Essays on Sustainable Finance

Dissertation Defense – Goethe University Frankfurt

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Underlying motivation

Climate change is a multi-disciplinary pressing global problem:

- Clear scientific evidence that GHGs are the leading cause (IPCC)
- Limit global warming to 1.5 ℃ from pre-industrial levels (COP21)
- “Green swan” (BIS)

How can we mitigate carbon emissions through **financial systems**?

- “Markets are not sufficiently pricing in climate risks, including climate physical and transition risks” (OECD)
- “Financial markets need clear, comprehensive, high-quality information on the impacts of climate change.” (TCFD)

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Three essays on sustainable finance

[1] **Energy Policy and Corporate Eco-Efficiency: Evidence from US Manufacturers**

Keywords: Porter hypothesis, environmental regulation, innovation, EISA 2007, EPAct 2005

[2] **Doctrine of Socially Responsible Investors: Clash of Government Policies**

Keywords: SRI, US Climate Alliance, differences of opinion, tail asymmetry

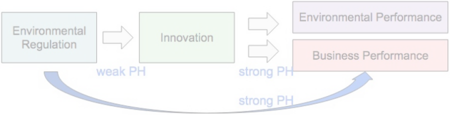
[3] **Does Climate Change Concern Lead to Greenium?**

Keywords: green bond, extreme weather, natural disaster, WTP–WTA disparity

Paper 1 – Framework of Porter Hypothesis (PH)

Question: Do weak and strong Porter hypotheses (PH) hold?

- Traditional view : environmental and financial performance ⇒ trade-off, static



- PH: environmental and financial performance ⇒ win-win, dynamic (Porter and van der Linde, 1995)
  - Eco-efficiency (WBCSD, 2006)
  - Market-based vs command-and-control instruments
  - Bottom line: reduced political uncertainty, information friction, organization inertia etc.
  - Prior empirical literature exhibits mixed results

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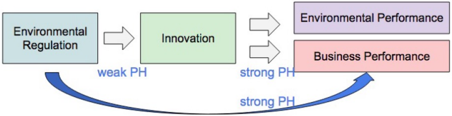

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Paper 1 – EISA 2007 and EPAct 2005

- **EISA 2007**: Focus on energy efficiency (e.g., fossil fuels, appliance and lighting), production of renewable energy ⇒ mainly manufacturers etc.
- **EPAct 2005**: Focus on energy supply diversification ⇒ mainly power sector

Panel A: Energy Independence and Security Act of 2007

Title I	Energy Security through Improved Vehicle Fuel Economy
Title II	Energy Security through Increased Production of Biofuels
Title III	Energy Savings through Improved Standards for Appliance and Lighting
Title IV	Energy Savings in Buildings and Industry
Title V	Energy Savings in Government and Public Institutions
Title VI	Accelerated Research and Development
Title VII	Carbon Capture and Sequestration
Title VIII	Improved Management of Energy Policy
Title IX	International Energy Programs
Title X	Green Jobs
Title XI	Energy Transportation and Infrastructure
Title XII	Small Business Energy Programs
Title XIII	Smart Grid

Panel B: Energy Policy Act of 2005

Title I	Energy Efficiency
Title II	Renewable Energy
Title III	Oil and Gas
Title IV	Coal
Title V	Indian Energy
Title VI	Nuclear Matters
Title VII	Vehicles and Fuels
Title VIII	Hydrogen
Title IX	Research and Development
Title X	Department of Energy Management
Title XI	Personnel and Training
Title XII	Electricity
Title XIII	Energy Policy Tax Incentives
Title XIV	Miscellaneous
Title XV	Ethanol and Motor Fuels
Title XVI	Climate Change

Paper 1 – Eco-innovation: concept and data

Concept

A frequently cited definition of eco-innovation:

- "**...** and which results, throughout its life cycle, in **a reduction of environmental risk, pollution and other negative impacts of resources use** (including energy use) compared to relevant alternatives." (MEI report, 2008)

Data

Environment-related variables from CSR ratings (TR Refinitiv): *Innovation*, *Resource Use*, and *Emissions* scores

- *Innovation* score: "a company's capacity to **reduce the environmental costs and burdens** for its customers, **...**"

Paper 1 – Weak PH: parametric approach

Link between eco-innovation and resource use (emissions) reinforced?

$$y_{i,j,t} = \beta_0 + \beta_1 \,\text{Innovation}_{i,t} + b' \text{X}_{i,t} + \alpha_i + \alpha_{j,t} + \varepsilon_{i,j,t}$$

where $y_{i,j,t}$: *Resource Use* or *Emissions* score

	Panel A: Resource Use						Panel B: Emissions					
	Pre-EISA		Post-EISA		Crisis		Pre-EISA		Post-EISA		Crisis	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Innovation	0.063	0.063	0.101***	0.101***	0.134***	0.133***	0.071	0.077	0.093***	0.093***	0.106**	0.110**
	(0.880)	(0.877)	(3.624)	(3.615)	(2.740)	(2.679)	(1.096)	(1.232)	(3.794)	(3.797)	(2.396)	(2.400)
KZ Index (T1)	2.131		0.879		-2.674		1.433		0.638		-2.614	
	(0.634)		(0.505)		(-0.849)		(0.343)		(0.455)		(-0.671)	
KZ Index (T2)	0.362		-0.166		-3.073		1.007		-0.018		-1.900	
	(0.105)		(-0.098)		(-1.048)		(0.305)		(-0.013)		(-0.538)	
KZ Index (T3)	3.403		0.261		-3.833		4.586		0.470		1.617	
	(0.918)		(0.152)		(-1.274)		(1.200)		(0.312)		(0.431)	
WW Index (T1)		10.470		1.410		-7.523		7.802		-0.197		-13.930*
		(1.460)		(0.820)		(-1.647)		(1.402)		(-0.113)		(-1.715)
WW Index (T2)		8.597		1.305		-4.368		2.838		-0.850		-16.018*
		(1.157)		(0.823)		(-0.920)		(0.452)		(-0.485)		(-1.792)
WW Index (T3)		12.261		1.497		-5.007		2.671		-0.849		-12.007
		(1.511)		(0.984)		(-1.054)		(0.388)		(-0.459)		(-1.385)
Log Revenue	2.672	3.072	1.267	1.220	-0.921	0.368	1.632	0.752	9.081***	9.050***	5.148	6.324
	(0.666)	(0.761)	(0.804)	(0.764)	(-0.250)	(0.098)	(0.351)	(0.161)	(4.253)	(4.216)	(1.071)	(1.426)
Sales Growth	3.553	3.569	-2.755**	-2.710**	-4.311	-5.183	0.883	1.757	0.413	0.429	1.613	1.351
	(1.126)	(1.124)	(-2.392)	(-2.328)	(-1.186)	(-1.335)	(0.285)	(0.576)	(0.267)	(0.274)	(0.436)	(0.381)
Log Total Assets	-0.514	-1.099	3.848**	3.909**	1.136	1.215	0.615	0.336	-2.129	-2.140	-2.365	-2.505
	(-0.115)	(-0.258)	(2.505)	(2.532)	(0.344)	(0.367)	(0.149)	(0.085)	(-1.275)	(-1.288)	(-0.581)	(-0.617)
ROA	-2.021	-1.293	-8.337**	-8.302**	2.262	1.100	11.881	10.920	4.509	4.649	8.268	9.921*
	(-0.291)	(-0.191)	(-2.038)	(-2.002)	(0.400)	(0.193)	(1.629)	(1.488)	(0.958)	(0.983)	(1.451)	(1.651)
Intercept	21.960	14.702	2.400	1.121	43.059	35.650	20.569	24.675	-13.009	-11.980	20.395	24.118
	(0.652)	(0.428)	(0.183)	(0.085)	(1.359)	(1.122)	(0.544)	(0.641)	(-0.982)	(-0.891)	(0.456)	(0.585)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SIC-2 × Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	1006	1006	4387	4387	806	806	1006	1006	4387	4387	806	806
Adj. R^2	0.627	0.628	0.833	0.833	0.872	0.872	0.652	0.653	0.828	0.828	0.866	0.866

t-statistics are adjusted for heteroskedasticity and in the parentheses: standard errors are clustered at the firm level.
*: significant at the 10% level; **: significant at the 5% level; ***: significant at the 1% level

Paper 1 – Excess risk-adjusted returns in post-EISA

Assumption 1: DCF model of stock valuation

Assumption 2: Normal return is the return that would have been realized without ER (i.e., abnormal return attributed to ER effect)

Assumption 3: Post-EISA period starts from January, 2007

Results

- Quintile portfolio formation: alpha of EW 4th portfolio (Carhart four factor model) ⇒ 90 basis points per month
- Fama-Macbeth regression ⇒ monthly 44 basis points

$$r_{i,t} = \beta_0 + \beta_1 \mathrm{Inn100\text{–}50}_{i,t} + bZ_{i,t} + \varepsilon_{i,t}$$

By and large, eco-innovation positively predicts stock returns

Potential reason: mispricing or latent risk factor

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Paper 1 – Strong PH: cause of the positive link

Mispricing or risk?

I explore operating performance and R&D channels in relation to the confirmed positive link between eco-innovation and stock returns

Specification: OLS or median regression

$$y_{i,t} = \beta_0 + \beta_1 \mathrm{Innovation}_{i,t-1} + \beta_2 \mathrm{logBME}_{i,t-1} + \beta_3 \mathrm{logMVE}_{i,t-1} + \varepsilon_{i,t}$$

- $y_{i,t}$: **Operating performance** (industry adj.)
  - Statistically significant negative relationship in post-EISA
  - Earnings announcements: no systematic patterns
- $y_{i,t}$: **R&D intensity** (industry adj.)
  - Statistically significant positive relationship in post-EISA
  - R&D announcements: some difficulty posed

Paper 1 – Strong PH: cause of the positive link (cont'd)

Link between eco-innovation and volatility alters in pre-/post-EISA?

$$\sigma_{i,t} = \beta_{0,t} + \beta_{1,t}\,\text{R\&D Intensity}_{i,t} + \beta_{2,t}\,\text{Innovation}_{i,t} + \beta_{3,t}\,\text{LNSIZE}_{i,t} + \beta_{4,t}\,\text{LNAGE}_{i,t} + \sum_{j=1}^{L}\phi_{j,t}\,\text{IND}_{i,j,t} + \varepsilon_{i,t}$$

	Subperiod									Full period		
	Pre-EISA			Post-EISA			Crisis					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
R&D/Sales	0.0450***	0.0444***	0.0447***	0.0203	0.0209	0.0202	-0.0431	-0.0399	-0.0441	0.0280**	0.0282**	0.0279**
	(12.27)	(10.70)	(10.10)	(1.08)	(1.16)	(1.07)	(-0.96)	(-0.94)	(-0.99)	(2.16)	(2.28)	(2.13)
Innovation	-0.0002**	-0.0002**		-0.0000	-0.0000		-0.0001	-0.0002		-0.0001*	-0.0001*	
	(-3.72)	(-3.71)		(-0.79)	(-0.77)		(-1.07)	(-1.69)		(-1.94)	(-1.90)	
Resource Use		-0.0002**			-0.0000			0.0001			-0.0001	
		(-2.82)			(-0.15)			(0.54)			(-1.02)	
Emissions		0.0001*			0.0000			0.0000			0.0000	
		(2.42)			(0.03)			(0.02)			(0.74)	
Inn75–100			-0.0090			-0.0023			-0.0073			-0.0044*
			(-1.86)			(-1.07)			(-2.04)			(-1.93)
Inn50–75			-0.0076			-0.0045			-0.0120			-0.0054*
			(-2.06)			(-1.29)			(-1.77)			(-2.07)
LNSIZE	-0.0092***	-0.0086***	-0.0095***	-0.0138***	-0.0135***	-0.0139***	-0.0181**	-0.0193**	-0.0186**	-0.0124***	-0.0120***	-0.0125***
	(-6.80)	(-4.91)	(-7.15)	(-7.32)	(-6.18)	(-7.10)	(-5.33)	(-6.73)	(-5.08)	(-8.43)	(-7.03)	(-8.30)
LNAGE	-0.0113**	-0.0111**	-0.0113**	-0.0079*	-0.0080*	-0.0080*	-0.0184	-0.0191	-0.0188	-0.0090**	-0.0090**	-0.0090**
	(-3.17)	(-2.97)	(-3.23)	(-1.98)	(-2.00)	(-1.94)	(-1.49)	(-1.61)	(-1.49)	(-2.75)	(-2.73)	(-2.70)
Intercept	0.1922***	0.1897***	0.1877***	0.2317***	0.2302***	0.2323***	0.3146*	0.3220*	0.3168*	0.2193***	0.2175***	0.2184***
	(7.36)	(6.81)	(7.11)	(7.12)	(6.85)	(7.15)	(3.31)	(3.57)	(3.43)	(8.86)	(8.47)	(8.69)
SIC-2 dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Obs.	1019	1019	1019	4628	4628	4628	867	867	867	5647	5647	5647
Time Periods	5	5	5	10	10	10	3	3	3	15	15	15

*: significant at the 10% level; **: significant at the 5% level; ***: significant at the 1% level

Paper 1 – Summary and future avenues

Summary

- Results support weak PH and also do not disprove strong PH
- Implication for favorable transition into low-carbon economy

Future avenues

- Focus on a narrower aspect of EISA
- Identification:
  - Include control group to address macroeconomic factors or trends orthogonal to ER
  - Use instrumental variable to address imperfect randomization

Paper 2 – Extant literature and research question

Literature

- A wealth of empirical literature addresses SRI performance under mean-variance framework
- CSR intensity can predict returns positively / negatively / neutrally
  - Mispricing (e.g., Gompers et al., 2003; Edmans, 2011)
  - Risk factor (e.g., Hong and Kacperczyk, 2009)
- Yet only a few studies exist on the relationship between CSR and higher moments (e.g., Kim et al., 2014; Belghitar et al., 2014)
  - Risk cannot be captured by second moment alone
  - Higher moments are (coarse) indicators of tail risk

Question: Relationship between firm's CSR (CER) intensity and higher moments in returns?

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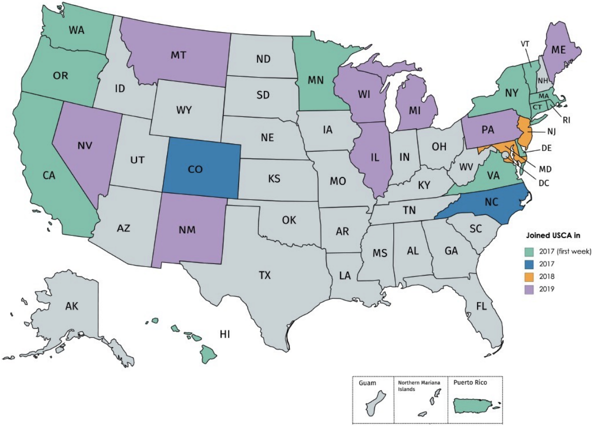
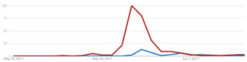
Paper 2 – Formation of US Climate Alliance

- Trump administration announced the withdrawal from Paris Agreement on June 1, 2017
- This event was paralleled by the formation of USCA (CA, NY, WA)





(Source: Google Trends)

Paper 2 – Hypotheses

Question: Relationship between firm's CER intensity and higher moments in returns, especially skewness?

- **H3a**: Surrounding the parallel announcements, (un)green firms experienced positive (negative) abnormal returns
- **H3b**: Surrounding the parallel announcements, (un)green firms experienced a negative (positive) abnormal turnover

A model based on differences of opinion (Hong and Stein, 2003)

- **H3c**: Following the parallel announcements, (un)green firms subsequently experienced a positive (negative) skewness shock in returns, reflecting the (dis)agreement among investors

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Paper 2 – H3a: Differential abnormal returns

	Alliance-state firms			Non-alliance-state firms		
	Thomson Reuters		Subtotal	Thomson Reuters		Subtotal
	Green	Ungreen		Green	Ungreen	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Mining & Construction						
Average	-0.032	-0.006	-0.001	-0.039***	-0.042***	-0.037***
t-statistic	(-0.932)	(-0.297)	(-0.060)	(-3.884)	(-4.526)	(-5.661)
Obs.	2	8	18	29	74	183
Panel B: Manufacturing						
Average	0.003	0.000	0.004	0.005	-0.003	0.001
t-statistic	(0.576)	(-0.03)	(0.892)	(1.133)	(-0.809)	(0.176)
Obs.	153	207	691	152	255	711
Panel C: Transportation						
Average	-0.002	-0.001	-0.002	0.002	-0.026	-0.021
t-statistic	(-0.123)	(-0.023)	(-0.104)	(0.196)	(-1.090)	(-1.598)
Obs.	3	13	20	12	26	65
Panel D: Communication						
Average	-0.107	-0.002	-0.024*	0.031	0.001	0.011
t-statistic	(-8.451)	(-0.102)	(-1.886)	(0.470)	(0.047)	(0.722)
Obs.	6	14	33	3	24	41
Panel E: Utilities						
Average	0.013*	-0.001	0.008	0.000	-0.004	-0.014**
t-statistic	(1.744)	(-0.061)	(1.230)	(-0.308)	(-0.404)	(-2.468)
Obs.	14	11	32	33	22	93
Panel F: Services						
Average	0.009	0.010*	0.004	0.004	0.002	0.003
t-statistic	(1.333)	(1.663)	(1.071)	(0.628)	(0.545)	(0.683)
Obs.	35	116	283	45	119	281

t-statistics are presented in the parentheses: standard errors are based on *t*-tests
*: significant at the 10% level; **: significant at the 5% level; ***: significant at the 1% level

Paper 2 – H3a: Differential abnormal returns (cont'd)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Env50–100 dummy	0.006	0.008*	0.007*	0.009**				
	(1.60)	(1.95)	(1.74)	(2.07)				
Env75–100 dummy					0.011**	0.015**	0.012**	0.016**
					(2.08)	(2.39)	(2.07)	(2.41)
Env50–75 dummy					0.004	0.006	0.005	0.007
					(1.04)	(1.54)	(1.26)	(1.66)
AS2017 dummy	0.000	0.001	0.005	0.006	0.000	0.001	0.005	0.006
	(0.07)	(0.33)	(1.42)	(1.60)	(0.03)	(0.33)	(1.39)	(1.59)
Env50–100 × AS2017		-0.005		-0.005				
		(-1.11)		(-1.29)				
Env75–100 × AS2017						-0.007*		-0.009*
						(-1.80)		(-1.95)
Env50–75 × AS2017						-0.004		-0.004
						(-0.76)		(-0.85)
LOGSIZE	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
	(-1.01)	(-0.99)	(-1.49)	(-1.46)	(-1.14)	(-1.12)	(-1.58)	(-1.55)
TR Uncovered dummy	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001
	(0.54)	(0.54)	(0.30)	(0.30)	(0.46)	(0.46)	(0.24)	(0.23)
Intercept	-0.010	-0.011	0.015	0.015	-0.007	-0.007	0.018	0.018
	(-0.77)	(-0.82)	(1.16)	(1.10)	(-0.45)	(-0.50)	(1.31)	(1.25)
SIC 2-digit dummies	Yes	Yes	–	–	Yes	Yes	–	–
Clustered at SIC 2-digit	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	2786	2786	2786	2786	2786	2786	2786	2786
Adj. R^2	0.019	0.019	0.001	0.001	0.019	0.019	0.001	0.001

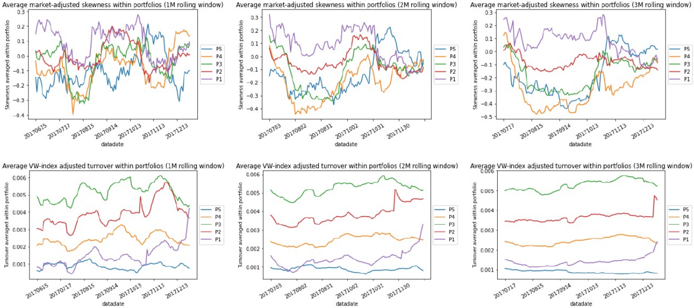
t-statistics adjusted for heteroskedasticity are in the parentheses
*: significant at the 10% level; **: significant at the 5% level; ***: significant at the 1% level

Paper 2 – H3b (turnover) + H3c (skewness–turnover)

H3b: Approach analogous to previous table from H3a

H3c: Exploratory data analysis (excl. carbon-intensive industry)

- Climate alliance and non climate alliance states combined
- Return skewness (row 1) and turnover (row 2)
- 1M, 2M, 3M rolling window (columns from left to right)



Paper 2 – H4: Reduction in corporate emission levels

I explore across industries how and why reduction in corporate emissions occurs following US climate alliance formation

Question 1: What is the driver of emissions reduction?

- The effect of US climate alliance?
- Local beliefs: reduction beyond regulation? (e.g., Dowell, n.d.)
- Larger firms receive more pressure? (e.g., Dowell, n.d.)

Question 2: What is the underlying mechanism of the reduction? e.g., stock market, investor sentiment as in H4 ⇒ **not addressed**

- Financial markets may provide incentives to alter environmental behaviors of firms (Konar and Cohen, 1997)
- Negative stock price response to TRI emission disclosure prompted firms to reduce emissions (Konar and Cohen, 1997)

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Question 1: What is the driver of emissions reduction?

- The effect of US climate alliance?
- Local beliefs: reduction beyond regulation? (e.g., Dowell, n.d.)
- Larger firms receive more pressure? (e.g., Dowell, n.d.)

Question 2: What is the underlying mechanism of the reduction? e.g., stock market, investor sentiment as in H4 $\Rightarrow$ **not addressed**

- Financial markets may provide incentives to alter environmental behaviors of firms (Konar and Cohen, 1997)
- Negative stock price response to TRI emission disclosure prompted firms to reduce emissions (Konar and Cohen, 1997)

Paper 2 – H4: emissions (excl. power, oil & gas sector)

Dep. variable is ln(CO_2eq): facility-level emissions from GHGRP

	All industries (excl. oil & gas and power plants)								
	Baseline	Regulate		Support RPS		Ln(No. facilities)		Placebo	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
AS × Post	-0.034	0.004	0.466	-0.004	0.204	-0.006	-0.047	-0.040	-0.038
	(-1.50)	(0.18)	(1.33)	(-0.18)	(0.71)	(-0.25)	(-1.68)	(-1.74)	(-1.65)
Regulate × Post		-0.011***				-0.011***	-0.011***		
		(-4.26)				(-4.21)	(-4.22)		
SupportRPS × Post				-0.008***					
				(-4.18)					
Ln(No. facilities) × Post						-0.028**			
						(-2.91)			
AS × Regulate × Post			-0.016***						
			(-3.49)						
NAS × Regulate × Post			-0.010***						
			(-3.57)						
AS × SupportRPS × Post					-0.011**				
					(-2.89)				
NAS × SupportRPS × Post					-0.008**				
					(-3.24)				
AS × Ln(No. facilities) × Post							-0.011		
							(-0.94)		
NAS × Ln(No. facilities) × Post							-0.033***		
							(-3.34)		
Social capital × Post								0.019*	
								(2.26)	
Social capital$^-$ × Post									0.010
									(1.26)
Facility FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	44008	43322	43322	43322	43322	43319	43319	43021	43021
Adj. R^2	0.849	0.848	0.848	0.848	0.848	0.848	0.848	0.848	0.848

Standard errors are clustered at the facility and reporting year level

*: significant at the 10% level; **: significant at the 5% level; ***: significant at the 1% level

Paper 2 – H4: emissions in power sector

Power sector is heavily regulated (e.g., RPS, RGGI)

	Power plants industry								
	Baseline	Regulate		Support RPS		Ln(No. facilities)		Placebo	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
AS × Post	-0.242**	-0.210**	0.311	-0.215**	-0.484	-0.211**	-0.232	-0.245**	-0.244**
	(-3.05)	(-2.70)	(0.34)	(-2.68)	(-0.67)	(-2.72)	(-1.83)	(-3.04)	(-3.03)
Regulate × Post		-0.007				-0.007	-0.007		
		(-1.45)				(-1.47)	(-1.47)		
SupportRPS × Post				-0.006					
				(-1.32)					
Ln(No. facilities) × Post						-0.009			
						(-0.60)			
AS × Regulate × Post			-0.012						
			(-1.18)						
NAS × Regulate × Post			-0.005						
			(-0.97)						
AS × SupportRPS × Post					-0.003				
					(-0.30)				
NAS × SupportRPS × Post					-0.007				
					(-1.36)				
AS × Ln(No. facilities) × Post							-0.002		
							(-0.07)		
NAS × Ln(No. facilities) × Post							-0.013		
							(-0.70)		
Social capital × Post								0.001	
								(0.04)	
Social capital$^-$ × Post									-0.010
									(-0.31)
Facility FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	17108	16720	16720	16720	16720	16720	16720	16573	16573
Adj. R^2	0.879	0.879	0.879	0.879	0.879	0.879	0.879	0.878	0.878

Standard errors are clustered at the facility and reporting year level

*: significant at the 10% level; **: significant at the 5% level; ***: significant at the 1% level

Paper 2 – Summary and future avenues

Summary

- H3: Stock market reactions to parallel announcements
  - Firms HQed in non alliance states: significantly affected
  - Firms HQed in alliance states: the event was probably anticipated to some extent, raising endogeneity concerns
- Q1 (H4): Outside carbon-intensive sectors (e.g., power, oil & gas), local beliefs of climate change can play a great role in reducing emissions beyond regulatory standards

Future avenues

- Paper division
- Q2 (H4): Investigation of emission reduction mechanism (e.g., stock market, investor sentiment)

Paper 3 – Extant literature and research question

Literature

Mixed evidence on green bond premium to date

- Baker et al. (2018) find favorable evidence of greenium
- Larcker and Watts (2020) find no greenium in contrast
- Some studies exploit shocks to sustainable preference

Question: Link between climate change concern and differential pricing of green/brown securities

- Target: municipal bond market
- Approaches: levels of and changes in local beliefs
- Setting: heterogeneous tax exemption, high net-worth individuals

Paper 3 – Data source and sample

Data

- MSRB: Transaction data from primary and secondary markets
- Bloomberg: green label
- Fidelity: credit ratings, issuance amount, callability
- Yale Climate Opinion Map: climate change concern variables
  - Measured at state and county levels
  - *Human* and CO_2 variables

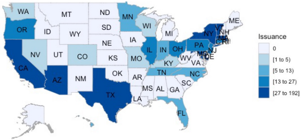
Sample

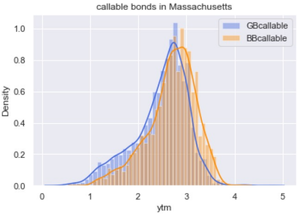
- Matching process: issuer, dated date, maturity (± 1 year), ratings
- Sample split into non-callable and callable universes
- Mixed evidence on greenium conditional on callable or not

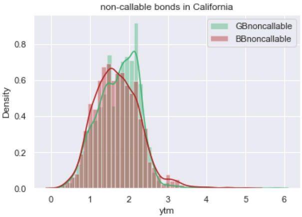
Paper 3 – Results and future avenues

Levels of local beliefs

- Univariate analysis: some states show evidence on greenium
- Bivariate analysis: inconclusive







Changes in local beliefs

- Need to control for a host of variables
- Preliminary analysis exploiting cold wave 2019: nuanced
- Concern: shorting munis is rare but can happen (FINRA, 2015)

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