capital intensity	0.036	0.045	0.063	0.075	0.055
Cash flow	0.107	0.099	0.104	0.092	0.100
Free cash flow	0.089	0.074	0.059	0.032	0.063
Cash holdings	0.184	0.168	0.123	0.059	0.134
Coverage ratio	59.371	57.571	35.820	15.970	41.572
Earnings per share (EPS)	2.263	2.162	2.366	2.770	2.390
Leverage ratio	0.880	0.909	1.031	1.063	0.971
Dividend payout ratio	0.900	0.783	0.687	0.634	0.751
Tangible asset	0.161	0.246	0.297	0.514	0.304
R&D intensity	0.050	0.051	0.032	0.013	0.040
AD intensity	0.036	0.022	0.029	0.029	0.029
Environmental strength	0.398	0.727	0.696	0.942	0.692
Environmental concern	0.045	0.237	0.393	1.232	0.481
Governance strength	0.131	0.188	0.169	0.267	0.189
Governance concern	0.675	0.666	0.549	0.535	0.606

Future Research Directions

- In what mechanisms do those carbon-efficient firms outperform in stock markets?

- Is it related to unidentified risk? Or is it related to governance and other characteristics?

Implications



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The full-length paper is accessible through:
https://gpc.stanford.edu/publications/being-green-rewarded-market-empirical-investigation-decarbonization-risk-and-stock

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