Corporate Taxation and Carbon Emissions

Luigi Iovino (Bocconi)

Thorsten Martin (Frankfurt)

Julien Sauvagnat (Bocconi)

May 2024

Climate & Biodiversity Conference

Research Question

Is there an environmental bias in corporate income taxation?

- If so, through which mechanism?
- Does it matter quantitatively for carbon emissions?

This Paper

- Estimates tax advantage for carbon-intensive firms

  $\Rightarrow$ lower fraction of their gross earnings is taxed

  $\Rightarrow$ works through debt tax shield

- Estimates causal impact of corporate income tax cuts

  $\Rightarrow$ disproportionately benefits clean firms

  $\Rightarrow$ leads to relative decline in carbon intensity

- Builds GE multi-sector model (calibrated to US economy)

  $\Rightarrow$ Today: clarifies mechanism

Empirical Analysis

Data

- Firms' balance sheet and income statement data
  - Compustat North America Fundamentals
  - Exclude financials
- Carbon emissions at the firm level from Trucost

▸ Coverage

  - covers 70% of publicly listed U.S. firms
  - 90% of their aggregate assets
  - sample period: 2004-2021

Descriptive Statistics

	Compustat Firms (U.S.) (Obs=11,322)				
	Mean	SD	p1	p50	p99
Carbon Emissions					
Carbon/Sales (tonnes of CO_2 per k. Sales)	0.099	0.361	0.000	0.017	1.449
Taxes paid by U.S. corporations					
Taxes/Capital Income	0.121	0.092	-0.063	0.111	0.412
Taxes/Pretax Income	0.234	0.184	0.000	0.209	1.000
Other Variables					
Sales (in USD Million)	11,345	30,850	116	3,282	139,865
PPE/Assets	0.229	0.192	0.015	0.168	0.843
Debt/Assets	0.276	0.185	0.000	0.258	0.874

Sample restricted to firms with positive pretax income

Taxes are corporate income taxes paid
Capital Income is Sales - cost of goods sold - selling, general and admin. expenses

Baseline Specification

Pooled OLS regressions at the firm f-year t level:

$$\textit{Taxes/Capital Income}_{f,t} = \beta \times \textit{Carbon/Sales}_{f,t} + \textit{Controls}_{f,t} + \gamma_t + \epsilon_{f,t}$$

- if $\beta < 0$, emission-intensive firms pay less taxes on their gross earnings

  Note: not interpreted in a causal sense

- Controls: profitability, size, age, firm-level statutory tax rates, foreign share pretax income, tax loss carry forward

- Standard errors clustered at firm level

Carbon Emissions and Corporate Taxes

	Taxes/Capital Income		Taxes/Pretax Income		Pretax Income/Capital Income	
Carbon Intensity	-0.021***	-0.023***	-0.013	-0.014	-0.050***	-0.055***
	(0.006)	(0.006)	(0.011)	(0.010)	(0.009)	(0.010)
Year FE	Y	Y	Y	Y	Y	Y
Firm Controls	N	Y	N	Y	N	Y
R^2	0.050	0.114	0.011	0.054	0.036	0.113
N	11322	11322	11322	11322	11322	11322

1 standard deviation in Carbon Intensity associated with $\approx$ 10% decline in effective tax rates on gross earnings.

▸ Robustness ▸ Leave-one-out industry

Carbon Emissions and Debt Tax Shield

	Dependent variables scaled by Capital Income					
	Debt		Interests		Pretax Inc. + Interests	
Carbon Intensity	0.749***	0.736***	0.059***	0.059***	0.009	0.004
	(0.099)	(0.100)	(0.006)	(0.006)	(0.008)	(0.010)
Year FE	Y	Y	Y	Y	Y	Y
Firm Controls	N	Y	N	Y	N	Y
R^2	0.095	0.149	0.066	0.122	0.019	0.135
N	11322	11322	11322	11322	11322	11322

Carbon bias of corporate taxation explained by debt tax shield

What Explains Higher Leverage in Dirty Firms?

	Dependent variables scaled by Capital Income			
	PPE	Debt	Pretax Income	Taxes
Carbon Intensity	1.892***	0.000	0.001	-0.004
	(0.282)	(0.145)	(0.010)	(0.005)
PPE/Capital Income		0.389***	-0.030***	-0.010***
		(0.026)	(0.003)	(0.001)
Year FE	Y	Y	Y	Y
Firm Controls	Y	Y	Y	Y
R^2	0.180	0.280	0.161	0.144
N	11322	11322	11322	11322

Asset tangibility explains carbon bias of corporate taxation

▸ Energy sector

Decomposing Tangible Capital into Different Items

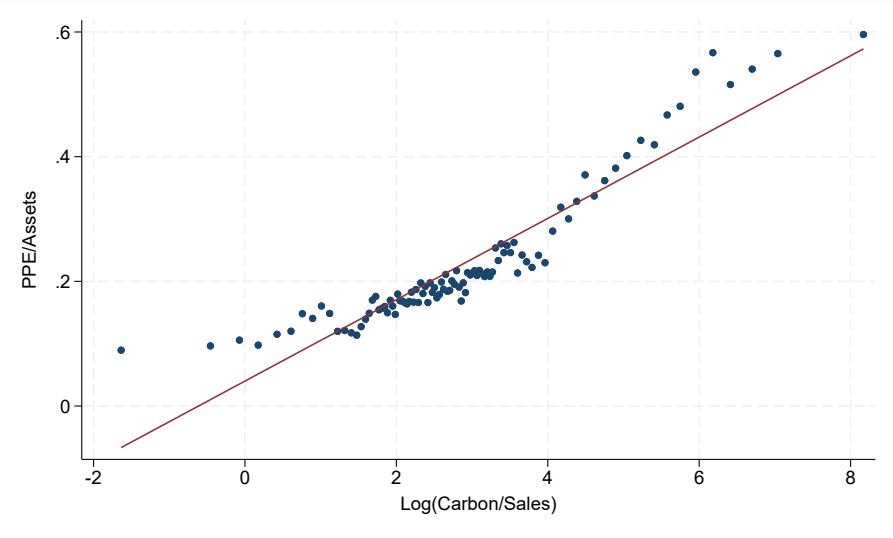
	Dependent variables scaled by Total Assets						
	Gross PPE	Machinery	Buildings	Leases	Land	ConstrInProg	Other
Carbon Intensity	0.408***	0.362***	0.009	-0.018***	0.010*	0.015***	0.002
	(0.081)	(0.069)	(0.010)	(0.004)	(0.005)	(0.005)	(0.003)
Year FE	Y	Y	Y	Y	Y	Y	Y
Firm Controls	Y	Y	Y	Y	Y	Y	Y
R^2	0.119	0.172	0.041	0.115	0.030	0.068	0.029
N	7504	7504	7504	7504	7504	7504	7504
Dep Var Mean	0.455	0.276	0.093	0.028	0.017	0.012	0.017

Correlation driven entirely by Machines & Equipment

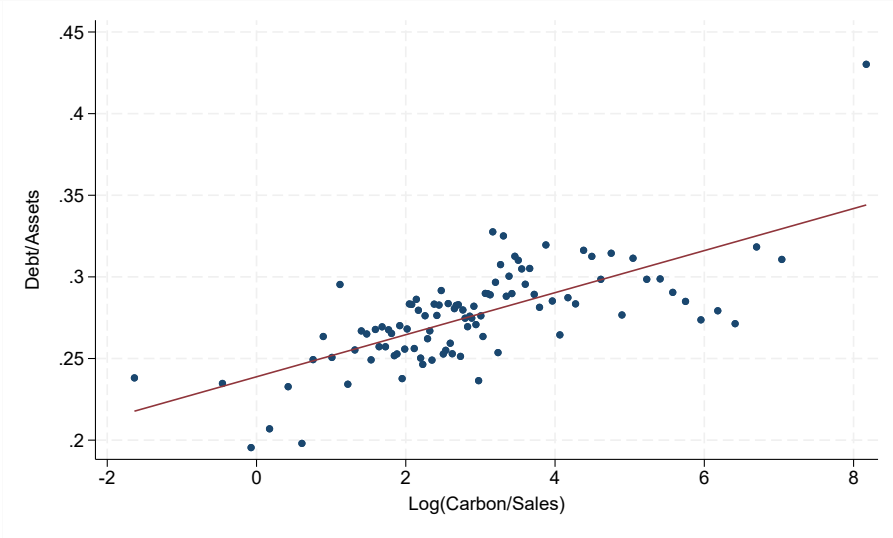
Summing up...

Dirty firms $\Rightarrow$ more tangible assets $\Rightarrow$ higher debt $\Rightarrow$ lower taxes

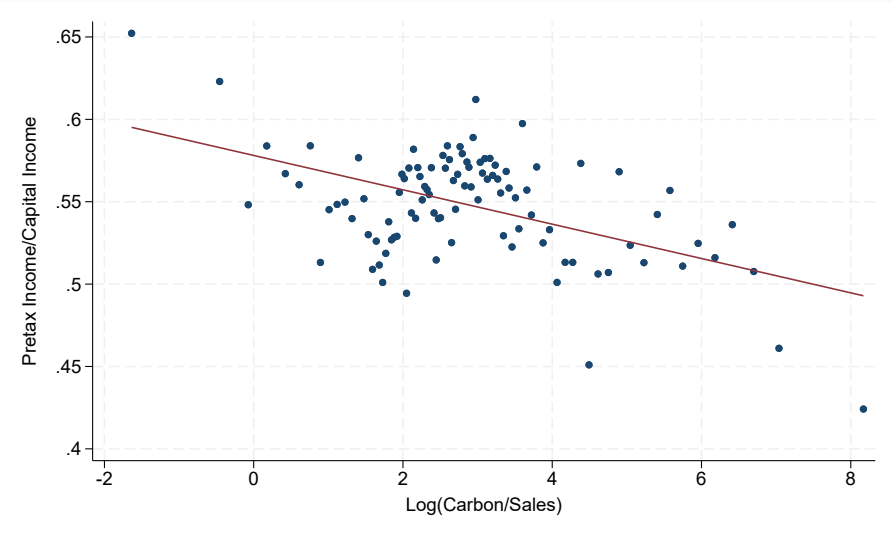
Summing up...



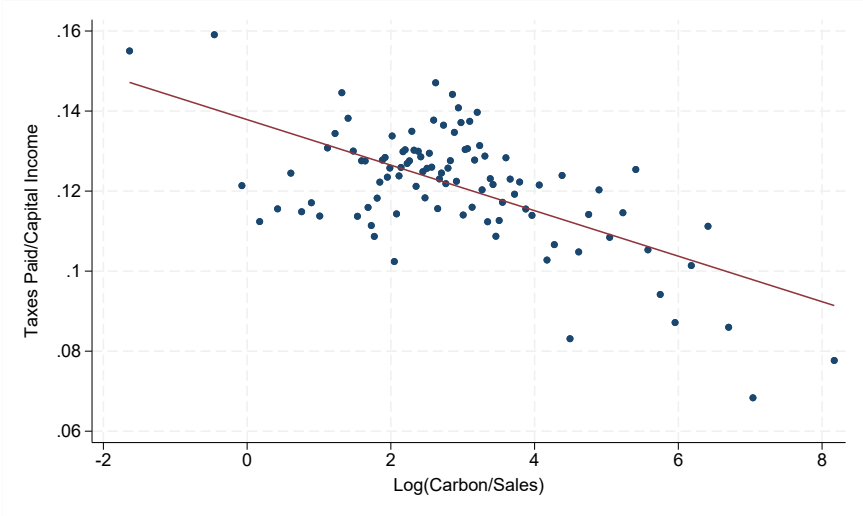
PPE



Debt



Tax Shield



Taxes Paid

Effects of 2018 Federal Corporate Income Tax Cut

Event-Study Specifications

- For identification: Tax Cuts and Jobs Act (2018)

  $\Rightarrow$ Decline in federal corporate income tax rate from 35% to 21%

  ▸ Background

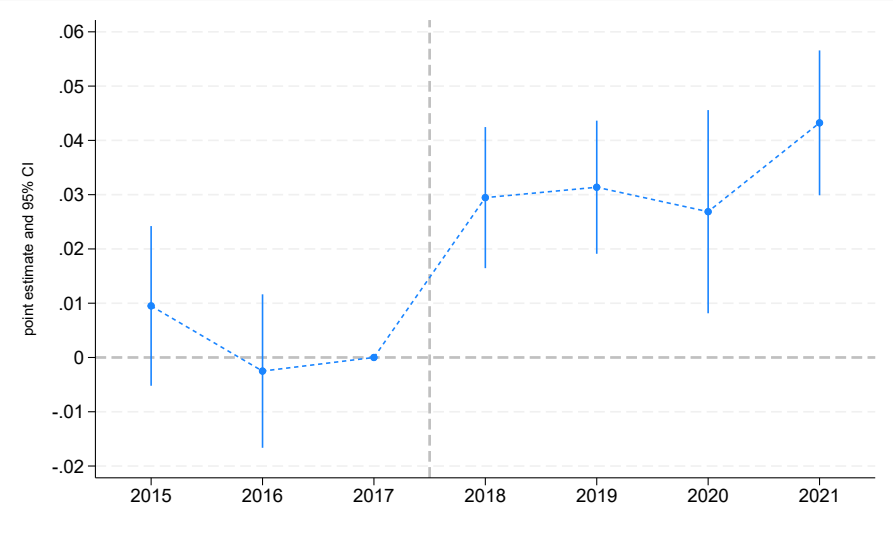
- Estimates effects on taxes of dirty firms vs. other firms.

- Event-study specification:

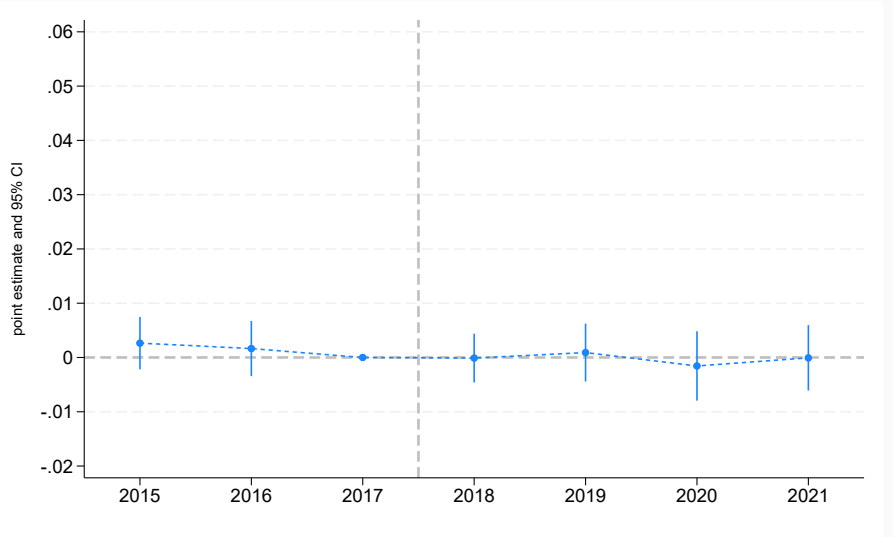
$$Taxes/Capital\ Income_{f,t} = \sum_{\tau \neq 2017}^{2021} \beta_\tau \times Year_\tau \times HighCarbon/Sales_{f,2017} + \alpha_f + \gamma_t + \epsilon_{i,t}$$

- Standard errors clustered at firm level

Effects of 2018 Federal Tax Cut on Taxes Paid

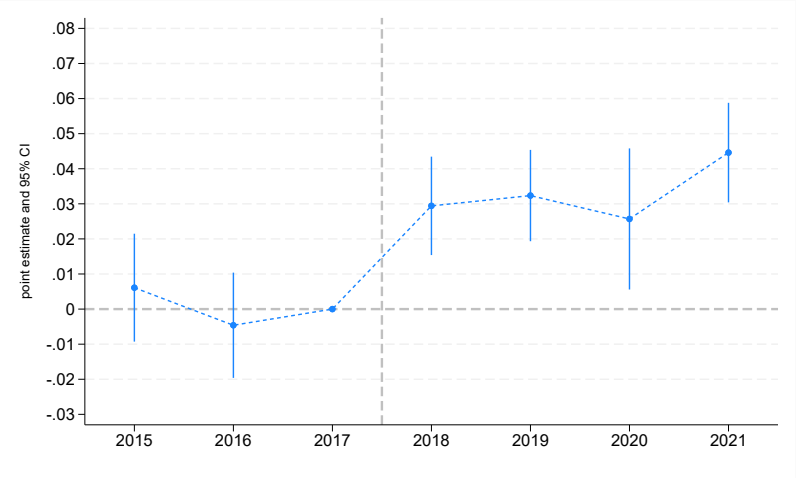


Federal Taxes

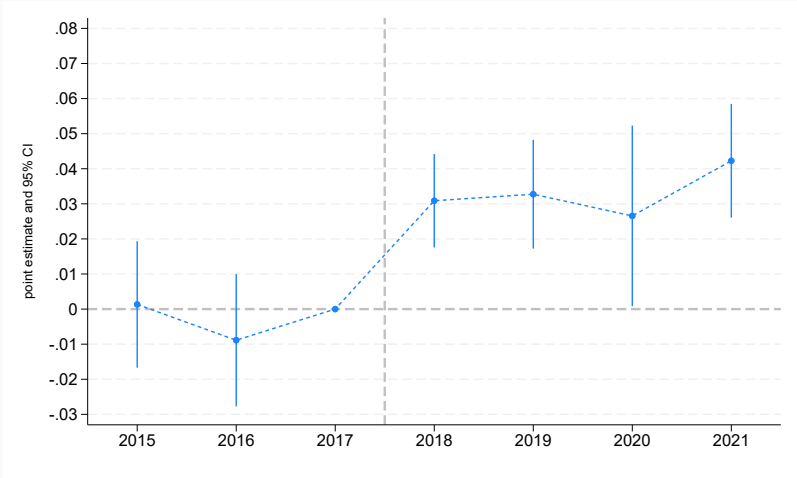


Other Profit Taxes

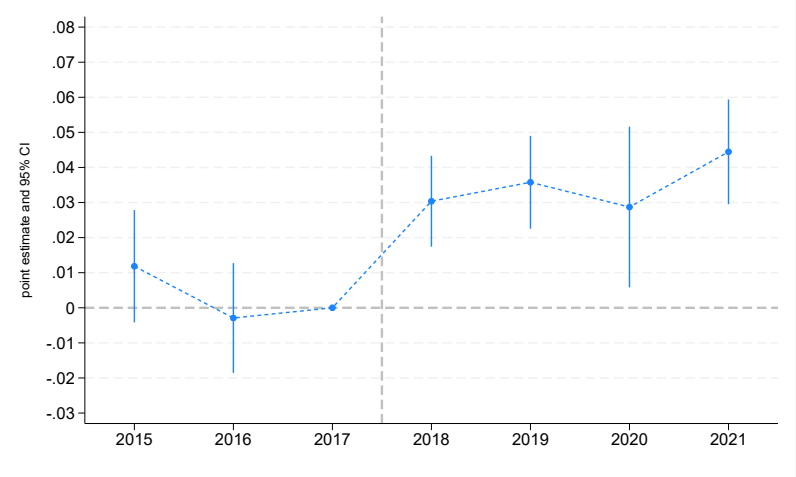
Effects of 2018 Federal Tax Cut on Taxes Paid



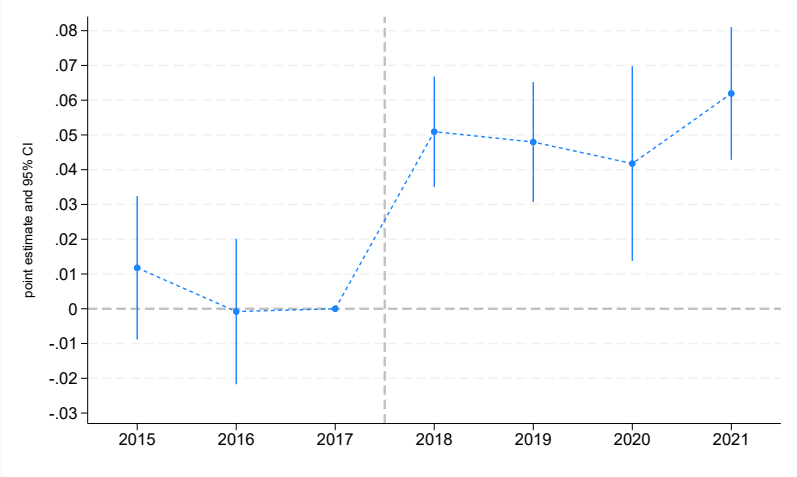
Excl. Firms with Interests> 0.3 EBITDA



Excl. Multinationals



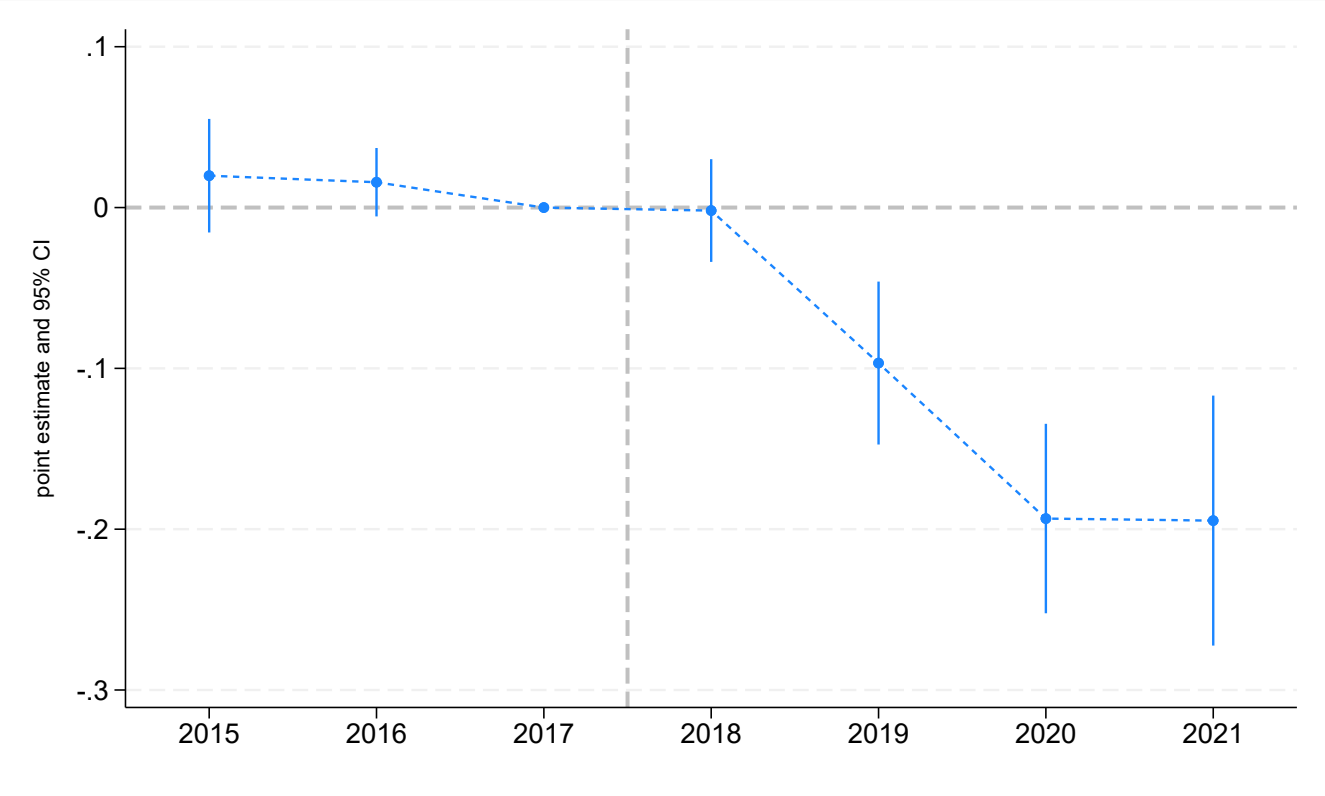
Excl. R&D-Intensive Firms



Excl. Firms Carrying Forward Losses

Effects of 2018 Federal Tax Cut on Asset Growth

Dependent variable is $Asset_t / Asset_{2017}$



Carbon Intensity of US versus Foreign Firm

- Compare US-Based vs. Foreign-Based Firms (G20)

  G20 countries without change in statutory tax rate over sample period: Australia, Brazil, Canada, China, Germany, Japan, Mexico, Russia, Saudi Arabia, South Africa

- Estimate effects on carbon intensity in event-study specification:

$$Carbon/Sales_{i,t} = \sum_{\tau \neq 2017}^{2021} \beta_\tau \times Year_\tau \times US_i + \alpha_i + \gamma_{s,t} + \epsilon_{i,t}$$

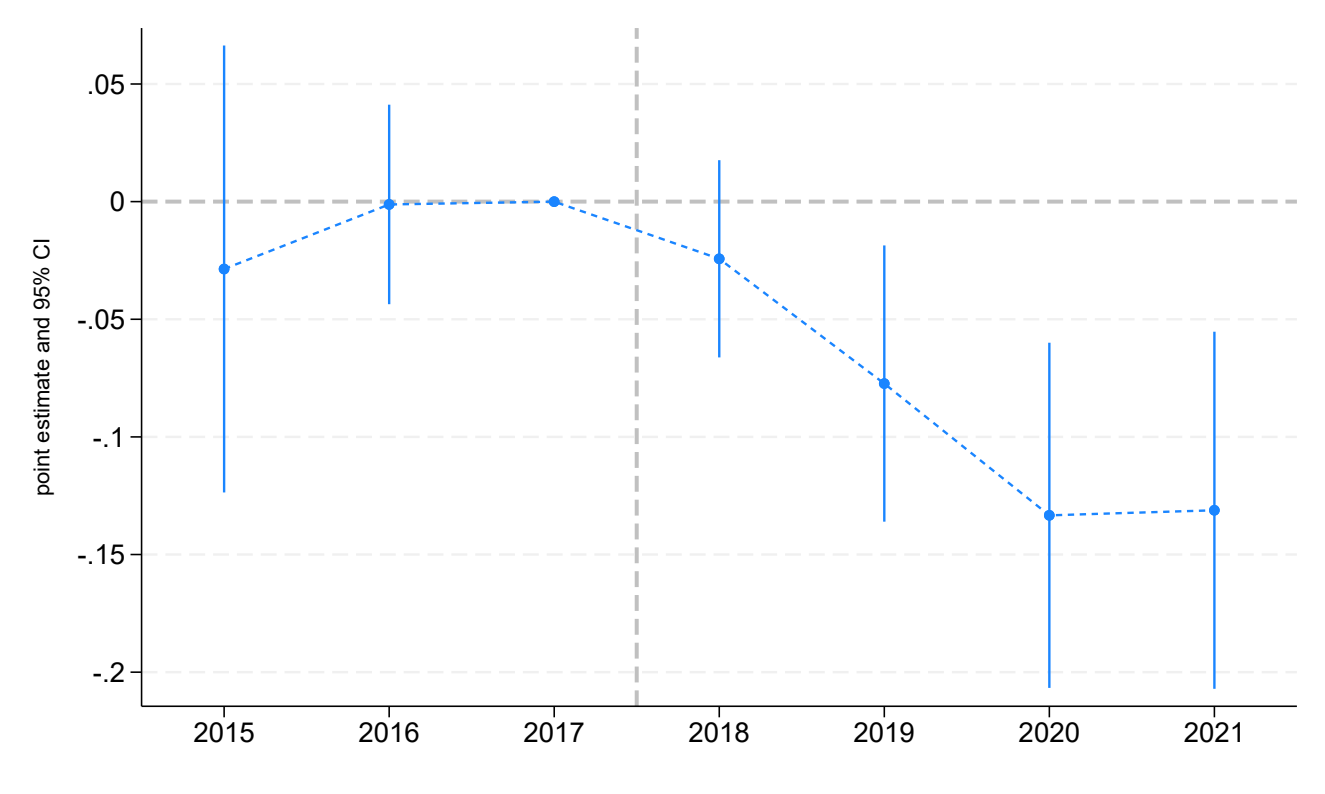
- $Carbon/Sales_{i,t}$ Scaled by its value in 2017

- Include industry-year FEs

- Standard errors clustered at firm level

Carbon Intensity of US versus Foreign Firms

Relative decline by around 10% for US firms.



▸ Robustness

The Model

The Model: Households

Representative Household

- consumes $C_t \equiv \prod_{i \in \mathcal{N}} c_{i,t}^{\theta_i}$ with $c_{i,t} \equiv \left(\int_0^1 c_{f,t}^{\frac{\sigma_i - 1}{\sigma_i}} \, dH(f|i) \right)^{\frac{\sigma_i}{\sigma_i - 1}}$

  $\rightarrow$ pays sales tax τ_c

- supplies labor L_t and receives wage w_t

  $\rightarrow$ pays income tax τ_h

- invests in three types of assets:
  - risk-free government bonds $\rightarrow$ pays income tax τ_h
  - risky corporate bonds $\rightarrow$ pays income tax τ_h
  - equity $\rightarrow$ pays dividend tax τ_d

- preferences: $\frac{1}{1-\varphi} C_t^{1-\varphi} - \frac{\epsilon}{1+\epsilon} L_t^{1+\frac{1}{\epsilon}}$

The Model: Firms

Continuum of monopolistic competitive firms in each sector

$\Rightarrow$ Representative Firm (in each sector)

- owned by consumers, maximizes PV of dividends
- issues risky corporate bonds
- hires labor $\ell_{i,t}$
- purchases intermediates $x_{i,j,t}$ from sector j
- owns capital $k^s_{i,t}$ of type $s \in \{\text{structures, equipment, intangibles}\}$
  - law of motion: $k^s_{i,t+1} = (1 - \delta^s_i)k^s_{i,t} + I^s_{i,t}$
  - investment network $\rightarrow I^s_{i,t} \equiv \prod_j (i^s_{ij,t})^{\omega^s_{ij}}$

▸ Networks

The Model: Firms

- Constant-returns-to-scale production function:

$$y_{i,t} = \mathcal{Y}_i \left(z_i, \{x_{i,j,t}\}_j, \ell_{i,t}, \{k^s_{i,t}\}_s \right),$$

- Using fuel in production generates carbon emissions:

$$E_{i,t} \equiv \sum_{j \in \mathcal{N}^F} e_j x_{i,j,t}$$

  with e_j the emission rate of input j in the fuel set $\mathcal{N}^F$ (coal, oil, gas).

- Profit tax τ_p on capital income

  after deductibles: R&D, depreciation, interest payments

The Model: Default

Default

In every period, random fraction of firms defaults:

- some firms are restructured (only debt-holders receive payment)
- other firms are liquidated (no creditor receives payment)

$\Rightarrow$ Debt and equity are risky

Leverage

Firms issue debt $b_{i,t+1}$ subject to

$$b_{i,t+1} \leq \frac{1}{1 + r^b_{i,t+1}} \sum_{s \in \mathcal{S}} \psi_{i,s} q^s_{i,t+1} k^s_{i,t+1}$$

$\Rightarrow$ Fraction $\psi_{i,s}$ is capital and sector specific

▸ Calibration

Mechanism - Rental rate of capital

Rental rate of type-s capital

$$R_i^s \equiv \delta_i^s + r_i^b \frac{\psi_{i,s}}{1 + r_i^b} + \frac{1}{1 - \tau_p} r_i^e \left(1 - \frac{\psi_{i,s}}{1 + r_i^b}\right)$$

If the corporate tax decreases, from τ_p to $\tilde{\tau}_p$, the rental rate decreases by:

$$\Delta R_i^s = -\frac{\tau_p - \tilde{\tau}_p}{(1 - \tau_p)(1 - \tilde{\tau}_p)} r_i^e \left(1 - \frac{\psi_{i,s}}{1 + r_i^b}\right).$$

$\Rightarrow$ smaller decline for capital with high pledgeability $\psi_{i,s}$

Mechanism - Which sectors benefit the least?

Partial Equilibrium (fix C & prices)

▸ PE vs. GE

($\mathcal{D}_i \equiv$ demand, $\mathcal{C}_i \equiv$ total cost per unit of y_i)

$$d \log y_i = \frac{d \log \mathcal{D}_i(p_i, C)}{d \log p_i} \times \sum_s \frac{d \log \mathcal{C}_i(\{R_i^s\}_s, w, \{p_j\}_j)}{dR_i^s} \times dR_i^s$$

Mechanism - Which sectors benefit the least?

Partial Equilibrium (fix C & prices)

▸ PE vs. GE

($\mathcal{D}_i \equiv$ demand, $\mathcal{C}_i \equiv$ total cost per unit of y_i)

$$d \log y_i = \frac{d \log \mathcal{D}_i(p_i, C)}{d \log p_i} \times \sum_s \frac{d \log \mathcal{C}_i(\{R_i^s\}_s, w, \{p_j\}_j)}{dR_i^s} \times \boxed{dR_i^s}$$

proportional to $\psi_{i,s}$

Mechanism - Which sectors benefit the least?

Partial Equilibrium (fix C & prices)

▸ PE vs. GE

($\mathcal{D}_i \equiv$ demand, $\mathcal{C}_i \equiv$ total cost per unit of y_i)

$$d \log y_i = \frac{d \log \mathcal{D}_i(p_i, C)}{d \log p_i} \times \sum_s \frac{d \log \mathcal{C}_i(\{R_i^s\}_s, w, \{p_j\}_j)}{dR_i^s} \times dR_i^s$$

proportional to $q_i^s k_i^s / p_i y_i$

proportional to $\psi_{i,s}$

Mechanism - Which sectors benefit the least?

Partial Equilibrium (fix C & prices)

▸ PE vs. GE

($\mathcal{D}_i \equiv$ demand, $\mathcal{C}_i \equiv$ total cost per unit of y_i)

$$d\log y_i = \underbrace{\frac{d\log \mathcal{D}_i(p_i, C)}{d\log p_i}}_{\text{demand elasticity}} \times \sum_s \underbrace{\frac{d\log \mathcal{C}_i(\{R_i^s\}_s, w, \{p_j\}_j)}{dR_i^s}}_{\text{proportional to } q_i^s k_i^s / p_i y_i} \times \underbrace{dR_i^s}_{\text{proportional to } \psi_{i,s}}$$

Mechanism - Which sectors benefit the least?

Partial Equilibrium (fix C & prices)

▸ PE vs. GE

($\mathcal{D}_i \equiv$ demand, $\mathcal{C}_i \equiv$ total cost per unit of y_i)

$$d \log y_i = \underbrace{\frac{d \log \mathcal{D}_i(p_i, C)}{d \log p_i}}_{\text{demand elasticity}} \times \sum_s \underbrace{\frac{d \log \mathcal{C}_i(\{R_i^s\}_s, w, \{p_j\}_j)}{dR_i^s}}_{\text{proportional to } q_i^s k_i^s / p_i y_i} \times \underbrace{dR_i^s}_{\text{proportional to } \psi_{i,s}}$$

Which sectors benefit the least?

- Those using more tangible capital
- which are the ones consuming more fuel

Conclusion

- Environmental bias in corporate taxation

  $\Rightarrow$ Debt tax shields subsidize firms with more tangible assets

- Tax cuts have a causal impact on carbon emissions

  $\Rightarrow$ Larger benefits for clean sectors

Counterfactual: No Debt Tax Shield

Remove tax shield of debt $\Rightarrow$ interest no longer deductible

- **Aggregate effects**

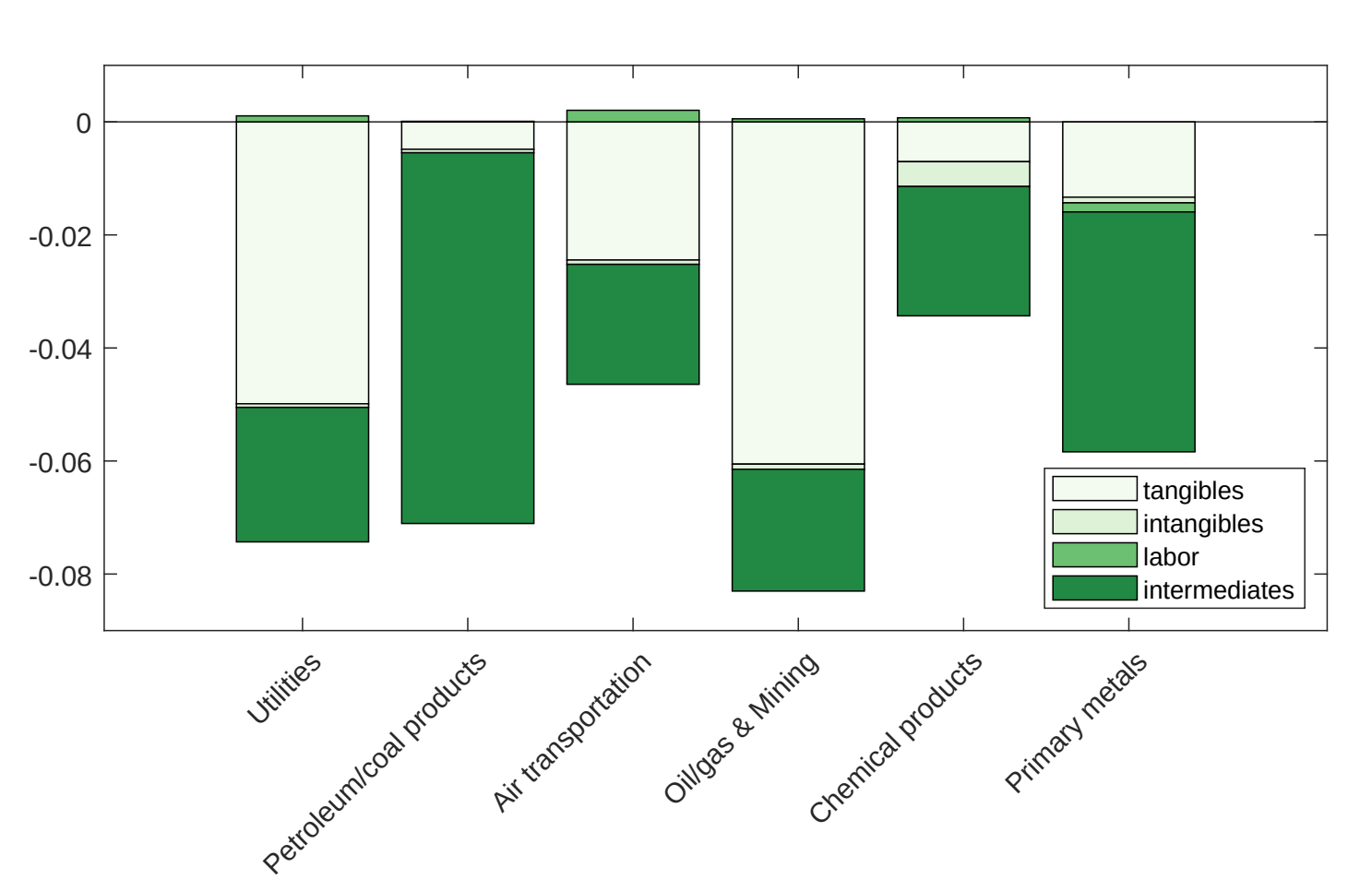
  GDP: -2.12%, consumption: -1.66%

  total emissions: -5.37%

▸ Energy elasticity ▸ Sensitivity

Counterfactual: No Debt Tax Shield

Key result: the most polluting sectors are more affected

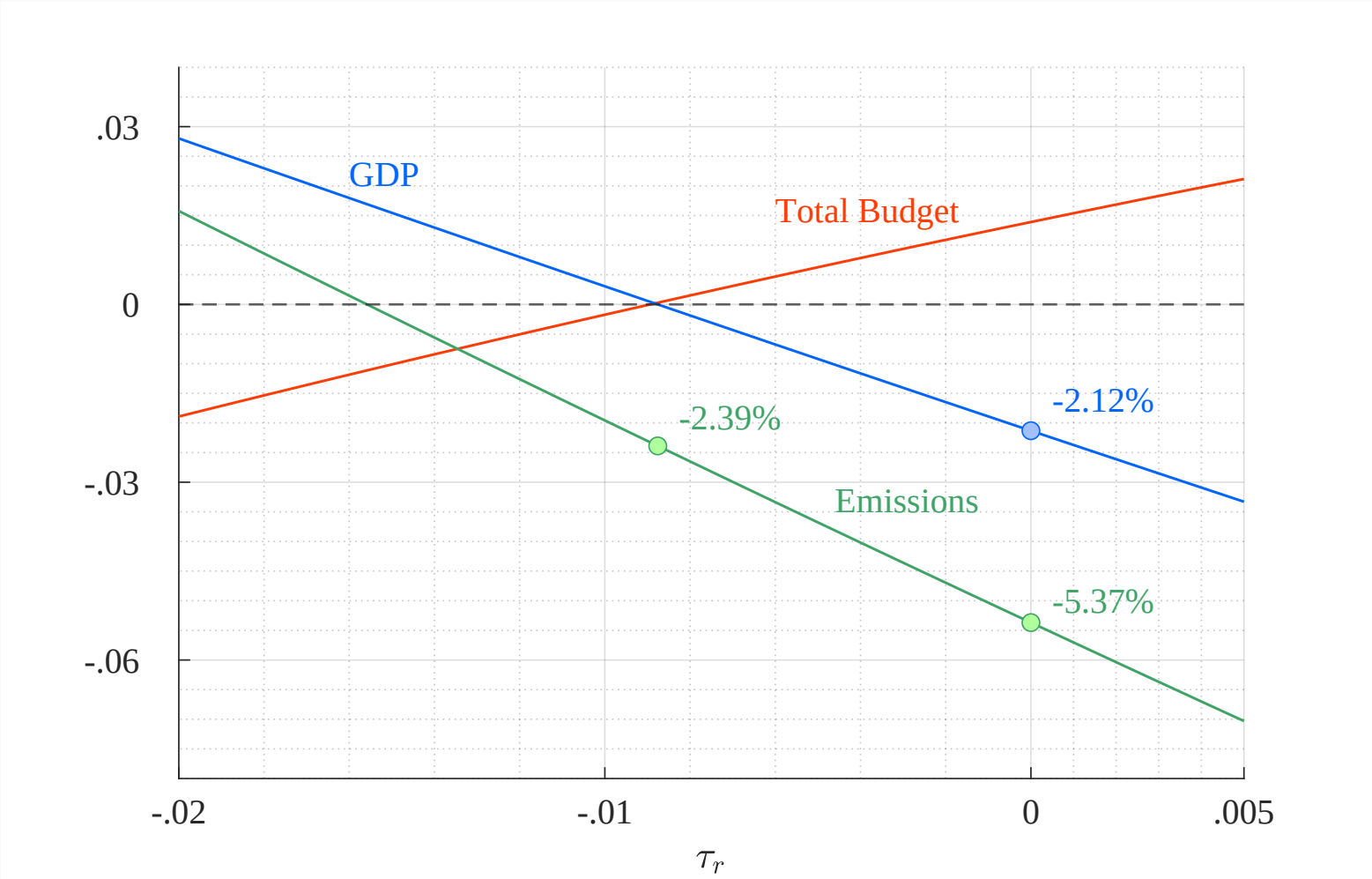


56 BEA sectors in calibration

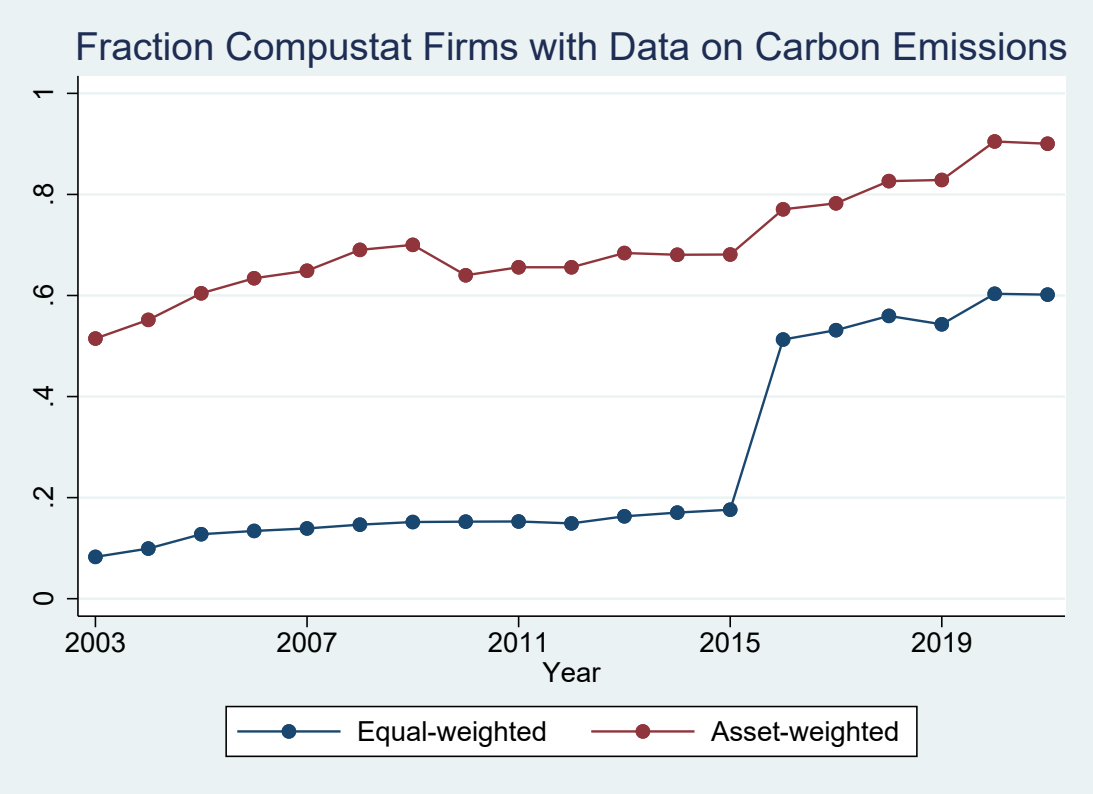
6 sectors above generate more than 85% of aggregate emissions

Offsetting removal of tax shield with revenue subsidy

Output neutral counterfactual: -2% emissions



Coverage of Compustat firms with data on carbon emissions in Trucost



This figure reports the fraction of Compustat firms for which we observe information on carbon emissions in Trucost.

Back

Energy Sector

Panel A:	Carbon Intensity	PPE/Sales	Debt/Sales	Tax Shield per k. Sales	Taxes per k. Sales
Carbon Intensity		0.278***	0.118***	2.648***	-2.898**
(tonnes of CO_2 per k. Sales)		(0.076)	(0.041)	(0.942)	(1.408)
Year FE		Y	Y	Y	Y
Firm Controls		Y	Y	Y	Y
R^2		0.559	0.294	0.335	0.236
N		969	969	969	969
Panel B:	**Carbon Intensity**	**PPE/Sales**	**Debt/Sales**	**Tax Shield per k. Sales**	**Taxes per k. Sales**
Fossil Fuel Capacity	0.609***	0.190***	0.090***	2.262***	-2.748**
(gigawatts per k. Sales)	(0.058)	(0.065)	(0.027)	(0.646)	(1.056)
Year FE	Y	Y	Y	Y	Y
Firm Controls	Y	Y	Y	Y	Y
R^2	0.637	0.448	0.217	0.263	0.246
N	969	1,296	1,296	1,296	1,296

Back

Industry vs. Firm-level Variation

	PPE/Sales	Debt/Sales	Tax Shield per k. Sales	Taxes per k. Sales
Carbon Intensity Industry	0.819***	0.327***	6.861***	-6.978***
	(0.081)	(0.050)	(1.066)	(1.010)
Firm Residual Carbon Intensity	0.241***	0.119***	2.075***	-2.041**
	(0.078)	(0.028)	(0.640)	(0.853)
HQ State x Year FE	Y	Y	Y	Y
Firm Controls	Y	Y	Y	Y
R^2	0.359	0.164	0.213	0.193
N	13,791	13,791	13,791	13,791

- Industry (SIC 4) main driver, but carbon bias also within industry

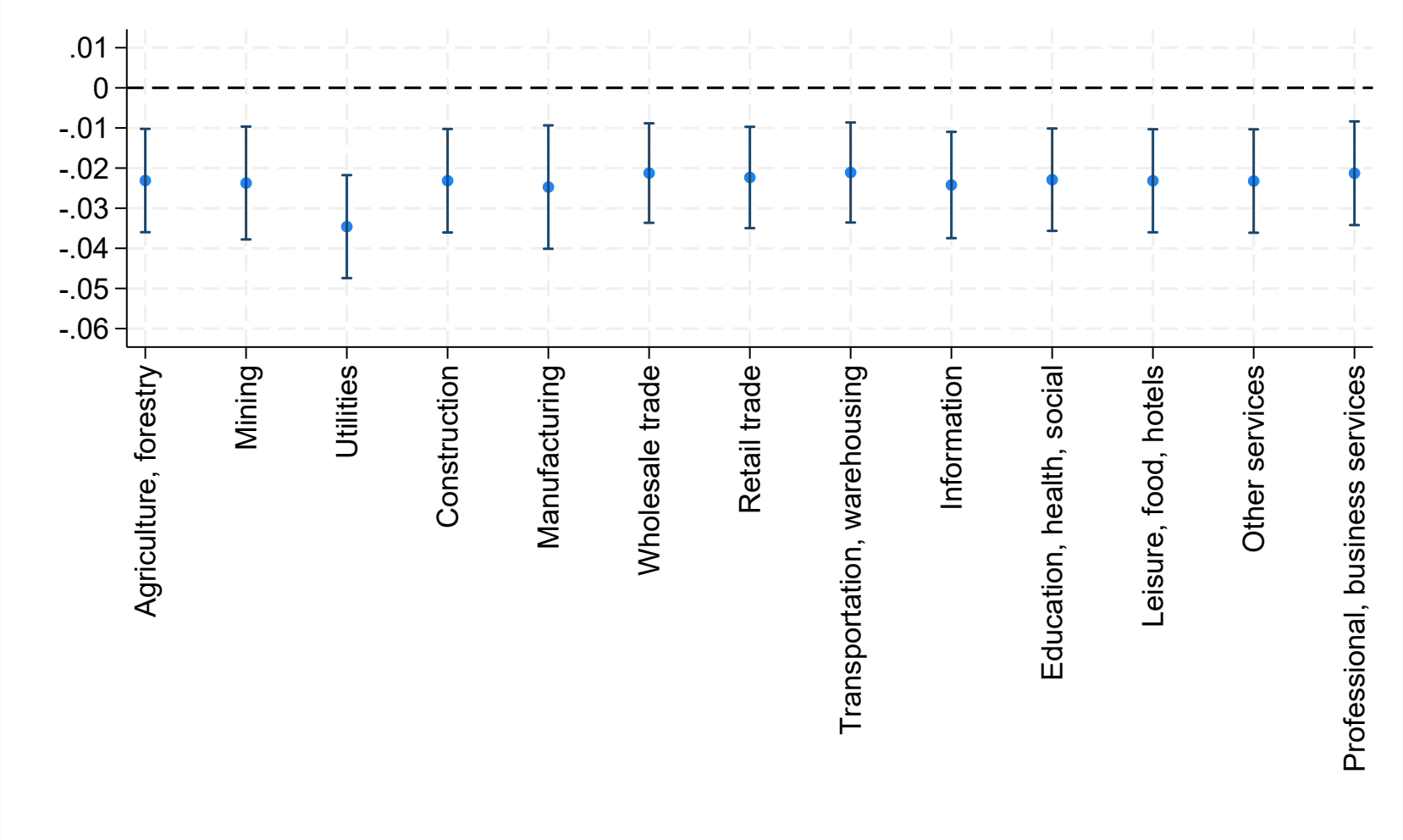
Back

Robustness

	Alternative Measures of Carbon Emissions				Inc. Neg. Profits Firms				
	Estimated	EPA Emissions	Scope 1+2	Scope 1+2+3	Scaled Sales	Scaled Assets	Federal Taxes	Log Spec	1_{Dirty}
Carbon/Sales	-0.037***	-0.031***	-0.033***	-0.025***	-0.004***	-0.006***	-0.026***		
	(0.008)	(0.009)	(0.006)	(0.005)	(0.001)	(0.001)	(0.006)		
Log(Carbon/Sales)								-0.006***	
								(0.001)	
1_{Dirty}									-0.032***
									(0.006)
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y
r2	0.117	0.098	0.118	0.117	0.018	0.146	0.181	0.117	0.116
N	6936	8573	11322	11322	14505	14505	10506	11316	11322

Back

Leave-one-out



Back

Carbon Emissions, Current and Deferred Taxes

	Dependent variables scaled by Capital Income			
	Taxes Paid	Total Taxes	Current Taxes	Deferred Taxes
Carbon Intensity	-0.023***	-0.018***	-0.027***	0.010***
	(0.006)	(0.006)	(0.007)	(0.003)
Year FE	Y	Y	Y	Y
Firm Controls	Y	Y	Y	Y
R^2	0.114	0.094	0.122	0.025
N	11322	11322	11322	11322

Carbon intensive firms have less current taxes and more deferred taxes.

Back

Robustness

	Scaled Assets	Scope 1+2	Scope 1+2+3	Exc. High Interests	Exc. Multinat	Exc. R&D	Exc. Loss Forward	Exposure to Carbon Taxes	High-Income Countries	1-to-1 Matching
Tax Cut$_{+1}$ × US	-0.134***	-0.110***	-0.054***	-0.108***	-0.085**	-0.070*	-0.090**	-0.108***	-0.078**	-0.144***
	(0.029)	(0.018)	(0.008)	(0.031)	(0.041)	(0.037)	(0.042)	(0.029)	(0.031)	(0.036)
Carbon Taxes								-0.042**		
								(0.018)		
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Industry-Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
R^2	0.465	0.465	0.453	0.456	0.449	0.451	0.457	0.455	0.459	0.473
N	29610	29611	29611	28640	24313	26239	24484	29611	21003	17623

Back

Tax Cuts and Jobs Act (2018) - Background

US Budgetary Impact as estimated by the Joint Committee on Taxation (Dec. 2017)

Provision	U.S Budget Impact (in billions)
Two tax-cutting provisions:	
Corporate tax rate of 21%	–$1348.50
100% bonus depreciation for capital expenditures	–$86.30
Three tax-increasing provisions:	
Interest expense deduction is limited to interest income plus 30% of EBITDA (EBIT starting in 2022)	$253.40
Limitations on deductions of net operating losses	$201.10
Amortization of R&D expenses and prevention of R&D related tax avoidance strategies	$119.70
Five changes to international taxation:	
Shift from modified worldwide taxation to modified territorial taxation	–$223.60
Global Intangible Low-Taxed Income (GILTI)	$112.40
Foreign-Derived Intangible Income (FDII)	–$63.80
Base Erosion Anti-abuse Tax (BEAT)	$149.60
One-time transition tax on unrepatriated foreign earnings	$338.80
Two tax simplifying provisions:	
Repeal of the corporate Alternative Minimum Tax (AMT)	–$40.30
Repeal of domestic production activities deduction (DPAD)	$98.00

Back