FINM 35000: Topics in Economics

Week 2: ESG and Climate Risk: Regulation and Disclosure

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Logistics

- The first homework is posted on Canvas. It is due next Wednesday (October 11) at 6pm
- Please sign up for homework groups! If you do not have a group and plan to stay enrolled in the class, please email me and I will assign you to a group
- The TA session is this Sunday at 5pm via Zoom
- Reminder that if you have feedback about the course, you can submit it here at any time: https://forms.gle/vcASo5yRXuadFRTH7
- The class recordings will be posted in Panopto video

From Last Week: Pricing Equation

- Note: the risk free rate is given by $R_f = \frac{1}{\mathbb{E}[m]}$ (see Cochrane's book if you want the derivation)
- Observation:

$$
\begin{aligned}
p_t &= \mathbb{E}_t[m_{t+1}x_{t+1}] \\
&= \mathrm{Cov}_t(m_{t+1}, x_{t+1}) + \mathbb{E}_t[m_{t+1}]\mathbb{E}_t[x_{t+1}] \\
&= \mathrm{Cov}_t(m_{t+1}, x_{t+1}) + \frac{\mathbb{E}_t[x_{t+1}]}{R_f}
\end{aligned}
$$

- Intuition from Cochrane:

$$
p_t = \underbrace{\frac{\mathbb{E}_t[x_{t+1}]}{R_f}}_{\text{Price if risk neutral}} + \underbrace{\mathrm{Cov}_t(m_{t+1}, x_{t+1})}_{\text{Risk correction}}
$$

Identification and Empirical Design

What is Selection Bias and Why is it a Problem?

- In a lot of empirical economics papers, the goal is to estimate the effect of D (treatment) on Y (outcome)
- For example, consider a study which wants to estimate the impact of going to college (treatment) on income at age 40 (outcome)
- Notation:
  - For each individual i, $D_i = 1$ means i is treated, $D_i = 0$ means i is not treated (e.g. $D_i = 1$ if individual i went to college)
  - Y_{1i} is the outcome if individual i is treated ($D_i = 1$)
  - Y_{0i} is the outcome if individual i is treated ($D_i = 0$)
- The goal is to estimate $\mathbb{E}[Y_{i1} - Y_{i0}]$, which we call the causal effect of D on Y

What is Selection Bias and Why is it a Problem? (cont'd)

- Problem: for each individual, we never observe both Y_{i1} and Y_{i0} (i.e. we cannot observe what a college-educated individual's income at age 40 would have been had they not gone to college)
- Recall that we want $\mathbb{E}[Y_{i1} - Y_{i0}]$. We observe:

$$\underbrace{\mathbb{E}[Y_{1i}|D_i = 1]}_{\text{Avg. outcome for treated}} \quad - \quad \underbrace{\mathbb{E}[Y_{0i}|D_i = 0]}_{\text{Avg. outcome for untreated}}$$

- Green terms denote things we observe and red terms denote things we do not observe. Rewrite the above:

$$\begin{aligned}
&\mathbb{E}[Y_{1i}|D_i = 1] - \mathbb{E}[Y_{0i}|D_i = 0] \\
&= \underbrace{\mathbb{E}[Y_{1i}|D_i = 1] - \mathbb{E}[Y_{1i}|D_i = 0]}_{\text{Treatment Effect}} + \underbrace{\mathbb{E}[Y_{1i}|D_i = 0] - \mathbb{E}[Y_{0i}|D_i = 0]}_{\text{Selection Bias}}
\end{aligned}$$

What is Selection Bias and Why is it a Problem? (cont'd)

- For example, selection bias is the difference between the average (counterfactual) income of college-educated people had they not gone to college and non-college-educated people. This would be non-zero if college-educated people are different along dimensions that affect income (e.g. parents' income, IQ, motivation)
- This matters because it means we cannot just compare treated and untreated groups to estimate the treatment effect (e.g. conclude that the causal effect of going to college on income is the difference between the incomes of those who went and those who did not)

Solutions to Selection Bias

1. Randomization: if we randomly assign treatment, then we can conclude that (on average) the treatment and control groups do not vary along any important dimensions
2. Regression: if we believe that, conditional on observables, the treatment and control group are the same, then we can control for these observables in a regression. In the college example, this would mean controlling for parents' income, IQ, grades in high school, etc. However, if there is some unobservable variable (call it motivation) that affects both the decision to go to college and income, then this is not sufficient.
3. Fixed effects.
4. Instrumental variables.

We will go into detail about 3 and 4.

Fixed Effects: Description

- Consider a dataset with observations of I individuals sorted into J groups. For example, the observations could be firms and the groups could be industries. A fixed effects regression estimates:

$$y_{ij} = \alpha + \beta X_{ij} + \sum_{j=1}^{J} \gamma_j Group_{ji} + \varepsilon_{ij},$$

  where $Group_{ji}$ is an indicator for whether individual i belongs to group j

- When does the fixed effects estimator lead to a causal estimate? When, within a group, treatment can be plausibly viewed as random

Fixed Effects Example: Baldauf et al. (2020)

- Research question: does the effect of the risk of sea-level rise on house prices vary based on whether local residents believe in climate change?
- The main regression specfication that they estimate is:

$$\ln P_{it} = \alpha_{zd} + \alpha_y + \zeta \text{UnderWater}_i \times \ln H_c + \gamma' X_i + \lambda'(\text{UnderWater}_i \times X_i) + \omega'(\text{UnderWater}_i \times X_z) + \varepsilon_{it}$$

- Variable definitions:
  - P_{it} is the dollar transaction price of home i at time t
  - α_{zd} and α_y are ZIP code$\times$ distance to the coast and year fixed effects, respectively
  - UnderWater_i is an indicator of whether home i is located in an area that is projected to be affected by sea level inundation of 6 ft. above current Mean Higher High Water (MHHW) by 2100, based on NOAA projections
  - H_c is the percentage of residents in county c who answered "Yes" to the Yale Climate Survey question: "Do you think that global warming is happening?"
  - X_i and X_z are home- and zip code- level controls

Fixed Effects Example: Baldauf et al. (2020) (cont'd)

- The coefficient of interest is ζ, which captures the effect of climate beliefs on house prices for properties that are projected to be under water by 2100
- What are the fixed effects doing here? Why might ζ be biased without them?
  - The fixed effects are ensuring that the estimation is within zip-code$\times$distance and within year
  - Within zip-code$\times$distance means that they are comparing properties in the same zip code that are the same distance from the coast. This eliminates the concern that the regression picks up the effect of being in a more desirable neighborhood and most importantly, the concern that the regression picks up a spurious positive relationship between sales price and a home being projected to be underwater due to sea-level rise
  - Year fixed effects address the concern that both climate beliefs and house prices might be changing over time, so the regression might pick up a correlation between climate beliefs and house prices that is not causal

Fixed Effects Example: Baldauf et al. (2020) (cont'd)

Table 4
Beliefs about climate change and house prices

	(1) Below median	(2) Above median	(3) Below median	(4) Above median	(5) Full sample	(6) Full sample	(7) Full sample
UnderWater_i	0.0610*	−0.0499	0.0388	−0.0783*	−0.311**	−0.353**	0.260
	(0.0318)	(0.0519)	(0.0235)	(0.0457)	(0.130)	(0.154)	(0.264)
$\text{UnderWater}_i \times \ln H_c$					−0.966***	−0.993**	−1.181***
					(0.362)	(0.410)	(0.353)
Regional controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
House controls	No	No	Yes	Yes	Yes	Yes	Yes
UnderWater_i × Regional controls	No	No	No	No	No	No	Yes
UnderWater_i × House controls	No	No	No	No	No	No	Yes
County × Distance × Elevation fixed effects	Yes	Yes	No	No	Yes	No	No
ZIP code × Distance fixed effects	No	No	Yes	Yes	No	Yes	Yes
Observations	5,879,841	5,659,145	5,879,841	5,659,145	11,538,986	11,538,986	11,538,986
R^2	.336	.498	.566	.692	.636	.645	.645

Quick Remark About Two-Way Fixed Effects vs. Interaction Fixed Effects

- Baldauf et al. (2020) uses Zip Code$\times$Distance to the Coast fixed effects
- This is a different specification than if they had used Zip Code and Distance to the Coast fixed effects separately
- The intuition is similar to the difference between including an interaction term in an OLS regression as opposed to including both terms separately
- In this example, including the interaction term allows the model to take into account the fact that distance to the coast may have a different effect on price in different zip codes
  - Hypothetical example: zip code 1 has a highway running along the beach so that it is difficult to access the beach even from homes that are very close (directly across the highway). Zip code 2 has a path that makes it easy to walk to the beach from a few blocks away.
  - Distance to the coast may have a different effect on price in these two zip codes, which this specification allows for

Instrumental Variables: Description

- Consider a data generated by the model:

$$y_i = \alpha + \beta X_{1i} + \underbrace{\gamma X_{2i} + \varepsilon_i}_{\equiv \eta_i}$$

  (as an example, imagine if income was solely determined by education and ability, so y_i is income, X_{1i} is education and X_{2i} is ability)
- If we do not observe X_{2i} and instead run the regression:

$$y_i = \alpha + \tilde{\beta} X_{1i} + \eta_i,$$

  our estimate, $\tilde{\beta}$, will be a biased estimate of β if X_{1i} and X_{2i} are correlated
- Introduce an instrument, Z_i, which satisfies two conditions: $Cov(X_{1i}, Z_i) \neq 0$ and $Cov(Z_i, \eta_i) = 0$. These conditions are called relevance and exclusion
- In the income and education example, a classic example of an instrument is distance from an individual's home to the nearest college

Instrumental Variables: Description (cont'd)

- Relevance and exclusion conditions in words:
  - Relevance: the instrument, Z, must be correlated with the observable regressor of interest, X_1
  - Exclusion: the only way the instrument, Z, affects the outcome Y is through its effect on the observable regressor X_1
  - Note: we can test relevance, but not exclusion
- Recall that the OLS estimator for a regression of Y_i on X_{1i} is given by:

$$\beta^{OLS} = \frac{Cov(X_{1i}, Y_i)}{Var(X_{1i})}$$

- The IV estimator for a regression of Y_i on X_{1i} using Z_i as an instrument is given by:

$$\beta^{IV} = \frac{Cov(Y_i, Z_i)/Var(Z_i)}{Cov(X_{1i}, Z_i)/Var(Z_i)} = \frac{Cov(Y_i, Z_i)}{Cov(X_{1i}, Z_i)}$$

- Can also think of this in two steps: first regress X_{1i} on Z_i (call the fitted value $\hat{X}_{1i}$). Then, regress Y_i on $\hat{X}_{1i}$. This is called two-stage least squares or TSLS.

Instrumental Variables Example: Heath et al. (2021)

- Recall from last week: this paper wants to estimate the effect of socially responsible investing on firm behavior (specifically greenness)
- To put this in our framework from above, Y_i is firm greenness, X_{1i} is money in socially responsible investment funds, but there is an omitted variable, X_{2i} that is correlated with both X_{1i} and Y_i
- The solution in this paper, is to introduce an instrument that is uncorrelated with greenness except through its effect on capital in SRI funds (exclusion), but affects the amount of capital in SRI funds (relevance)
- This instrument is Morningstar fund rating

Instrumental Variables Example: Heath et al. (2021) (cont'd)

Table III

Selection Effects: SRI funds and corporate environmental behavior

The table presents estimates of the relation between SRI fund investment and firm total pollution (*Total releases*), air pollution (*Air*), water pollution (*Water*), land pollution (*Land*), investments in pollution abatement (*Abatement* and *logAbatements*), and climate change exposure (*CCExposure*). *SRI Investment* is the percentage of a firm's ownership held by SRI funds (to facilitate the interpretation of the results, the measure is standardized). Definitions for all variables are in the Appendix Section A2. Robust standard errors, clustered at the firm level, are shown in parenthesis with raw and Romano and Wolf (2005) p-values shown below. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	Total releases (1)	Air (2)	Water (3)	Land (4)	Abatement (5)	logAbatements (6)	CCExposure (7)
SRI Investment	-0.245	-0.251	-0.684	-0.340	0.022	0.032	-0.061
	(0.094)	(0.092)	(0.162)	(0.286)	(0.012)	(0.040)	(0.023)
Unadjusted p	0.010***	0.007***	0.001***	0.233	0.067*	0.421	0.009***
Romano-Wolf p	0.081*	0.077*	0.004***	0.435	0.229	0.435	0.081*
Observations	3,759	3,584	1,885	1,222	3,579	1,526	15,004
Adjusted R-squared	0.005	0.006	0.038	-0.000	0.015	0.013	0.002
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Instrumental Variables Example: Heath et al. (2021) (cont'd)

Table V

Treatment effects: SRI funds and corporate environmental behavior

The table presents estimates of the effect of SRI fund investment on firm total pollution (*Total releases*), air pollution (*Air*), water pollution (*Water*), land pollution (*Land*), total off-site pollution (*Off-site*), one time pollution (*One-time*), investments in pollution abatement (*Abatement* and *logAbatements*), and climate change exposure (*CCExposure*). $\Delta SRI\widehat{Investment}$ is the predicted change in SRI investment for each firm in the sample from our paired fund-level difference-in-differences regression (to facilitate the interpretation of the results, the measure is standardized). MDES is the minimum detectable effect size (Bloom, 1995). Definitions for all variables are in the Appendix Section A2. Robust standard errors, clustered at the firm level, are shown in parenthesis with raw and Romano and Wolf (2005) p-values shown below. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

	Total releases (1)	Air (2)	Water (3)	Land (4)	Abatement (5)	logAbatements (6)	CCExposure (7)
$\Delta SRI\widehat{Investment}$	0.030	0.018	0.077	0.031	0.013	0.019	-0.000
	(0.042)	(0.041)	(0.064)	(0.098)	(0.016)	(0.040)	(0.023)
MDES	±0.119	±0.116	±0.181	±0.278	±0.046	±0.114	±0.065
Unadjusted p	0.481	0.658	0.230	0.729	0.420	0.628	0.998
Romano-Wolf p	0.959	0.985	0.811	0.985	0.959	0.985	0.996
Observations	3,728	3,555	1,869	1,183	3,551	1,456	14,973
Adjusted R-squared	0.887	0.892	0.888	0.906	0.508	0.718	0.857
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Quick Preview of Next Week: Climate Risk

Defining Climate Risk

- Two types of climate risk:
  1. **Physical:** the firm's operations will be affected by changing weather patterns and increasingly frequent natural disasters
  2. **Transition:** the firm's ability to operate profitably will be affected by regulations intended to mitigate the effects of climate change (e.g. carbon taxes or emission standards) or by decreased demand for its products as a result of concerns about climate change
- Important to note that these are very distinct concepts and have different policy implications
  - There is a tradeoff between policies that help physical risky firms (strict environmental regulation to mitigate climate change) and policies that help transition risky firms (less environmental regulation)
  - Many firms are exposed to both, but generally transition risk is more near term

Continued from Last Week: Incentivizing Socially Responsible Behavior

Hartzmark and Shue (2023): Overview

Does ESG Incentivize Greenness?

- Recall mechanism through which ESG affects firm greenness:

$$\text{ESG Investing} \underbrace{\Longrightarrow}_{①} \text{Higher Cost of Capital for Brown Firms}$$

$$\underbrace{\Longrightarrow}_{②} \text{Firms Become Greener}$$

- This paper tries to test $\underbrace{\Longrightarrow}_{②}$ by measuring *impact elasticity*:

$$\text{impact elasticity} \equiv \frac{\partial \text{ emissions}}{\partial \text{ cost of capital}}$$

Hartzmark and Shue (2023): Preview of Results

1. A reduction in financing costs for green firms leads to small (or zero) reductions in emissions
2. Increasing financing costs for brown firms leads to large increases changes in emissions
3. ESG scores and ESG funds prioritize percentage reductions in emissions, which leads green firms to be rewarded for economically trivial reductions in their already low levels of emissions

Hartzmark and Shue (2023): Results I

Table 3: Emissions and firm performance

	Changes in emissions			
	(1)	(2)	(3)	(4)
Brown × Annual return	-49.95***			
	(8.150)			
Neutral × Annual return	1.260			
	(0.944)			
Green × Annual return	1.245			
	(1.101)			
Brown × Industry annual return		-72.84***		
		(16.96)		
Neutral × Industry annual return		-0.315		
		(5.014)		
Green × Industry annual return		1.445		
		(5.487)		
Brown × ΔROA			-133.1***	
			(37.82)	
Neutral × ΔROA			9.273***	
			(3.112)	
Green × ΔROA			7.486	
			(5.461)	
Brown × ΔIndustry ROA				-222.2**
				(104.7)
Neutral × ΔIndustry ROA				43.49*
				(24.51)
Green × ΔIndustry ROA				140.8***
				(40.65)
p-value: Brown × X = Green × X	0.000	0.000	0.000	0.001
Type FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
SIC2 industry FE	Yes	Yes	Yes	Yes
N	23818	24271	21863	24262
R^2	0.0493	0.0432	0.0421	0.0392

This table shows changes in firms' emissions following changes in firm or industry performance. The dependent variable is $e_{t+1} - e_t$, the change in scope 1 and scope 2 greenhouse gases emissions, where emissions is measured in tons of CO_2 equivalents emitted per million dollars of revenue. We regress the dependent variable on the interactions between firm- or industry-level financial or real performance in the previous year and indicators for whether the firm is brown, neutral, or green. All other variables are as define in Table 1. All columns include year fixed effects, SIC2 industry fixed effects, and indicators for whether the firm is brown, neutral, or green. Below each regression, we report the p-value for the test of whether coefficients on the interaction with brown firms and the interaction with green firms are equal. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Standard errors are in parentheses and are clustered at the firm-level.

Hartzmark and Shue (2023): Results II

Table 8: Sustainable investing and changes in emissions by firm type

	Overweight in green funds		Environmental score	
	(1)	(2)	(3)	(4)
Emissions	-0.00633**	-0.00608**	-0.0161***	-0.0155***
	(0.00308)	(0.00303)	(0.00444)	(0.00464)
Brown × $\Delta_{t,t-1}$Emissions (changes in percents)	-0.0142		-0.133*	
	(0.0734)		(0.0698)	
Neutral × $\Delta_{t,t-1}$Emissions (changes in percents)	-0.161***		-0.121**	
	(0.0553)		(0.0538)	
Green × $\Delta_{t,t-1}$Emissions (changes in percents)	-0.199***		-0.146**	
	(0.0574)		(0.0589)	
Brown × $\Delta_{t,t-2}$Emissions (changes in percents)		0.00814		-0.0836
		(0.0473)		(0.0526)
Neutral × $\Delta_{t,t-2}$Emissions (changes in percents)		-0.0908**		-0.0673*
		(0.0385)		(0.0364)
Green × $\Delta_{t,t-2}$Emissions (changes in percents)		-0.169**		-0.147***
		(0.0704)		(0.0489)
p-value: Brown × X = Green × X	0.050	0.042	0.890	0.370
Type FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	24345	21118	9887	8568
R^2	0.0110	0.0119	0.159	0.173

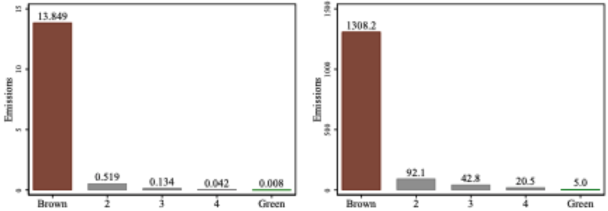
This table shows how sustainable investing differentially reacts to percentage changes in firm emissions depending on whether the firm is brown, netural, or green. The dependent variable in Columns (1) and (2) is the stock's overweight in green investment funds as defined in Table 6. The dependent variable in Columns (3) and (4) is the stock's MSCI KLD environmental rating as defined in Table 8. All columns include year fixed effects and indicators for whether the firm is brown, neutral, or green. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Standard errors are in parentheses and are clustered at the firm-level.

Hartzmark and Shue (2023): Emissions by Quintile

Figure 1: Average GHG emissions in each quintile

(a) Total emissions

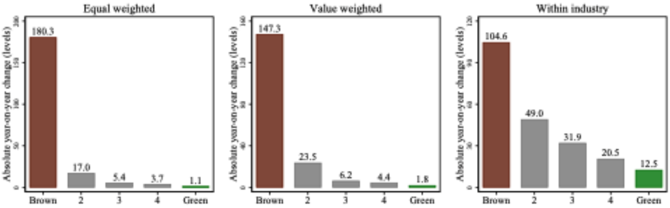
(b) Emissions intensity (emissions/revenue)



This figure plots the average emissions of scope 1 and scope 2 greenhouse gases by firms, sorted into quintiles within each year, with quintile 1 representing brown firms and quintile 5 representing green firms. In Panel (a), emissions are measured as million tons of CO_2 equivalents. In Panel (b), emissions are measured as tons of CO_2 equivalents emitted per million dollars of revenue.

Hartzmark and Shue (2023): Variation in Emissions by Quintile

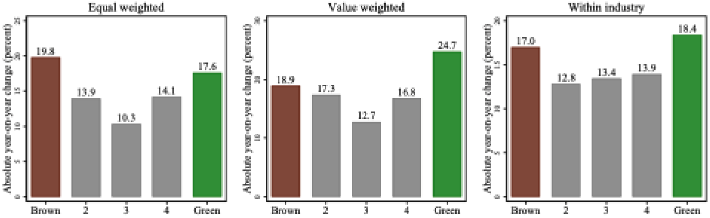
Figure 2: Absolute variation of emissions intensity by quintile



This figure plots year-on-year variation in emissions across quintiles for the level of emissions. Variation in emissions is $|e_{t+1} - e_t|$, the absolute change in scope 1 and scope 2 greenhouse gases emissions intensity, where emissions intensity is measured in tons of CO_2 equivalents emitted per million dollars of revenue. Absolute changes are winsorized at the 1% level. In the left and middle panels, quintiles are computed within each fiscal year. In the right panel, quintiles are computed within each year×SIC2 industry. Observations in the left and right panels are equal weighted. In the middle panel, observations are weighted by the firm's market capitalization as a fraction of total CRSP market size in the same year.

Hartzmark and Shue (2023): Variation in Percentage Emissions by Quintile

Figure 3: Absolute percentage variation of emissions intensity by quintile



This figure plots year-on-year percentage variation in emissions across quintiles for the level of emissions. Variation in emissions is $|\frac{e_{t+1}-e_t}{e_t} \times 100|$, the absolute percentage change in scope 1 and scope 2 greenhouse gases emissions intensity, where emissions intensity is measured in tons of CO_2 equivalents emitted per million dollars of revenue. In the left and middle panels, quintiles are computed within each fiscal year. In the right panel, quintiles are computed within each year$\times$SIC2 industry. Observations in the left and right panels are equal weighted. In the middle panel, observations are weighted by the firm's market capitalization as a fraction of total CRSP market size in the same year.

Example from Hartzmark and Shue (2023)

- Traveler's: insurance firm with high ESG score, low emissions (1 ton per million USD of revenue)
- Martin Marietta: building materials firm with low ESG score, high emissions (1,000 tons per million USD of revenue)
- Typical ESG strategy: invest in Traveler's, avoid MM
- Problems:
  - If Traveler's reduces emissions by 100%, equivalent amount of CO2 reduction to MM reducing by 0.1%
  - Traveler's unlikely to develop green technology
  - MM has cut its emissions per ton of cement from 0.84 in 2016 to 0.77 in 2019 (1 million tons or 30 times Traveler's total emissions)

Takeaways from Hartzmark and Shue (2023)

- Does this mean that ESG investing will lead brown firms to become browner and have no impact on green firms?
  - The authors argue: "sustainable investing that directs capital away from brown firms and toward green firms may be counterproductive, in that it makes brown firms more brown without making green firms more green"
  - I don't necessarily agree. Why not?
- ESG ratings agency and ESG funds focus on percentage reductions in emissions, which penalizes firms in sectors with high emissions (e.g. Martin Marietta) while favoring firms in sectors with low emissions (e.g. Traveler's)
  - Transitioning to a green economy will require brown sectors to become more efficient (insurance and building materials are not substitutes)
  - What can regulators do to ensure that green investors are choosing investments that are consistent with a green transition?

Regulation and Disclosure

Overview of Current Legal Environment

- EU is the world leader in sustainability regulations:
    1. Taxonomy
    2. Corporate Sustainability Reporting Directive
    3. Sustainable Finance Disclosure Regulation
- Australia, Brazil, China, Japan, Singapore, Switzerland, the UK and others have enacted similar regulations
- Many countries, including the US, have regulations in progress
- We will discuss the US and EU policies in detail
- Goal of disclosure requirements as described by the EU Parliament: "end greenwashing, strengthen the EU's social market economy and lay the groundwork for sustainability reporting standards at global level."

EU Taxonomy

- Enacted in 2020, the Taxonomy is a green classification system
- Environmental objectives are:
  1. Climate change mitigation
  2. Climate change adaptation
  3. Sustainable use and protection of water and marine resources
  4. Transition to a circular economy
  5. Pollution prevention and control
  6. Protection and restoration of biodiversity and ecosystems
- To be considered sustainable, an economic activity must:
  1. Contribute to at least one of six environmental objectives
  2. Do no significant harm to any of the other objectives, while respecting basic human rights and labour standards

EU Taxonomy: Types of Green Activities

- Activities can be categorized by three types:
  1. Contribute directly to an objective, e.g. solar power generation
  2. Enable other activities that contribute directly, e.g. manufacturing solar panels
  3. Transitional activities for which low-carbon alternatives are not yet available. These can be aligned under the taxonomy if they have greenhouse gas emission levels that correspond to the best performance in the sector or industry, e.g. fuel efficient aircraft
- How does the Taxonomy help address the issues raised by Hartzmark and Shue (2023)?

EU Corporate Sustainability Reporting Directive

- The Taxonomy is like a dictionary, but the CSRD and SFDR lay out how corporations and investors should use the dictionary
- The CSRD was introduced in January 2023 and succeeds the Non-Finacial Reporting Directive (2014)
  - The first CSRD reports will be published in 2025 using data from 2024
  - Primary difference from NFRD is that more companies must comply and that the disclosures will be more detailed
- The CSRD reports will contain the following:
  1. Governance processes to monitor, manage, and oversee sustainability matters
  2. Strategy addressing sustainability impacts, risks and opportunities
  3. Process by which firm identifies sustainability impacts, risks and opportunities
  4. How the firm measures sustainability performance, including targets it has set and progress toward meeting them

EU Sustainable Finance Disclosure Regulation

- The Sustainable Finance Disclosure Regulation (SFDR) was enacted by the European Commission in November 2019 and came into effect in March 2021
- Requires all financial market participants to classify their products into one of Article 6, 8 or 9
  - Article 6 are funds that do not promote ESG
  - Article 8 are funds that promote environmental or social characteristics
  - Article 9 are funds that have sustainability as an objective
- Why does the SFDR allow for estimation of the causal effect of investor environmental preferences on firm greenness?
  - A fund's SFDR classification is only weakly correlated with other measures of portfolio greenness (Ramos et al. (2022))
  - By choosing Article 8 or 9, funds commit to considering greenness when making their investment decisions

SFDR vs. ESG Rating

From Emiris et al. (2023)

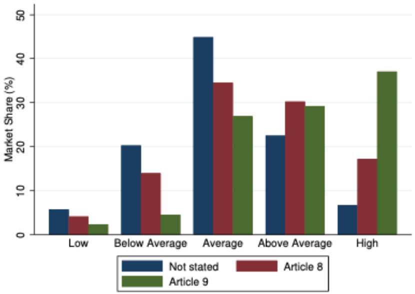


Figure 6. Distribution of sustainability rating by SFDR category

This figure shows the distribution of investment fund shares outstanding by Morningstar Sustainability rating for SFDR Article 8, Article 9 and other investment funds.

SFDR and Portfolio CO2 Intensity

From Emiris et al. (2023)

Table 9. Carbon Intensity and SFDR Choice

The dependent variable is the change in fund-level carbon intensity from 2019 Q4 to 2022 Q4. $\mathbb{1}\{\text{Brownwasher}\}$ is an indicator for whether the fund had a Morningstar Globe rating in 2019 Q4 of 4 or 5 and chose Article 6. $\mathbb{1}\{\text{Light Greenwasher}\}$ is an indicator for whether the fund had a Morningstar Globe rating in 2019 Q4 of 1 or 2 and chose Article 8. $\mathbb{1}\{\text{Dark Greenwasher}\}$ is an indicator for whether the fund had a Morningstar Globe rating in 2019 Q4 of 1 or 2 and chose Article 9.

	Carbon Intensity Change (2019-2022)			
	(1)	(2)	(3)	(4)
$\mathbb{1}\{\text{Brownwasher}\}$	0.942***	0.983***	0.943***	0.983***
	(0.138)	(0.140)	(0.138)	(0.140)
$\mathbb{1}\{\text{Light Greenwasher}\}$	-1.199***	-1.285***	-1.235***	-1.328***
	(0.249)	(0.252)	(0.250)	(0.253)
$\mathbb{1}\{\text{Dark Greenwasher}\}$	-4.046**	-4.099**	-4.085**	-4.149**
	(1.708)	(1.710)	(1.718)	(1.719)
Observations	5,153	5,137	5,153	5,137
SFDR Category	Yes	Yes	Yes	Yes
Fund Category	No	Yes	No	Yes
Issuer Country	No	No	Yes	Yes
R^2	0.024	0.040	0.035	0.051

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Proposed US Regulations

- SEC has proposed (but not enacted) a rule requiring the inclusion of climate-related disclosures in financial statements
  - Would require disclosure of climate-related risks, as well as Scope 1, 2 and 3 emissions
  - Has faced pushback, in particular against disclosing Scope 3 emissions
- In September 2023, California lawmakers passed a law requiring large companies to publicly disclose their greenhouse gas emissions (not yet signed by Gov. Newsom)
  - Will apply to companies that operate in California and earn more than $1 billion in revenue annually (about 5,000 companies)

Types of Corporate Emissions

- **Scope 1**: emissions directly produced by the firm (for example FedEx burns fuel to power its trucks and planes)
- **Scope 2**: emissions caused indirectly by the production of energy purchased by the company (for example FedEx uses electricity in its sorting facility)
- **Scope 3**: emissions produced by customers using the firm's products or those produced by suppliers making products that the firm uses (for example Ford generates emissions in order to manufacture trucks used by FedEx)

Carbon Offsets

- Carbon offsets are tradable "rights" or certificates linked to activities that lower the amount of $CO2$ in the atmosphere
- How do offsets work in an ideal world?
  1. Firm A owns a rainforest, which an agricultural firm has offered to purchase (the purchase would lead to the rainforest being cut down)
  2. Firm B is an airline who has made a net zero pledge, but does not have the technology to reduce its actual emissions to zero
  3. Instead of selling the rainforest to the agricultural firm, Firm A keeps the rainforest and sells carbon offsets to Firm B, enabling the rainforest to stay intact and continue to remove carbon from the atmosphere
- But what if the rainforest wasn't at risk in the first place? Then Firm B gets to "offset" its emissions, but no real change has been made

Greenstone et al. (2023): Overview

- Analyze emissions data (focus on scope 1) for firms globally
  - Data is from Trucost, which is available on WRDS
- Goal is to estimate carbon damages in $
- To convert between emissions (measured in tons of CO2) and $, use social cost of carbon
- Main findings:
  1. Corporate carbon emissions equal roughly 44% of firms' operating profits and 3.1% of their revenues on average
  2. There is substantial variation across firms (both across and within industries)
  3. Largest carbon damages occur in the energy-intensive industries (i.e., utilities, materials, energy, transportation and food, beverage and tobacco), for which the industry average of the damages is well above the mean of the global sample, but there is substantial heterogeneity within industries

What is the Social Cost of Carbon?

- **Definition**: estimate of the cost, in dollars, of the damage done by each additional ton of carbon emissions
  - Alternatively, it is an estimate of the benefit of any action taken to reduce a ton of carbon emissions
- Why is the SCC useful?
  - Can help evaluate policy proposals because if a policy to prevent one ton of carbon emissions costs less than the SCC, then the benefits of the policy outweigh the costs (and vice versa)
- How is the SCC calculated?
  - General idea is to model what will happen to the environment and economy when atmospheric CO2 increases (requires integrating climate and economic models because need to understand CO2 $\implies$ temperature $\implies$ economy)
  - Estimates vary, for example, Greenstone et al. (2023) use $51 (Obama administration), $190 (EPA in 2022) and $250 (includes effects on migration and conflict)

Greenstone et al. (2023): Problems with Emissions Data

- Only 31% of the firms with non-missing GHG emissions come from firms' direct reporting
- In most of the world, reporting is voluntary, lacks independent verification and/or faces no penalties for misreporting
- Emissions for the remaining 69% of the sample firms are estimated by Trucost using a model that relies on mostly voluntary emissions reports from a wide array of data sources to determine sector-specific emission intensities, the company's business sectors, and its revenue share by sectors

Greenstone et al. (2023): Why Might Mandatory Disclosure Help?

1. Meaningful policies to restrict emissions are not possible without reliable data (true for both market-based policies such as emissions trading and “command-and-control” policies)
2. Mandatory disclosure based on reliable measurement would help financial markets to discipline GHG emissions
3. Disclosure mandates can incentivize firms to reign in environmental externalities, such as GHG emissions

Yang et al. (2021): Overview

- Starting in 2010, Greenhouse Gas Reporting Program requires both the reporting of greenhouse gas emissions by facilities emitting more than 25,000 metric tons of carbon dioxide per year to the Environmental Protection Agency and the public dissemination of the reported data in a comprehensive and accessible manner
- Finds that power plants that are subject to the GHGRP reduced carbon dioxide emission rates by 7%
- Effect is stronger for plants owned by publicly traded firms (example of discipline by financial markets)
- Firms strategically reallocate emissions between plants to reduce GHGRP-disclosed emissions

Yang et al. (2021): Empirical Design

- Difference-in-difference design:

$$log(CO_2Rate)_{it} = \beta_0 + \beta_1 \text{GHGRP}_{it} + \beta_2 \text{Post}_{it} + \beta_3 \text{Post}_{it} \times \text{GHGRP}_{it} + \alpha_t + \delta_c + u_{it} \quad \text{(1a)}$$

$$log(CO_2Rate)_{ft} = \beta_0 + \beta_1 \text{GHGRP}_{ft} + \beta_2 \text{Post}_{ft} + \beta_3 \text{Post}_{ft} \times \text{GHGRP}_{ft} + \alpha_t + \gamma_f + \epsilon_{ft} \quad \text{(1b)}$$

- t indexes the year, i the plant, f the firm
- Post is equal to 1 if the year is 2010 or later
- In 1a, GHGRP_{it} is equal to 1 if the plant was ever subject to the mandatory disclosure requirement
- In 1b, GHGRP_{ft} if the firm owns at least one GHGRP plant

Yang et al. (2021): Results I

Table 3: Effects of the GHGRP on Plant-level Emissions Rates

	log(CO_2 Emission Rate)					
	eGRID Reported Emissions				EIA Est. Emissions	
	(1)	(2)	(3)	(4)	(5)	(6)
$\text{GHGRP}_{i,t}$	-0.149***	-0.091***		-0.249***	-0.280***	
	(-4.45)	(-3.73)		(-6.67)	(-16.25)	
$\text{Post}_{i,t}$	0.011	0.029	0.006	0.007	-0.028**	0.018
	(0.70)	(1.59)	(0.34)	(0.33)	(-1.99)	(1.20)
$\text{GHGRP}_{i,t}$	-0.071***	-0.106***	-0.050***	-0.080***	-0.037***	-0.042***
$\times$ $\text{Post}_{i,t}$	(-4.75)	(-6.64)	(-3.27)	(-4.22)	(-3.08)	(-3.35)
N	16,075	16,075	16,075	13,486	22,862	22,862
Adj.R^2	0.388	0.100	0.663	0.345	0.080	0.625
Year FE	Y	Y	Y	Y	Y	Y
County FE	Y	N	N	N	N	N
State FE	N	Y	N	N	N	N
Plant FE	N	N	Y	N	N	Y
Owner FE	N	N	N	Y	N	N

This table presents results on the effects of the GHGRP on plant-level carbon emission rates. Columns (1) - (4) use reported annual CO_2 emission rates from eGrid in the sample period 2004-2018 with missing observations for years 2006, 2008, 2011, 2013, 2015 and 2017. Columns (4) and (5) use estimated annual CO_2 emission rates with fuel consumption data from Form EIA906/923 in the sample period 2006-2015. The outcome variables are winsorized at 1 and 99 percentiles for each year. Standard errors are clustered by plants, and t-statistics are shown in the parentheses below the coefficient estimates. *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

Yang et al. (2021): Results II

Table 6: Effects of the GHGRP and Publicly Traded Firms

	log(CO_2 Emission Rate)			
	Full Sample		Sub-Sample	
			Public	Non-Public
	(1)	(2)	(3)	(4)
$\text{GHGRP}_{i,t}$	-0.145***	-0.160***	-0.145	-0.168***
	(-3.94)	(-4.37)	(-1.57)	(-3.95)
$\text{Post}_{i,t}$	0.010	0.008	-0.031	0.013
	(0.57)	(0.45)	(-0.70)	(0.65)
$\text{GHGRP}_{i,t} \times \text{Post}_{i,t}$	-0.084***	-0.066***	-0.099**	-0.060***
	(-5.36)	(-3.88)	(-2.31)	(-3.47)
Owned by $\text{Public}_{i,t}$	0.091***	0.072		
	(3.43)	(1.10)		
Owned by $\text{Public}_{i,t}$		0.008		
$\times \text{Post}_{i,t}$		(0.20)		
Owned by $\text{Public}_{i,t}$		0.052		
$\times \text{GHGRP}_{i,t}$		(0.72)		
$\text{GHGRP}_{i,t} \times \text{Post}_{i,t}$		-0.056		
$\times$ Owned by $\text{Public}_{i,t}$		(-1.22)		
N	14,357	14,357	4,311	10,046
Adj.R^2	0.390	0.390	0.470	0.425
Year FE	Y	Y	Y	Y
County FE	Y	Y	Y	Y

This table presents results on the effects of the GHGRP on plant-level outcomes for plants owned by publicly traded firms. Column (1) adds the Owned by Public indicator variable as an additional control in our main DiD model. Column (2) presents the triple difference regression described in Equation 2 with Owned by Public as a second treatment variable. In Columns (3) and (4), we sort our sample into two groups based on whether the plant is owned by a publicly-traded firm, and estimate Equation 1a. The outcome variables are winsorized at 1 and 99 percentiles for each year. Standard errors are clustered by plants, and t-statistics are shown in the parentheses below the coefficient estimates. $^*p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Yang et al. (2021): Results III

Table 8: Effects of the GHGRP on Firm-level Emissions

	log(CO_2 Emission Rate)			
	Firm Average		Non-GHGRP Plants' Average	
	(1)	(2)	(3)	(4)
$\text{GHGRP}_{f,t}$	-0.086	-0.386**	-0.377*	-0.125
	(-0.81)	(-1.81)	(-1.65)	(-0.94)
$\text{Post}_{f,t}$	-0.266**	-0.320***	0.159	-0.092
	(-2.06)	(-3.38)	(0.52)	(-0.46)
$\text{GHGRP}_{f,t} \times \text{Post}_{f,t}$	0.154	0.072	0.556**	0.247*
	(1.39)	(0.99)	(2.42)	(1.69)
N	744	744	407	407
Adj.R^2	0.301	0.605	0.003	0.607
Year FE	Y	Y	Y	Y
Firm FE	N	Y	N	Y
Firm Controls	Y	N	Y	N

This table presents results on the effects of the GHGRP on firm-level carbon emissions rates using Equation 1b. The outcome variable in Columns (1) and (2) is the weighted average of all plants owned by a firm. In Columns (3) and (4), we take the weighted average of all non-GHGRP plants owned by a firm as the outcome variable, hence the observation size drops from 744 to 408 due to the exclusion of firms with no GHGRP plants. Columns (1) and (3) use year fixed effects and control for the following firm characteristics, firm size, leverage ratio, number of plants owned, number of gas plants owned, and number of coal plants owned. Columns (2) and (4) include both year and firm fixed effects. All continuous variables are winsorized at 1 and 99 percentiles for each year, and t-statistics are shown in the parentheses below the coefficient estimates. *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

Next Week

- Disclosure and regulation continued:
  - How prevalent is greenwashing?
  - How do disclosure regulations help investors?
  - Discuss other regulations including Emissions Trading in the EU and the Inflation Reduction Act in the US
- Climate risk
  - Physical vs transition risk
  - How is climate risk measured?
  - Does climate risk matter to investors?

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