The Climate and Financial Effects of Fossil Fuel Power Plant Sales in the US by Publicly Traded Firms

Joanne Im

MIT Sloan

March 12, 2024

Motivation

- ESG pressure on publicly traded firms to reduce firm-level emissions
- Publicly traded firms selling "dirty", high carbon assets to privately held firms
- Concerns about greenwashing–the phenomenon of taking actions that appear superficially green but that in reality, have zero or negative climate effects.

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Greenwashing Concerns in the Press

POLITICO

SUSTAINABILITY

When companies go green, the planet doesn't always win

The New York Times

Oil Giants Sell Dirty Wells to Buyers With Looser Climate Goals, Study Finds

The transactions can help major oil and gas companies clean up their own production by transferring polluting assets to a different firm, the analysis said.

CNBC MARKETS BUSINESS INVESTING TECH POLITICS CNBC TV INVESTING CLUB PRO

An energy transition loophole is allowing Big Oil to offload high-polluting assets to private buyers

Case Study: Nigerian Oil and Gas Field

The New York Times

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By Hiroko Tabuchi

May 10, 2022

For the four years before the Umuechem sale in Nigeria, satellites had spotted no routine flaring from the field, which Shell, together with the European energy giants Total and Eni, operated in the Niger Delta. But immediately after those companies $\boxed{\text{sold the field to a private-equity backed firm,}}$ Trans-Niger Oil & Gas, an operator with no stated net zero goals, levels of flaring quadrupled, according to data from the VIIRS satellite collected by EDF as part of the analysis. Trans-Niger said last year it intends to triple production at the field.

Post-Sale Quadrupling of Methane Flaring

The New York Times

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This Paper

- Whether and when **public to private** sales
  - led to near zero changes to, or large increases in emissions (i.e. innocuous or perverse greenwashing)
  - were incentivized by the stock market
- Understand climate consequences of ESG strategies that pressure public, but not private, firms to reduce firm-level emissions

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Fossil Fuel Power Plant Sector

- This paper looks for evidence of these effects in public-private sales in the US fossil fuel power plant sector from 1999-2023.
    - Average treatment effects on the treated
- Power plants generate **25% of annual US GHG emissions**
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Fossil Fuel Power Plant Sector

- High quality emissions data
  - 96% of sectoral emissions
  - accurate and precise
  - at the weekly frequency
  - power plant unit level
  - linkable with asset characteristics and product market data and deals data.
- Sizeable deal volume
  - 27% of 2022 sectoral emissions
  - 82 deals
  - 601 power plant units

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Outline

Climate Effects

Question

What are the public-to-private sale effects on short-horizon (i.e. eighteen months) plant emissions?

Identification Strategy

- M&A deals in plants with a public seller
- Difference-in-difference design

Climate Effects

Question

What are the public-to-private sale effects on short-horizon (i.e. eighteen months) plant emissions?

Findings

1. In observed **public to private** sales, emissions effects are **small**, and **statistically indistinguishable from zero**
2. Result holds in observed **public to public sales**

Climate Effects

Question

What are the public-to-private sale effects on short-horizon (i.e. eighteen months) plant emissions?

Implications

Innocuous greenwashing (near zero effects) but not perverse greenwashing (large negative effects) may be a concern

Financial Effects

Question

What are public to private sale effects on seller valuations?

Identification Strategy

- Plant sale announcements by public sellers
- Event study methodology

Financial Effects

Question

What are public to private sale effects on seller valuations?

Findings

1. Sales to private firms earn CARs of 1.4% over an eleven day symmetric window
2. Difference in returns from announcing sales to private versus public firms is **statistically indistinguishable from zero**

Financial Effects

Question:

What are public to private sale effects on seller valuations?

Implication

- Market not incentivizing dirty asset transfers to more opaque private firms over public firms

Outline

Model with Greenwashing Equilibrium

- Effects on asset ownership and emissions when public, but not private, firms are shocked with higher costs of emitting

- Multiple equilibria

- Greenwashing equilibrium
  - Public firms sell dirty assets to private firms
  - When firms are identical pre-shock, the post-shock, observed asset emissions will be unchanged but emissions will increase vis-a-vis the unobserved counterfactual when trading is suppressed

d

Literature Review

- Environmental and financial effects of divestitures of pollutive assets: (Duchin, Gao, and Xu, 2023; Jacqz, 2021; Kahn, Matsusaka, and Shu, 2023)
  - **This paper** studies an asset class with climate relevance using high quality, accurate, and precise GHG emissions data
- Operational effects of divestitures on power plants: (Andonov and Rauh, 2023; Demirer and Karaduman, 2022)
  - **This paper** studies comprehensively the operational decisions that determine assets' emissions effects and financial effects
- Divestitures and firm value: (Hite, Owers, and Rogers, 1987; Wright and Ferris, 1997)
- Firm characteristics and asset operations: (Akey and Appel, 2021; Bellon, 2021; Bernstein, 2022; Shiver and Forster, 2020)
- Effectiveness of ESG investment strategies: (Berk and Binsbergen, 2022; Hartzmark and Shue, 2023; Broccardo, Hart, and Zingales, 2022)

Road map

Outline

Ambiguous Climate Effects

We might expect a public-to-private sale to

- Increase emissions
  - Private firm faces weaker incentives to operate assets in environmentally responsible ways
- Leave emissions unchanged
  - If the public firm sold assets in response to an increase in the cost of emitting and sold assets to a private firm with the same cost of emitting as itself pre-shock
- Decrease emissions
  - Private firm has a competitive advantage in improving the asset's productive efficiency, which would lead to a decline in the emission intensity of production

Ambiguous Financial Effects

We might expect a public-to-private sale to

- Increase seller valuations
  - Private firm operates assets in ways that are more profitable, but more emitting, implying gains to trade from selling
- No change/decline in seller valuations
  - Public firms take zero/negative net present value actions to assuage public outrage over corporate contributions to climate change

Outline

What is a Fossil Fuel Powerplant?

Unit A

Unit B

Unit C

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Unit A

Unit B

Unit C

Unit A

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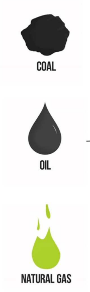


→ Unit A →

Electricity
min($q^f \times 1/h^{i,f}$, nameplate)

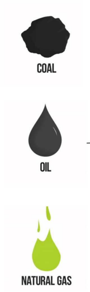
Notation (i = unit; f = fuel)
q^f : quantity of fuel type *f* burned measured by heat content (mmBtu)
$h^{i,f}$: heat rate, the inverse of the productive efficiency of unit *i*, fuel *f* (mmBtu/MWh of electricity)
ξ^f : emissions factor of fuel *f* (CO2/MWh of electricity)

What is a Fossil Fuel Powerplant?

Unit A

Unit B

Unit C



→ Unit A →

Electricity
min($q^f \times 1/h^{i,f}$, nameplate)

CO_2 Emissions
$q^f \times 1/h^{i,f} \times \xi^f$

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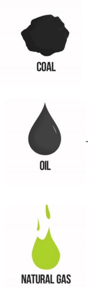
What is a Fossil Fuel Powerplant?

Three key, observable decisions that new buyers make that determine plant emissions:

1. Turn on/off
2. How much to produce
3. The emissions intensity of production
   a. Productive efficiency
   b. Fuel mix (primary and secondary fuels burned)



→ Unit A

→ **Electricity**
min($q^f \times 1/h^{i,f}$, nameplate)

→ **CO2 Emissions**
$q^f \times 1/h^{i,f} \times \xi^f$

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Data Sources

- **Environmental Protection Agency** (CAMD program, eGrid)
  - Plant production, emissions, technological characteristics (e.g., the primary and second fuel burned, fuel quantity by heat content, electricity output, emissions, combined cycle indicator)
- **Energy Information Administration** (Forms 860 and 920/923)
  - Plant characteristics, and ownership (e.g., electricity region, state, owner's regulation status)
- **S&P Capital IQ Pro**
  - Deal characteristics (e.g., buyer and seller identities, share percentages transferred, announcement dates, completion dates, deal summaries)

High Quality, Comprehensive Data

- Panel dataset of plant emissions, production, technological specifications, and ownership changes at the **weekly frequency**, and **plant unit level** from **1999-2023.**
- Comprehensive, and high-quality emissions and production data
- Complete deals data because of state and federal regulation of plant ownership

Summary Statistics

Panel A: Counts				
	Buyer Type			Combined as % of Sector
	Public	Private	Combined	in 2022
# of Deals	45	37	82	
# of Units	333	268	601	20
Coal-fired	144	16	160	5
Gas-fired	189	252	441	15
# of Plants	130	106	236	21
Coal-fired	56	8	64	6
Gas-fired	77	98	175	15

Panel B: Sums/Averages the Year of Sale Completion				
	Buyer Type			% of Sector
	Public	Private	Combined	2022
Emissions (bn. short tons)	0.33	0.15	0.48	27
Coal-fired	0.28	0.08	0.36	20
Gas-fired	0.05	0.07	0.12	7
Emissions Intensity ($\frac{s.tons}{MWh}$)	0.85	0.68	0.77	-

Selection

Empirical Model

- **Difference-in-difference** framework to estimate average treatment effects on treated
- Two treatments: Sale by a public firm to
  - a public firm,
  - a private firm
- Sale recognized if
  1. the seller was listed on a major US trading exchange (i.e. NASDAQ, NYSE)
  2. the divestment involved a majority ownership transfer
  3. the buyer was a for-profit entity
  4. non-repeat sale.

Empirical Model

Specification

Let $i = unit$, $t = week$.

$$\begin{aligned} y_{it} = \quad & \beta_1(Post \times Public\,Buyer)_{it} \\ + \quad & \beta_2(Post \times Private\,Buyer)_{it} + \alpha_i + X_{it} + \eta_{it} \end{aligned}$$

Standard errors clustered at the plant level.

Dependent Variables

$$y_{it} = \begin{bmatrix} Weekly\ Starts \\ Capacity\ Factor \\ \ln(Emissions\,\text{Intensity}) \end{bmatrix}_{it} = \begin{bmatrix} 1(MWh > 0) \\ \frac{MWh}{MWh}\big|_{MWh>0} \\ ln(\frac{CO_2}{MWh})\big|_{MWh>0} \end{bmatrix}_{it}.$$

Parameters of Interest

Specification

Let $i = unit$, $t = week$.

$$\begin{aligned} y_{it} = \quad & \beta_1 (Post \times Public\,Buyer)_{it} \\ + \quad & \beta_2 (Post \times Private\,Buyer)_{it} + \alpha_i + X_{it} + \eta_{it} \end{aligned}$$

Standard errors clustered at the plant level.

Independent Variables

- $Post \times Public\,Buyer$: Unit sold to a public firm and is in the post-divestment period
- $Post \times Private\,Buyer$: Unit sold to a private firm and is in the post-divestment period

Controls

Specification

Let $i = unit$, $t = week$.

$$\begin{aligned} y_{it} = \quad & \beta_1(Post \times Public\,Buyer)_{it} \\ + \quad & \beta_2(Post \times Private\,Buyer)_{it} + \alpha_i + X_{it} + \eta_{it} \end{aligned}$$

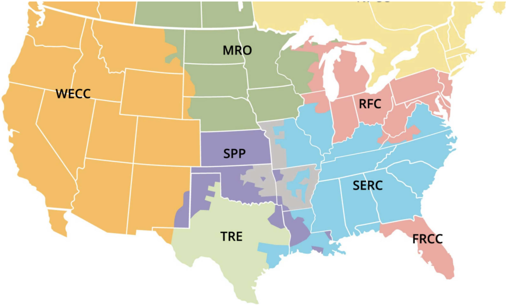
Standard errors clustered at the plant level.

Independent Variables

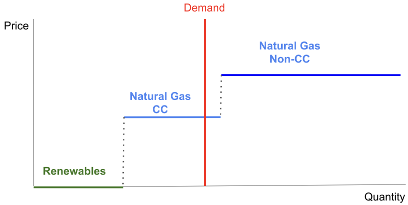
- α_i : Unit FE
- X_{it}: Electricity Region $\times$ State $\times$ Fuel Set $\times$ Week $\times$ Year FE
- η_{it}: Error term

Why Match on Electricity Region, State, Fuel Set?

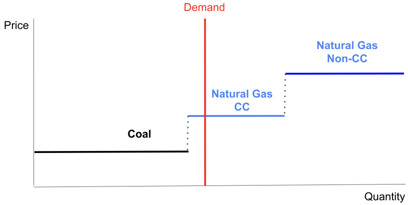
- Controls should face the **same demand**, **supply, marginal costs** in the **same electricity region** as treated units
  - Electricity region = 7 North American Electric Reliability Council (NERC) regions)
  - State level regulation of power plant pollutants (e.g., mercury, SO_2, NOX)
  - Fuel set ≈ 80% of marginal operating costs (net of private costs of emitting)



Dispatch Curve



(a) WECC region, California



(b) SERC region, Kentucky

Treatment Group Slightly Younger Than Controls

Comparison of Treatment and Controls

	Treated Units	Control Units	Difference
	(1)	(2)	(3)
Annual Generation (MWh)			
Mean	938,291	876,716	61,574
Std. Dev./Std. Error	(1,268,854)	(1,227,594)	(61,066)
Annual Emissions (s. tons)			
Mean	734,039	653,970	80,068
Std. Dev./Std. Error	(1,249,113)	(1,126,822)	(58,058)
Emissions Intensity $(\frac{s.tons}{MWh})$			
Mean	0.70	0.69	0.01
Std. Dev./Std. Error	(0.23)	(0.21)	(0.01)
Age (Years)			
Mean	37	41	-5***
Std. Dev./Std. Error	(21)	(24)	(1)

Hypotheses

Specification

$$
\begin{aligned}
y_{it} = \quad & \beta_1(Post \times Public\,Buyer)_{it} \\
+ \quad & \beta_2(Post \times Private\,Buyer)_{it} + X_{it} + \alpha_i + \eta_{it}
\end{aligned}
$$

Hypotheses

- *Absolute* public-to-private divestment effect

$$H_0 : (Post \times Private\,Buyer) = 0$$
$$H_a : (Post \times Private\,Buyer) \neq 0$$

- *Relative* public-to-private divestment effect

$$H_0 : (Post \times Private\,Buyer) = (Post \times Public\,Buyer)$$
$$H_a : (Post \times Private\,Buyer) \neq (Post \times Public\,Buyer)$$

Identification Assumptions

- Absolute effects
  - Parallel trends Dynamic DID
  - Stable unit treatment value assumption
  - Exogeneity
- Relative effects
  - Units involved in public to public sales and public to private sales have identical opportunities to be operated in more or less emitting ways

Effects Statistically Indistinguishable From Zero

	Starts (1)	Capacity Factor (2)	$ln(E.Intensity)$ (3)
Panel A. Point Estimates			
	All		
$Post \times Public\ Buyer$	-0.017	-0.005	-0.011
	(0.013)	(0.008)	(0.010)
$Post \times Private\ Buyer$	-0.028	-0.011	0.000
	(0.017)	(0.013)	(0.017)
Panel B. Regression Statistics			
Observations	356,704	273,278	273,278
R-squared	0.40	0.72	0.93
R-squared contribution	0.00	0.00	0.00
Panel C. Wald Test P-Value, $H_0 : (Post \times Public) = (Post \times Private)$			
	0.58	0.68	0.61

Difference in Effects by Buyer Type Statistically Insignificant

	Starts	Capacity Factor	$ln(E.Intensity)$
	(1)	(2)	(3)
Panel A. Point Estimates			
	All		
$Post \times Public\,Buyer$	-0.017	-0.005	-0.011
	(0.013)	(0.008)	(0.010)
$Post \times Private\,Buyer$	-0.028	-0.011	0.000
	(0.017)	(0.013)	(0.017)
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Panel C. Wald Test P-Value, H_0 : $(Post \times Public) = (Post \times Private)$			
	0.58	0.68	0.61

Near-Zero Asset-level Climate Effects

Asset-level Effects

- If generation declines in units sold to private firms were replaced by
  - zero-emissions, clean technology $\implies$ decline of ≤ 20 bp in US annual emissions

- Implication: Public to private sales had near zero climate impacts, which is supportive of arguments in favor of innocuous, but not perverse greenwashing.

Asset-level Implications $\neq$ Aggregate Implications

- Inelastic demand and market clearing implies generation declines will be offset by generation elsewhere
- Aggregate implications depend on the emissions profile of **replacement** generation **vis-a-vis replaced** generation

Near-Zero Aggregate Climate Effects

Aggregate Effects

- If generation declines in units sold to private firms were replaced by
  - zero-emissions, clean technology $\Longrightarrow$ decline of ≤ 20 bp in US annual emissions
  - dirty technology $\Longrightarrow$ increase ≤ 20 bp in US annual emissions
- Inflation Reduction Act (IRA) seeks emissions declines of 88-100% from this sector

Additional Analyses

Robustness

- Lengthening horizon to five years
- Weight observations by nameplate capacity (i.e. production capacity)

Heterogeneity

- Post-COP21
- Green Sale
- Green Buyer
- Private Equity Buyer
- In Regulated State
- Marginal Unit
- Old Unit
- Large Unit

Heterogeneity

Break Out Effects by Fuel Type

- Aggregating across coal, and gas units may mask effects
- Differences in opportunities to change emissions behavior of unit. For e.g.,
  - Coal plants can become more or less emitting by changing coal rank (anthracite coal is 10% more emitting per fuel heat content than bituminous coal)
  - Most gas plants burn pipeline natural gas

Effects by Fuel Type

- Effects generally indistinguishable from zero By Fuel
- But economically meaningful, and statistically significant reductions in the emissions intensity of coal-fired units (but not gas fired units)
  - sale to **private firm** $\rightarrow$ 4.1% decline in the emissions intensity
  - sale to **public firm** $\rightarrow$ 1.3% decline in the emissions intensity

Possible Causes of Declines

- Decline can be from
  - Fuel mixing ✖ Co-firing
  - Changing reporting or fuel subtype (e.g., switching from subituminuous to anthracite coal)
  - Changing the productive efficiency (e.g., improving routine maintenance, turbine coating, implementing neutral-network sootblowing)

Declines ≈ Improvements in Productive Efficiency

$$\underbrace{\Delta ln(\frac{CO_2}{Generation})}_{\substack{\Delta Emissions\ Rate \\ (net\ of\ fuel\ mixing)}} = \underbrace{\Delta ln(\frac{CO_2}{Heat\ Input})}_{\substack{\Delta Reporting\,/ \\ Fuel\ Subtype}} - \underbrace{\Delta ln(\frac{Generation}{Heat\ Input})}_{\substack{\Delta Productive \\ Efficiency}}$$

Private Buyer	$-0.043**$	-0.005	$-0.038**$
Public Buyer	$-0.016**$	0.000	$-0.015**$

Stories | Pre-Sale Dummies | Reg Specification

Alignment of Incentives

- Improvements to productive efficiency are one area in which

$$\text{Productive Efficiency} \propto \text{Economic Efficiency} \propto \text{Evironmental Efficiency}$$

  can be aligned

  - fossil fuel combustion accounts for 73% of annual US GHG emissions and 45% of annual US GHG emissions from industrial assets

- Caveats
  - Private effects estimated on 8 power plants and 16 units. These, however, were very large units that emitted, at the time of sale completion, 4% of 2022 emissions from this sector.
  - Even if private firms were to acquire all coal units in existence and reduce emissions intensities by 4.1% **would decrease US emissions by a modest 60bps**

By Fuel Type | Specification

Power Plants Unlike a Nigerian Oil and Gas Field

- Why do we see near zero climate effects here when methane flaring in the Nigerian oil and gas field quadrupled post-sale?
- Differences in emissions decision function
  - Methane flaring involves a possible "capture/no capture" decision
  - Fossil fuel combustion **does not** because industrial-scale, carbon capture systems are commercially unavailable
- Sales may have weakly positive impacts in this setting if the "capture/no capture" decision is unavailable and assets flow to better users
- Implications: Think about asset's emissions function when signing the effect of public to private transfers

Summary

- Looked for evidence on the following operating decisions that determine emissions
  - turn on
  - how much to produce
  - emissions intensity
    - fuel mix
    - productive efficiency
- Evidence suggesting that **innocuous, not perverse, greenwashing** may have been a concern in this sample
- Decreases in the emission intensity at coal-fired (but not gas-fired plants) driven by improvements in productive efficiency. But effects very modest!

Outline

Data

Data Sources

- **Datasets covered previously**
- **Center for Research in Security Prices (CRSP)**
  - U.S. firm stock prices, factor returns, risk-free rates from 2000-2022

Deal Counts

Sale Type	Deal Count: Asset Purchases Only
Public to Public	62
Public to Private	91
All	153

Empirical Model

- **Methodology:** Event study
- **Parameter of interest:** Cumulative abnormal returns around plant sale announcements for asset sales (excl. M&A)
- **Event window:** 11 day symmetric window

Empirical Model

- **Return model:** Carhart four-factor model

$$
\begin{aligned}
AR^i_{t-1,t} &\equiv r^i_{t-1,t} - \mathbb{E}_{t-1}(r^i_{t-1,t}) \\
&= (r^i_{t-1,t} - r^{Risk-free}_{t-1,t}) \\
&- (\alpha^i + \beta_1 f^{Market}_{t-1,t} + \beta_2 f^{SMB}_{t-1,t} + \beta_3 f^{HML}_{t-1,t} + \beta_4 f^{Mom}_{t-1,t})
\end{aligned}
$$

  - f^{Market} : Market excess return
  - f^{SMB} : Size factor
  - f^{HML} : Book-to-market factor
  - f^{Mom} : Momentum factor

Empirical Model

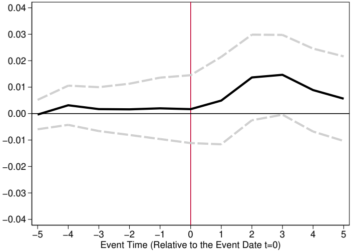
Question

What are public to private sale effects on seller valuations?

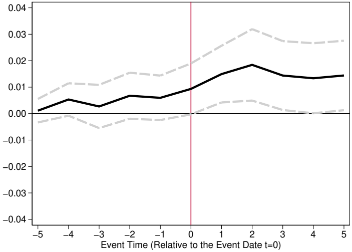
Findings

- Public seller experiences cumulative abnormal returns of 1.4% around announcement
- Difference in returns from announcing sales to private versus public firms is **statistically indistinguishable from zero**

Positive Cumulative Abnormal Returns



(a) Publicly Traded to Publicly Traded



(b) Publicly Traded to Private

Empirical Model

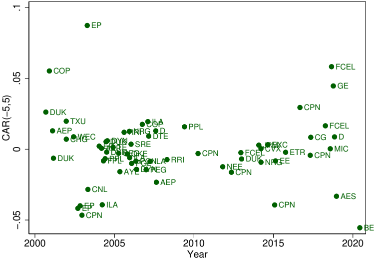
Question

What are public to private sale effects on seller valuations?

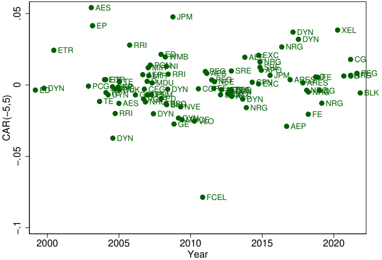
Implication

- No incentive to sell to more opaque operators

Time Series



(c) Public to Public



(d) Public to Private

Emissions

Additional Analyses

Robustness

- Weighing observations by nameplate
- Shortening, and lengthening event window
- Including M&A

Motivation

Question

What is the effect on dirty asset ownership and emissions public, but not private, firms are shocked with higher costs of emitting?

Model

- General equilibrium model

Firms

- Two firm types in unit continuum: public and private firms
  - Identical endowments of production technologies
  - Private cost of emitting
- Private firm variables denoted by tilde

Firms

Endowments

- Each firm is endowed with two types of assets–a zero-marginal cost, clean asset (e.g. wind, solar)–and a dirty asset. Assets are indexed by $f \in \{C, D\}$
- No firm entry or asset creation
- Asset f takes input x_f and produces final goods output y_f and emissions e_f

Firms

Asset Types

- Assets have capacity constraints and production functions

$$y_C \equiv min(x_C^{1/2}, \bar{np}_C),$$
$$y_D \equiv min(x_D^{1/2}, \bar{np}_D)$$

  - np_C: clean asset's capacity constraint
  - np_D: dirty asset's capacity constraint

- Emissions function

$$e_C = 0,$$
$$e_D = x_D.$$

Firms

Optimization Problem

- Firm i chooses input demands x_C^i, x_D^i to maximize

$$\max_{\{x_C, x_D\}} \underbrace{py_C^i + py_D^i}_{Revenue} - \underbrace{cx_D^i}_{Cost\,of\,Inputs} - \underbrace{\phi^i x_D}_{Cost\,of\,Emitting}$$

$$s.t.\, py_C^i + py_D^i - cx_D^i - \phi^i x_D^i \geq 0,$$

  - c: dirty asset input price, exogenous
  - p: final goods price, as if exogenous
  - ϕ^i : cost of emitting, exogenous

Representative Consumer

Aggregate Demand Function

- Aggregate demand function is

$$d = \bar{a} - bp, \tag{1}$$

  where b determines the elasticity of demand and $\bar{a}, b > 0$
- Assume clean assets are operating at maximum capacities; and the dirty asset is the marginal asset and never at capacity.

Timing

1. Public and private firms are ex-ante identical. They begin with identical endowments and costs of emitting.
2. Public (but not private) firms experience an unanticipated positive shock Φ to their cost of emitting
$$\Phi \equiv \frac{\phi}{\tilde{\phi}} > 0.$$
3. Firms trade assets.
4. Firms demand inputs, produce the final good and emissions as a byproduct, and sell in the final goods market.

Trading

- Key Assumption: Within a firm type, firms have **symmetric** beliefs and strategies
  - each firm believes that if its type finds it individually profitable to sell all firms of its type will sell
- Relative bargaining power of public firms is fixed and parameterized by $\lambda \in (0,1)$.

Equilibrium

[redacted]

An equilibrium is the set of ownership choices, input demands, production quantities, and the final goods price $\{s^*, x^*, \tilde{x}^*, y^*, \tilde{y}^*, p^*\}$ such that shocked firms and unshocked firms maximize their private firm values and the final goods market clears.

Summary

- There can be multiple equilibria
  - Greenwashing Equilibrium
  - No Trade Equilibrium
  - Impact Equilibrium
- Prevailing equilibrium will be pinned down by the final good's **demand elasticity**

Summary

Equilibrium	Asset Flow	Demand Elasticity	Change in Emissions of Public Firm's Initial Dirty Asset	
			Baseline	
			Pre-shock	No Trade
Greenwashing	Public to Private	High	0	$\uparrow$
No Trade	-	Medium	$\downarrow$	0
Impact	Private to Public	Low	$\downarrow$	0

- The emissions consequence is sensitive to the **choice of the baseline** for emissions, which may be an unobservable counterfactual.

Aggregate Implications

Greenwashing Equilibrium

- The equilibrium of interest and of anecodotal relevance
- Occurs when final goods demand is elastic
- Shocking a subset of firms with higher costs of emitting leads to sales with zero emissions impacts
  - Consistent with the empirical results we observe
- ESG strategies that are
  - intended to reduce aggregate emissions, and
  - that mimick this shock

  may be ineffective when there is trading assets.

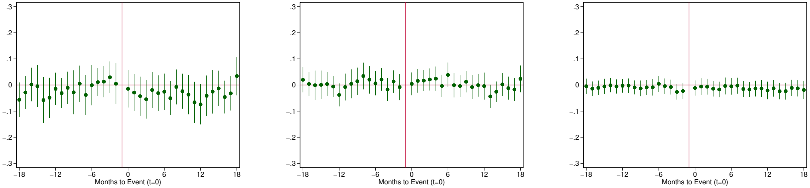
Conclusion

- My paper was motivated by concerns that pressure on public firms to undertake firm-level reductions in emissions incentivize public to private sales
  - that lead to near zero changes to or increases in emissions, and
  - financially rewards public sellers **above and beyond** public to public sales.
- Empirical
  - I find **no evidence to support these hypotheses** after examining public sales in the past two decades using unit level emissions data at the weekly frequency in an asset class that generates 25% of US emissions
- Theoretical
  - I show that **innocuous greenwashing by public firms can occur** in a competitive equilibrium when public firms are shocked with higher costs of emitting
  - Emissions impacts are going to depend on the emissions baseline which can be an unobserved counterfactual

Conclusion

- How can we align corporate behavior with the mitigation of climate change and its harms?
- ESG pressure on public firms to reduce emissions **at the firm-level**
- With trading in assets, pressure may have near-zero emissions impacts
- Goal is net zero

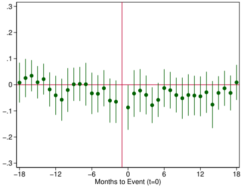
Dynamic DID for Public to Public



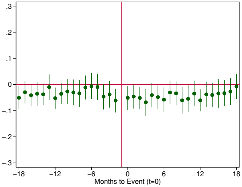
(a) Starts (b) Capacity Factor (c) Emissions Intensity

Back

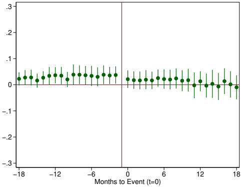
Dynamic DID for Public to Private



(a) Starts



(b) Capacity Factor



(c) Emissions Intensity

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Divestment Effects

Divestment Effects by Fuel Type

- Divestment effects generally insignificant except for emissions intensity effects on coal units and starts for gas units sold to private buyers

	Panel A. Point Estimates		
	By Fuel		
	Starts (1)	Capacity Factor (2)	$ln(E.\,Intensity)$ (3)
$Post \times Public\,Buyer \times Coal\,Unit$	-0.026	-0.008	-0.013*
	(0.019)	(0.012)	(0.007)
$Post \times Private\,Buyer \times Coal\,Unit$	0.019	-0.007	-0.041**
	(0.029)	(0.022)	(0.020)
$Post \times Public\,Buyer \times Gas\,Unit$	-0.011	-0.003	-0.010
	(0.018)	(0.012)	(0.016)
$Post \times Private\,Buyer \times Gas\,Unit$	-0.031*	-0.011	0.003
	(0.019)	(0.014)	(0.018)
	Panel B. Regression Statistics		
Observations	356,704	273,278	273,278
R-squared	0.40	0.72	0.93
	Panel C. Wald Test P-Value, H_0 : $(Post \times Public) = (Post \times Private)$		
Coal	0.19	0.99	0.18
Gas	0.39	0.62	0.64

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Selection

Average Marginal Effects	$P(Public\,Seller)$	$P(Private\,Buyer\,|\,Public\,Seller)$
	(1)	(2)
Gas unit	0.149***	0.323***
	(0.041)	(0.057)
Combined cycle	-0.148***	-0.012
	(0.029)	(0.040)
Nameplate quartile	0.011	0.071***
	(0.014)	(0.020)
Age quartile	0.057***	-0.101***
	(0.014)	(0.018)
In deregulated retail electricity state	-0.085***	0.156***
	(0.024)	(0.033)
Pseudo R-squared	0.04	0.16

Co-firing

Dependent Variable: Burned Secondary Fuel	Coal (1)	Gas (2)
Post × *Public Buyer*	0.014	0.004
	(0.014)	(0.003)
Post × *Private Buyer*	0.000	-0.044
	0.000	(0.039)
Observations	15,493	88,685
R-squared	0.59	0.80
R-squared contribution	0.00	0.01
Wald Test P-value	0.32	0.23

Notes: Of divested units sold to public buyers, 33% of coal-fired units (48 units) and 49% of gas-fired units (96 units) were able to co-fire; Of those divested to private buyers, 13% of coal-fired units (2 units) and 29% of gas-fired units (76 units) were able to co-fire.

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Results

Decomposition of Emissions Intensity Change

- Do the following decomposition by modifying regression to take out effects of fuel mixing

$$\underbrace{\Delta ln(\frac{CO_2}{Generation})}_{\Delta Emissions\, Intensity} = \underbrace{\Delta ln(\frac{CO_2}{Heat\ Input})}_{\substack{\Delta Reporting\, / \\ Fuel\ Subtype}} - \underbrace{\Delta ln(\frac{Generation}{Heat\ Input})}_{\substack{\Delta Productive \\ Efficiency}} + \Delta Fuel\ Mix$$

Results

Decomposition of Emissions Intensity Change

Specification

$$
\begin{aligned}
y_{it} = \quad & \beta_1 (Post \times Public\,Buyer)_{it} \\
+ \quad & \beta_2 (Post \times Private\,Buyer)_{it} \\
+ \quad & X_{it} + \alpha_i + \eta_{it}
\end{aligned}
$$

Independent Variables

X_{it}: State $\times$Electricity Region $\times$ Fuel Set $\times$ Week $\times$ Year FE

Results

Decomposition of Emissions Intensity Change

Specification

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\begin{aligned}
y_{it} = \quad & \beta_1 (Post \times Public\,Buyer)_{it} \\
+ \quad & \beta_2 (Post \times Private\,Buyer)_{it} \\
+ \quad & X_{it} + \alpha_i + \eta_{it}
\end{aligned}
$$

Independent Variables

X_{it}: State $\times$ Electricity Region $\times$ **Primary and Secondary Fuel Burned** $\times$ Combined cycle $\times$ Week $\times$ Year FE

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Decomposition

What might explain emissions intensity reductions at coal fired plants ?

- Selection of assets that would have improved on their own
  - Physical assets tend towards depreciation
- Pre-sale effect: sellers forgot maintenance and let assets depreciate
  - Possible, but effect persists when we expand horizon to five years
- Selection of relatively emissions intense units to improve
  - Coal units sold to private and public had emissions rates that were 5.7% and 0.8% higher vis-a-vis comparables, respectively, in the pre-divestment period.
  - Imprecise estimates

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Pre-Sale Dummies

	$ln(Emissions\,Intensity)$	$ln(Heat\,Rate)$
	(1)	(2)
$Pre \times Public\,Buyer \times Coal\,Unit$	0.008	0.008
	(0.015)	(0.015)
$Pre \times Private\,Buyer \times Coal\,Unit$	0.057	0.029
	(0.055)	(0.047)
$Pre \times Public\,Buyer \times Gas\,Unit$	0.016	0.031
	(0.023)	(0.022)
$Pre \times Private\,Buyer \times Gas\,Unit$	0.043	0.048*
	(0.026)	(0.026)
Sample		
Observations	273,278	273,278
R-squared	0.80	0.54
R-squared contribution	0.00	0.01
Wald Test P-value		
Coal	0.41	0.67
Gas	0.43	0.59

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Heterogeneity

		Starts	Capacity Factor	$ln(E.Intensity)$
In Post-COP21 Period	ME	0.02	0.01	0.02
	Test P-value	0.05	0.92	0.42
Seller Mentioned Environmental Concerns	ME	-0.02	-0.06**	0.02
	Test P-value	0.73	0.01	0.06
Green Buyer	ME	0.04	0.03	-0.01
	Test P-value	0.70	0.61	0.86
Private Equity Buyer	ME	0.03	0.01	-0.03
	Test P-value	0.99	0.99	0.77
In Regulated State	ME	-0.02	0.02	0.01
	Test P-value	0.34	0.06	0.40
In Cap and Trade State	ME	0.06*	-0.02	0.04*
	Test P-value	0.01	0.59	0.06
Marginal Unit	ME	0.00	-0.02	-0.01
	Test P-value	0.51	1.00	0.62
Old Unit	ME	0.03	-0.04	-0.02
	Test P-value	0.49	0.08	0.80
Large Unit	ME	-0.02	-0.02	-0.04
	Test P-value	0.03	0.07	0.80

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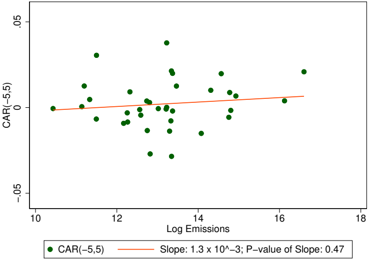
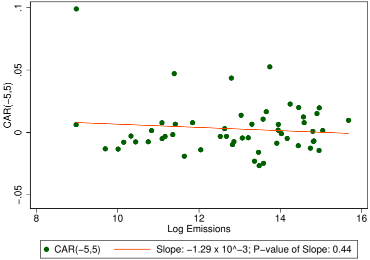
Cross Section



(d) Public to Public



(e) Public to Private

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Preview of Findings

Theoretical: Model Insights

Equilibrium	Asset Flow	Demand Elasticity	Change in Emissions (Traded Asset, Aggregate)	
			Baseline	
			Pre-shock	No Trade
Greenwashing	Public to Private	High	0,0	↑,↑
No Trade	-	Medium	↓,↓	0,0
Impact	Private to Public	Low	↓,↓	0,↓

- The emissions consequence is **equilibrium-dependent** and sensitive to the **choice of the baseline** for emissions, which may be an unobservable counterfactual.

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