The Enemy of My Enemy: When Firms Support Climate Change Regulation

(Supplementary Materials)

Appendix A: Proofs

Proof of Proposition 1. Call any equilibrium as described in Proposition 1 a competitive equilibrium. The game is solved via backwards induction, beginning with the market competition stage. Let $\gamma_i = \frac{1}{F_j} - \frac{2}{F_i}$.

Lemma 1. *Firm i's equilibrium output and profit are as follows:*

$$q_i^* = \frac{1}{3}(\alpha + r\gamma_i) \tag{1}$$

$$\pi_i(q_i^*) = \frac{1}{9}(\alpha + r\gamma_i)^2 \tag{2}$$

Proof of Lemma 1. In the final stage of the game, firm i maximizes profits, taking into account firm j's output q_j:

$$\underset{q_i}{Max} \quad q_i\left(\alpha - q_i - q_j - \frac{r}{F_i}\right) \tag{3}$$

Re-arranging i's first order condition yields i's best response as a function of q_j:

$$\tilde{q}_i(q_j) = \frac{1}{2}\left(\alpha - q_j - \frac{r}{F_i}\right) \tag{4}$$

Letting $\gamma_i = \frac{1}{F_j} - \frac{2}{F_i}$ and recalling the assumption from the text that $\alpha >> 0$, we obtain i's equilibrium output and profits:

$$q_i^* = \frac{1}{3}(\alpha + r\gamma_i) \tag{5}$$

$$\pi_i(q_i^*) = \frac{1}{9}(\alpha + r\gamma_i)^2 \tag{6}$$

■

Next letting $\beta = \frac{1}{9} \cdot \frac{1-\lambda}{\lambda}$, lemma 2 characterizes the level of equilibrium regulation.

Lemma 2. *In any Truthful Nash Equilibrium regulation is given by,*

$$r^* = \min\left\{\max\left\{\frac{\left(r^{PM} + \alpha\beta(\gamma_i + \gamma_j)\right)}{1 - \beta(\gamma_i^2 + \gamma_j^2)}, 0\right\}, R\right\} \tag{7}$$

Proof of Lemma 2. The policy maker's problem is:

$$\underset{r\in[0,R]}{Max} \quad -\lambda(r^{PM} - r)^2 + (1-\lambda)(s_1(r) + s_2(r)) \tag{8}$$

The first order condition is,

$$0 = 2\lambda(r^{PM} - r^*) + (1-\lambda)\left(\left.\frac{\partial s_i(r)}{\partial r}\right|_{r^*} + \left.\frac{\partial s_j(r)}{\partial r}\right|_{r^*}\right) \tag{9}$$

Given the assumption of truthful contribution schedules, firm contributions are such that they receive the same level of utility given policy choice r^* as for any $r' \neq r^*$. This implies that any change in profits brought about by a shift in policy must be exactly offset by a corresponding change in the firm's expenditure on lobbying. Since each firm's marginal value for money is constant (and equal to one) this in turn implies that any change in profits must be offset by an identical and opposite change in the firm's contribution. For small deviations from the equilibrium policy, this yields the following relation for both firms:

$$\left.\frac{\partial s_i(r)}{\partial r}\right|_{r^*} = \left.\frac{\partial \pi_i}{\partial r}\right|_{r^*}$$

Note that by the assumption on α, both firms produce positive quantities in equilibrium and thus contributions are continuously differentiable on the interval $[0, R]$. Taking the derivative of (6) and plugging into (9) we obtain the expression for equilibrium policy,

$$r^* = \min\left\{\max\left\{\frac{\left(r^{PM} + \alpha\beta(\gamma_i + \gamma_j)\right)}{1 - \beta(\gamma_i^2 + \gamma_j^2)}, 0\right\}, R\right\} \tag{10}$$

Assumption A1 noted in the text ensures that the second order condition is met everywhere in the interval $[0, R]$.[1]

■

Lemma 3 characterizes equilibrium contribution schedules for each firm.

Lemma 3. *Firm i's equilibrium contribution schedule takes the form,*

$$s_i(r) = \pi_i(r) - \pi_i(r^*) + s_i(r^*) \tag{11}$$

where $s_i(r^*) = \frac{\lambda}{1-\lambda}[(r^{PM} - r^*)^2 - (r^{PM} - r^j)^2] + \left(\pi_j(r_j) - \pi_j(r^*)\right)$.

Proof of Lemma 3. Equilibrium contribution thus take the form:

$$s_i(r) = \max\{\pi_i(r) - \pi_i(r^*) + s_i(r^*), 0\} \tag{12}$$

where r^* is the equilibrium policy outcome. The schedule is completely pinned down by firm i's equilibrium contribution, $s_i(r^*)$. All that remains then is to calculate this contribution. The calculation is made tractable by the fact that we have already characterized equilibrium regulation, r^*. Additionally, using a similar method to that above we can easily characterize the equilibrium outcome if firm i chose *not* to contribute anything. Setting $s_i(r) = 0$ for all r in equation (9) and solving yields,

$$r^j = \max\left\{\frac{r^{PM} + \alpha\beta\gamma_j}{1 - \beta\gamma_j^2}, 0\right\}$$

[1] A1 ensures that the solution represents a global optimum, though does not rule out the possibility of corner solutions.

If firm i chooses not to contribute anything the policy maker attains utility $g(r^j)$. Taking into account i's equilibrium contribution, the policy maker attains utility $g(r^*)$. Given that the policy maker can attain $g(r^j)$ by ignoring firm i and choosing r^j, it must be that if she chooses r^* in equilibrium, she is at least as well off. Firm i never optimally provides a greater contribution than what is strictly required to induce r^* thus the equilibrium contribution is that which yields exactly $g(r^j) = g(r^*)$, or

$$-\lambda(r^{PM} - r^*)^2 + (1-\lambda)(s_i(r^*) + s_j(r^*)) = -\lambda(r^{PM} - r^j)^2 + (1-\lambda)s_j(r^j) \tag{13}$$

Given firm j's contribution schedule (defined similarly to (12)) we can plug-in the resulting value for $s_j(r^j)$. Re-arranging yields,

$$s_i(r^*) = \frac{\lambda}{1-\lambda}[(r^{PM} - r^*)^2 - (r^{PM} - r^j)^2] + \big(\pi_j(r_j) - \pi_j(r^*)\big) \tag{14}$$

■

This concludes the proof of Proposition 1. ■

Proof of Proposition 2. The marginal effect of r on firm i's profits is:

$$\frac{d\pi_i}{dr} = \frac{2}{9}(\alpha + r\gamma_i)\gamma_i \tag{15}$$

This is positive if and only if $\gamma_i > 0$. For the second part, recall firm i's equilibrium contribution schedule:

$$s_i(r) = \pi_i(r) - \pi_i(r^*) + s_i(r^*)$$

Suppose $\gamma_i > 0$. By Lemma 1, $\pi_i(r) > \pi_i(r^*)$ for any $r > r^*$. This implies $s_i(r) > s_i(r^*)$ for all $r > r^*$. Thus firm i offers greater contributions for higher levels of regulation and lesser contributions for lower levels of regulation. Since $\gamma_j < 0$ when $\gamma_i > 0$ the reverse is true for firm j. ■

Proof of Proposition 3. The partial derivatives of r^* with respect to F_i and F_j are:

$$\frac{\partial r^*}{\partial F_i} = \frac{1}{F_i^2}\left[\frac{\alpha\beta + 2r^*\beta(2\gamma_i - \gamma_j)}{1-\beta(\gamma_i^2+\gamma_j^2)}\right]$$
$$\frac{\partial r^*}{\partial F_j} = \frac{1}{F_j^2}\left[\frac{\alpha\beta + 2r^*\beta(2\gamma_j - \gamma_i)}{1-\beta(\gamma_j^2+\gamma_i^2)}\right]$$

The first expression is strictly positive. The second expression will be strictly negative whenever $\alpha < 2r^*(\gamma_i - 2\gamma_j)$. For this upper bound to be strictly less than the lower bound on α provided in the text requires that,

$$2r^*(\gamma_i - 2\gamma_j) > -R\gamma_j$$

or

$$\left(\frac{10r^*}{R} - 2\right) F_i > \left(\frac{8r^*}{R} - 1\right) F_j$$

Finally, note that $\lim_{r^* \to R} \frac{r^*}{R} = 1$ and that at $r^* = R$ the above expression reduces to $F_j > \frac{7}{8}F_j$ which surely holds. Thus there exists an $\epsilon > 0$ such that for any $r^* \in [R, R-\epsilon]$ the expression will continue to hold.

■

Proof of Proposition 4.

As $n \to N$, $r^{PM} \to 0$ as stated in the text. Note that $0 > \alpha\beta(\gamma_i + \gamma_j)$. Thus there exists a threshold $\bar{n}$ such that in any corresponding equilibrium with $n \geq \bar{n}$, the regulatory outcome is exactly 0. Noting that for any $n \geq \bar{n}$, it must be that $r^* = r^j$ as defined in Lemma 3. We subsequently have $\underset{n\to\bar{n}}{lim}\ s_i(r^*) = \frac{\lambda}{1-\lambda}\left[\left(r^{PM}\right)^2 - \left(r^{PM}\right)^2\right] = 0$. The efficient firm's contribution goes to zero. For the less efficient firm we have $\underset{n\to\bar{n}}{lim}\ s_j(r^*) =$

$\frac{\lambda}{1-\lambda}\left[\left(r^{PM}\right)^2 - \left(r^{PM}\right)^2\right] + (\pi_i(r^i) - \pi_i(0)) = (\pi_i(r^i) - \pi_i(0))$. As $r^i > 0$ and $\frac{d\pi_i(r)}{dr} > 0$ the last expression implies that the less efficient firm's equilibrium contribution remains strictly positive for any $n \geq \bar{n}$.

■

***Proof of Proposition 5*.**

Consider the production problem facing any firm i,

$$\begin{aligned} &\underset{q_i}{max}\;\; q_i\left(\alpha - \textstyle\sum_i q_i - \frac{r}{F_i}\right) \quad \text{if } i \in \mathcal{M} \\ &\underset{q_i}{max}\;\; q_i\left(\alpha - \textstyle\sum_i q_i - \tau\right) \quad \text{if } i \notin \mathcal{M} \end{aligned}$$

Best responses are,

$$\begin{aligned} \tilde{q}_i &= \tfrac{1}{2}\left(\alpha - \textstyle\sum_{j\neq i} q_j - \frac{r}{F_i}\right) \quad \text{if } i \in \mathcal{M} \\ \tilde{q}_i &= \tfrac{1}{2}\left(\alpha - \textstyle\sum_{j\neq i} q_j - \tau\right) \quad \text{if } i \notin \mathcal{M} \end{aligned}$$

Note that equilibrium price is given by $P(Q) = \alpha - Q$ where Q denotes total demand. Re-writing best responses in terms of this equilibrium price yields,

$$\begin{aligned} \tilde{q}_i &= P(Q) - \tfrac{r}{F_i} \quad \text{if } i \in \mathcal{M} \\ \tilde{q}_i &= P(Q) - \tau \quad \text{if } i \notin \mathcal{M} \end{aligned} \tag{16}$$

Summing across all i and re-arranging we obtain the following expression for equilibrium price in terms of primitives, $P(Q) = \frac{\alpha + r\sum_{j\in\mathcal{M}}\frac{1}{F_j} + (N-M)\tau}{N+1}$. Plugging this back into the best response gives optimal production levels for domestic and foreign firms respectively,

$$q_i^{*,N} = \tfrac{1}{N+1}\left[\alpha + (N-M)\tau + r\left(\sum_{j\in\mathcal{M}\setminus i}\tfrac{1}{F_j} - \tfrac{N}{F_i}\right)\right] \quad \text{if } i \in \mathcal{M}$$

$$q_i^{*,N} = \tfrac{1}{N+1}\left[\alpha - (M+1)\tau + \sum_{j\in\mathcal{M}}\tfrac{r}{F_j}\right] \quad \text{if } i \notin \mathcal{M}$$

As in Proposition 1 above, all firms will produce non-zero output given α sufficiently large as assumed in the text. Note that (16) is also exactly equivalent to firm i's per unit net revenue. Thus equilibrium profits are,

$$\pi_i^N = \tfrac{1}{(N+1)^2}\left[\alpha + (N-M)\tau + r\left(\sum_{j\in\mathcal{M}\setminus i}\tfrac{1}{F_j} - \tfrac{N}{F_i}\right)\right]^2 \quad \text{if } i \in \mathcal{M}$$

$$\pi_i^N = \tfrac{1}{(N+1)^2}\left[\alpha - (M+1)\tau + \sum_{j\in\mathcal{M}}\tfrac{r}{F_j}\right]^2 \quad \text{if } i \notin \mathcal{M}$$

Differentiating with respect to r and re-arranging yields,

$$\tfrac{d\pi_i}{dr} = \tfrac{2}{(N+1)^2}\left[\alpha + (N-M)\tau + r\left(\sum_{j\in\mathcal{M}\setminus i}\tfrac{1}{F_j} - \tfrac{N}{F_i}\right)\right]\cdot\left[\sum_{j\in\mathcal{M}\setminus i}\tfrac{1}{F_j} - \tfrac{N}{F_i}\right] \quad \text{if } i \in \mathcal{M}$$

$$\tfrac{d\pi_i}{dr} = \tfrac{2}{(N+1)^2}\left[\alpha - (M+1)\tau + r\sum_{j\in\mathcal{M}}\tfrac{1}{F_j}\right]\cdot\left[\sum_{j\in\mathcal{M}}\tfrac{1}{F_j}\right] \quad \text{if } i \notin \mathcal{M}$$

Thus domestic firm i's profits are increasing in r whenever $\gamma_i^N = \sum_{j\neq i}\frac{1}{F_j} - \frac{N}{F_i} > 0$ or,

$$F_i > \frac{N}{M-1}\cdot F_{-i}^M$$

where F_{-i}^M is the harmonic mean of green capital for all firms not including i.[2] For foreign firms, profits are always strictly increasing in the level of domestic regulation. ■

[2] That is, $F_{-i}^M = \frac{1}{\frac{1}{M-1}\sum_{j\neq i}\frac{1}{F_j}}$.

Proof of Proposition 6

For the first part, export profits are,

$$\pi_i^e = \frac{1}{(J+K+1)^2}\left[\alpha^* + J\phi + \tau r\left(\sum_{k\in\mathcal{K}\setminus i}\frac{1}{F_k} - \frac{J+K}{F_i}\right)\right]^2$$

These are strictly positive reflecting the assumption on α^*. Differentiating with respect to r gives,

$$\frac{\partial \pi_i^e}{\partial r} = \frac{2\tau\left(\alpha^* + J\phi + \tau r\left(\sum_{k\in\mathcal{K}\setminus i}\frac{1}{F_k} - \frac{J+K}{F_i}\right)\right)}{(J+K+1)^2}\cdot\left(\sum_{k\in\mathcal{K}\setminus i}\frac{1}{F_k} - \frac{J+K}{F_i}\right)$$

which is positive if and only if $F_i \geq \frac{J+K}{K-1}F_{-i}^K$, where the latter is defined as in the text.

For the second part, total profits to firm $i \in \mathcal{K}$ are $\pi_i^d + \pi_i^e$, or

$$\frac{1}{(M+1)^2}\left[\alpha + r\left(\sum_{m\in\mathcal{M}\setminus i}\frac{1}{F_m} - \frac{M}{F_i}\right)\right]^2 + \frac{1}{(J+K+1)^2}\left[\alpha^* + J\phi + \tau r\left(\sum_{k\in\mathcal{K}\setminus i}\frac{1}{F_k} - \frac{J+K}{F_i}\right)\right]^2$$

Differentiating with respect to r gives,

$$\frac{2}{(M+1)^2}\left[\alpha + r\left(\sum_{m\in\mathcal{M}\setminus i}\frac{1}{F_m} - \frac{M}{F_i}\right)\right]\cdot\left(\sum_{m\in\mathcal{M}\setminus i}\frac{1}{F_m} - \frac{M}{F_i}\right) +$$
$$\frac{2\tau}{(J+K+1)^2}\left[\alpha^* + J\phi + \tau r\left(\sum_{k\in\mathcal{K}\setminus i}\frac{1}{F_k} - \frac{J+K}{F_i}\right)\right]\cdot\left(\sum_{k\in\mathcal{K}\setminus i}\frac{1}{F_k} - \frac{J+K}{F_i}\right)$$

Note that the left hand term is strictly greater than zero if and only if $F_i \geq \frac{M}{M-1}F_{-i}^M$ and the right hand term is greater than or equal to zero if $F_i \geq \frac{J+K}{K-1}F_{-i}^K$. Also recall that by assumption $\frac{J+K}{K-1}F^K_{-i} > \frac{M}{M-1}F^M_{-i}$. For $F_i < \frac{M}{M-1}F^M_{-i}$ both terms are strictly negative. For $F_i \geq \frac{J+K}{K-1}F^K_{-i}$ both terms are (weakly) positive. Finally, note that both terms are continuously and monotonically increasing in F_i. Thus there exists an F^* such that $\frac{J+K}{K-1}F^K_{-i} > F^* > \frac{M}{M-1}F^M_{-i}$ and the above expression exactly equals zero. ■

Proof of Proposition 7

For any production level q_i firm i selects inputs to solve,

$$\min_{h_i,m_i} \theta h_i + p_i m_i \qquad \text{s.t. } q_i = \left(\frac{h_i}{\eta}\right)^{\eta}\left(\frac{m_i}{1-\eta}\right)^{1-\eta}$$

where $p_1 = \tau\phi^*$ and $p_2 = r\phi$. Re-arranging the constraint gives,

$$h_i = \eta\left[q\left(\frac{1-\eta}{m_i}\right)^{1-\eta}\right]^{\frac{1}{\eta}}$$

Plugging this into the original minimization problem, the firm minimizes,

$$\min_{m_i} \theta\eta\left[q\left(\frac{1-\eta}{m_i}\right)^{1-\eta}\right]^{\frac{1}{\eta}} + p_i m_i$$

Re-arranging the first order condition we have,

$$p_i = \theta\left[q\left(\frac{1-\eta}{m_i}\right)\right]^{\frac{1}{\eta}}$$

This and the original constraint together imply the following optimal input levels for any q_i,

$$h_i^* = \left(\frac{p_i}{\theta}\right)^{(1-\eta)} q\eta$$

$$m_i^* = \left(\frac{\theta}{p_i}\right)^{\eta} q(1-\eta)$$

Given optimal input choices, total costs are,

$$c(q_i) = \theta^\eta p_i^{(1-\eta)} q_i$$

implying a constant marginal cost of final goods production. Plugging marginal costs into the results from Proposition 1, equilibrium profits are,

$$\pi_1 = \frac{S_k}{9}\left[\alpha + \theta^\eta\left[(r\phi)^{(1-\eta)} - (\tau\phi^*)^{(1-\eta)}\right]\right]^2$$
$$\pi_2 = \frac{S_k}{9}\left[\alpha + \theta^\eta\left[(\tau\phi^*)^{(1-\eta)} - (r\phi)^{(1-\eta)}\right]\right]^2$$

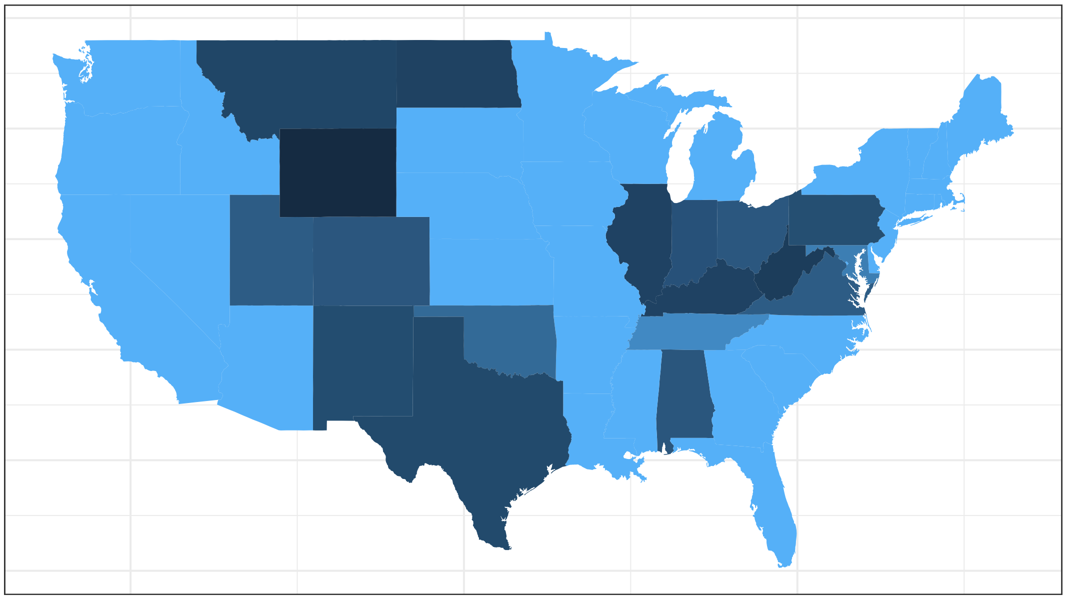
Again, these profits are strictly positive by the assumption on α as given in the text. Differentiating with respect to r we have,

$$\frac{\partial\pi_1}{\partial r} = \frac{2S_k}{9}\left[\alpha + \theta^\eta\left[(r\phi)^{(1-\eta)} - (\tau\phi^*)^{(1-\eta)}\right]\right]\cdot(1-\eta)\left(\frac{\theta}{r\phi}\right)^\eta\cdot\phi > 0$$
$$\frac{\partial\pi_2}{\partial r} = -\frac{2S_k}{9}\left[\alpha + \theta^\eta\left[(\tau\phi^*)^{(1-\eta)} - (r\phi)^{(1-\eta)}\right]\right]\cdot(1-\eta)\left(\frac{\theta}{r\phi}\right)^\eta\cdot\phi^* < 0$$

Note that $S_V > S_O$ implies the absolute value of either derivative is greater for vertically integrated firms. Thus both firms lobby more intensively under vertical integration than under outsourcing. ■

Appendix B1: Additional Figures and Empirical Results

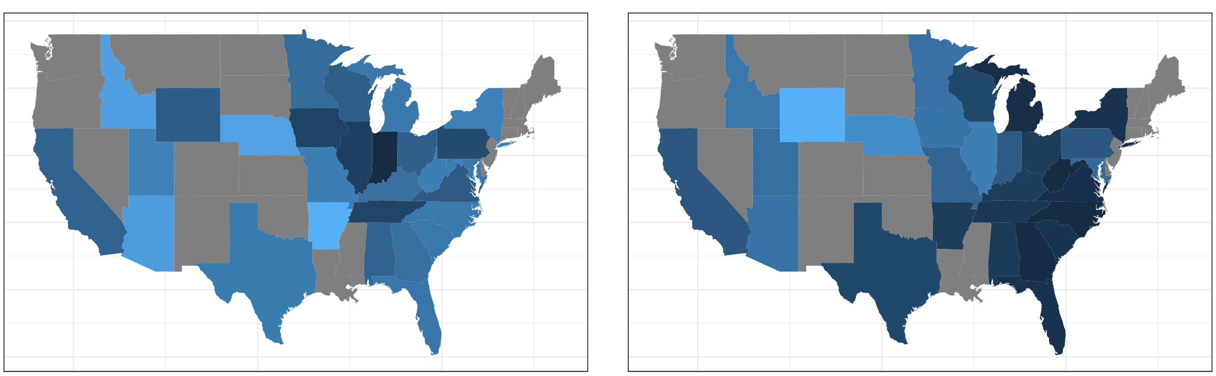
Figure 10: Coal Reserves by State



Coal Reserves by State

Spatial distribution of (logged) coal reserves by state in 2009. Darker shades indicate greater coal reserves. Data provided by U.S. Energy Information Administration.

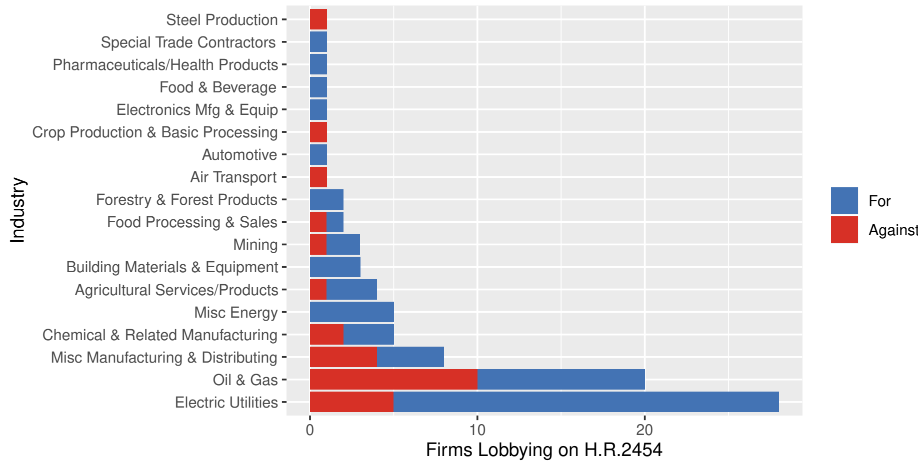
Figure 11: Industrial Coal Usage by State



Industrial Coal Consumption (Scaled by GDP) | Average Coal Price (Industrial End Use)

Left hand panel depicts spatial distribution of (logged) coal consumption by industrial consumers by state in 2009. Consumption scaled by private industry GDP in same year (provided by the U.S. Bureau of Economic Analysis). Darker shades indicate greater intensity of coal consumption. Right hand panel depicts (logged) average price of coal for industrial end users, also in 2009. Lighter shades indicate lower average coal prices. Grey indicates data withheld. Data for both panels provided by U.S. Energy Information Administration.

Figure 12: Position-Taking by Industry



Distribution of firms by industry lobbying for and against the American Clean Energy and Security Act. The data reveal a striking amount of support for cap and trade legislation from the private sector. I estimate that, at a minimum, nearly 35% of firms lobbying on the bill supported its passage. Also notable is the amount of support for cap and trade legislation among electric utilities themselves. Around 32% of firms identified as lobbying in favor of cap and trade are electric utilities while the remainder are firms engaged in manufacturing or other sectors.

Note on Sample Size for Baseline Results (Table 1): Table 1 exhibits a significant difference in sample size across the two specifications. This difference arises from limitations of the zip-code level carbon intensity measure. Carbon intensity from electricity generation is available for 6,623 plants located in just 4,421 zip codes. In principle estimates of carbon intensity for remaining zip codes - those proximal to, but not containing an electricity generation plant - could be imputed based on geographic proximity. However this would require strong assumptions about electricity distribution networks across zip codes and is beyond the scope of the current project. Instead, for a larger sample I rely on the measure of coal reserves which are comprehensively available for all U.S. zip codes.

Note also that while the zip code level carbon intensity measure is surely not missing at random (but rather missing for zip codes not containing their own electricity generation plant) the missingness is unlikely to bias coefficient estimates provided it is uncorrelated with both the dependent and independent variables. That is, missinginess in this case may inflate the variance of the resulting parameter estimates but will not introduce bias provided

Table 1: Baseline Results

	Model 1	Model 2
(Intercept)	-5.31^*	-5.19^*
	(1.06)	(0.39)
Competitor Costs (Coal Reliance)	23.81^*	
	(8.81)	
Own Costs (Coal Reliance)	0.69	
	(0.85)	
Competitor Costs (Coal Reserves)		3.47^*
		(1.20)
Own Cost (Coal Reserves)		0.21
		(0.41)
Market Share	-1.17	0.35
	(4.67)	(1.72)
Productivity	0.00	0.00
	(0.00)	(0.00)
Net PP&E	0.00^*	0.00^*
	(0.00)	(0.00)
Market Cap	-0.02	-0.02
	(0.06)	(0.02)
Energy Intensive Manufacturing	-14.49^*	1.69^*
	(0.98)	(0.81)
Multinational	0.81	0.53^*
	(0.75)	(0.26)
Electricity Provider	0.86	3.63^*
	(1.36)	(0.51)
N	531	2724

Logistic regression with standard errors clustered by industry. Dependent variable is support for H.R. 5424 The American Clean Energy and Security Act of 2009. Competitor Costs (Coal Reliance) is share of competitors located in high adjustment cost zip codes as measured by coal usage in electricity generation. Competitor Costs (Coal Reserves) is share of competitors in high adjustment cost zip codes as measured by local coal reserves. Standard errors in parentheses clustered by industry. * indicates significance at $p < 0.05$.

that 1) firms do not locate strategically within zip codes containing utility generators and 2) that location within these zip codes does not disproportionately impact firms' propensity to lobby. Both of these appear to be reasonable assumptions. The results are further corroborated by additional specifications employing the coal-based measure.

Table 2: Additional Results

	Model 1	Model 2	Model 3	Model 4
(Intercept)	-5.22^{*}	-5.21^{*}	-5.30^{*}	-5.17^{*}
	(1.04)	(0.41)	(1.06)	(0.39)
Competitor Costs (Coal Reliance)	23.85		23.68^{*}	
	(12.38)		(8.82)	
Competitor Costs (Coal Reliance)	1.06		0.69	
	(1.34)		(0.85)	
Competitor Costs (Coal Reserves)		3.47^{*}		3.47^{*}
		(1.03)		(1.20)
Own Costs (Coal Reserves)		0.26		0.21
		(0.45)		(0.41)
Market Share	0.51	0.60	-1.16	0.34
	(3.61)	(1.08)	(4.68)	(1.72)
Productivity	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Net PP&E	0.00^{*}	0.00^{*}	0.00^{*}	0.00^{*}
	(0.00)	(0.00)	(0.00)	(0.00)
Market Cap	0.02	-0.01	-0.02	-0.02
	(0.06)	(0.02)	(0.06)	(0.02)
Energy Intensive Manufacturing	3433614.78^{*}	2.06	-14.49^{*}	1.68^{*}
	(1589.44)	(1.06)	(0.98)	(0.81)
Multinational	0.59	0.50	0.80	0.52^{*}
	(0.95)	(0.35)	(0.75)	(0.26)
Electricity Provider	1.13	3.61^{*}	0.86	3.64^{*}
	(1.47)	(0.42)	(1.36)	(0.51)
N	531	2724	524	2692
Rare Events Correction	*Yes*	*Yes*	*No*	*No*
Outliers Excluded	*No*	*No*	*Yes*	*Yes*

Logistic regression with standard errors clustered by industry. Dependent variable is support for H.R. 5424 The American Clean Energy and Security Act of 2009. Competitor Costs (Coal Reliance) is share of competitors located in high adjustment cost zip codes as measured by coal usage in electricity generation. Competitor Costs (Coal Reserves) is share of competitors in high adjustment cost zip codes as measured by local coal reserves. Rare events correction implemented using the Zelig package in R. Outliers defined as observations with residuals greater than three times the standard deviation. * indicates significance at $p < 0.05$.

Note on Lobbying for Private Goods

One potential objection to modeling climate change regulation as a unidimensional choice is that firms engaged in the policy making process may not simply support or oppose the ACES but rather attempt to shape its implied distributional consequences through the pursuit of private benefits. Indeed many firms not only express support for climate change legislation but also more narrow support for particular features of the legislation relevant to their industry. Provisions related to offsets, carbon sequestration, investments in energy efficiency, and funding for new research and development all provide potential for private rents (Stokes and Breetz, 2018). Perhaps the most direct source of these private benefits is the legislation's initial allocation of carbon allowances which was the subject of intense lobbying and the design of which was widely viewed as key to the political success of any cap and trade program. At the same time the majority of these provisions redistribute costs and benefits on an industry-wide basis. This suggests that intra-industry variation in lobbying behavior is unlikely to be explained by the pursuit of particularistic benefits. Table 3 shows that the empirical results are robust to consideration of such benefits.

Table 3: Lobbying for Private Goods

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
(Intercept)	-6.58^{*}	-5.74^{*}	-5.41^{*}	-5.28^{*}	-5.31^{*}	-5.21^{*}
	(0.88)	(0.34)	(1.04)	(0.40)	(1.06)	(0.40)
Comp. Costs (Coal Reliance)	24.90^{*}		21.95^{*}		23.82^{*}	
	(11.93)		(9.09)		(8.80)	
Comp. Costs (Coal Reliance)	0.39		0.41		0.69	
	(0.94)		(0.88)		(0.85)	
Comp. Costs (Coal Reserves)		2.39^{*}		3.54^{*}		3.53^{*}
		(0.94)		(1.24)		(1.20)
Comp. Costs (Coal Reserves)		0.09		0.19		0.21
		(0.40)		(0.40)		(0.41)
Market Share	1.93	1.36	-1.62	0.31	-1.19	0.35
	(3.74)	(1.03)	(4.68)	(1.73)	(4.66)	(1.72)
Productivity	0.00	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Net PP&E	0.00^{*}	0.00^{*}	0.00^{*}	0.00^{*}	0.00^{*}	0.00^{*}
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Market Cap	0.01	-0.01	-0.02	-0.02	-0.02	-0.02
	(0.03)	(0.01)	(0.06)	(0.02)	(0.06)	(0.02)
Energy Intensive Manuf.	-17.30^{*}	0.60			-14.49^{*}	1.73^{*}
	(1.84)	(1.32)			(0.98)	(0.81)
Multinational	0.94	0.60^{*}	0.78	0.50	0.81	0.51^{*}
	(0.79)	(0.24)	(0.73)	(0.26)	(0.74)	(0.26)
Electricity Provider	-0.82	2.21^{*}	0.94	3.71^{*}	0.85	3.66^{*}
	(1.30)	(0.34)	(1.37)	(0.53)	(1.36)	(0.52)
Permit Allocation	3.23^{*}	2.14^{*}				
	(0.84)	(0.37)				
Trade Exp. Energy Intens.			1.31	1.21^{*}		
			(1.14)	(0.44)		
Elec. Comp. Manuf.					-13.76^{*}	1.91^{*}
					(1.19)	(0.25)
N	531	2724	531	2724	531	2724

Logistic regression with standard errors clustered by industry. Dependent variable is support for H.R. 5424 The American Clean Energy and Security Act of 2009. Competitor Costs (Coal Reliance) is share of competitors located in high adjustment cost zip codes as measured by coal usage in electricity generation. Competitor Costs (Coal Reserves) is share of competitors in high adjustment cost zip codes as measured by local coal reserves. * indicates significance at $p < 0.05$.

Table 4: Dynamics of Climate Change Policy

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
(Intercept)	-5.42^*	-5.35^*	-5.03^*	-5.24^*	-5.26^*	-5.36^*
	(1.83)	(0.73)	(1.15)	(0.44)	(1.69)	(0.70)
Comp. Costs (Coal Reliance)	23.90^*		23.41^*		23.97^*	
	(8.94)		(9.05)		(8.98)	
Own Costs (Coal Reliance)	0.70		0.59		0.65	
	(0.87)		(0.89)		(0.83)	
Comp. Costs (Coal Reliance)		3.47^*		3.45^*		3.47^*
		(1.21)		(1.22)		(1.22)
Own Costs (Coal Reliance)		0.22		0.23		0.22
		(0.41)		(0.42)		(0.40)
Market Share	-1.13	0.37	-1.39	0.37	-1.00	0.37
	(4.79)	(1.74)	(4.81)	(1.73)	(4.57)	(1.74)
Productivity	0.00	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Net PP&E	0.00^*	0.00^*	0.00^*	0.00^*	0.00^*	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Market Cap	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02
	(0.06)	(0.02)	(0.05)	(0.02)	(0.06)	(0.02)
Energy Intensive Manufacturing	-14.48^*	1.70^*	-14.65^*	1.69^*	-14.46^*	1.70^*
	(0.98)	(0.79)	(0.96)	(0.81)	(0.96)	(0.79)
Multinational	0.79	0.52^*	0.93	0.53^*	0.78	0.52^*
	(0.68)	(0.25)	(0.73)	(0.26)	(0.67)	(0.25)
Electricity Provider	0.80	3.62^*	0.96	3.64^*	0.65	3.62^*
	(1.14)	(0.51)	(1.28)	(0.52)	(1.25)	(0.51)
RES	0.14	0.21			-0.04	0.22
	(1.18)	(0.54)			(1.03)	(0.49)
Years under RES			-0.08	0.01		
			(0.09)	(0.03)		
Net PP&E × RES					0.00	0.00
					(0.00)	(0.00)
N	531	2724	531	2724	531	2724

Logistic regression with standard errors clustered by industry. Dependent variable is support for H.R. 5424 The American Clean Energy and Security Act of 2009. Competitor Costs (Coal Reliance) is share of competitors located in high adjustment cost zip codes as measured by coal usage in electricity generation. Competitor Costs (Coal Reserves) is share of competitors in high adjustment cost zip codes as measured by local coal reserves. * indicates significance at $p < 0.05$.

Table 5: Interaction with Firm Size and Productivity

	Model 1	Model 2	Model 3	Model 4
(Intercept)	-5.19^{*}	-5.13^{*}	-5.33^{*}	-5.12^{*}
	(1.02)	(0.39)	(1.09)	(0.40)
Comp. Costs (Coal Reliance)	14.48		25.80	
	(10.72)		(23.61)	
Own Costs (Cost Reliance)	0.73		0.69	
	(0.86)		(0.85)	
Comp. Costs (Coal Reserves)		3.30^{*}		2.92^{*}
		(1.14)		(1.20)
Own Costs (Coal Reserves)		0.07		0.22
		(0.45)		(0.40)
Total Assets	0.00	0.00		
	(0.00)	(0.00)		
Productivity	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Market Share	-2.71	-0.04	-1.23	0.43
	(4.15)	(1.73)	(4.89)	(1.61)
Net PP&E	0.00^{*}	0.00	0.00^{*}	0.00^{*}
	(0.00)	(0.00)	(0.00)	(0.00)
Market Cap	-0.02	-0.02	-0.02	-0.02
	(0.05)	(0.02)	(0.06)	(0.02)
Energy Intensive Manufacturing	-14.38^{*}	1.57	-14.40^{*}	1.72^{*}
	(0.96)	(0.92)	(1.05)	(0.82)
Multinational	0.73	0.42	0.81	0.54^{*}
	(0.79)	(0.24)	(0.75)	(0.26)
Electricity Provider	0.34	3.69^{*}	0.86	3.71^{*}
	(1.49)	(0.55)	(1.37)	(0.50)
Total Assets × Comp. Costs (Coal Reliance)	0.00^{*}			
	(0.00)			
Total Assets × Comp. Costs (Coal Reserves)		0.00		
		(0.00)		
Productivity × Comp. Costs (Coal Reliance)			0.00	
			(0.03)	
Productivity × Comp. Costs. (Coal Reserves)				0.00
				(0.00)
N	531	2724	531	2724

Logistic regression with standard errors clustered by industry. Dependent variable is support for H.R. 5424 The American Clean Energy and Security Act of 2009. Competitor Costs (Coal Reliance) is share of competitors located in high adjustment cost zip codes as measured by coal usage in electricity generation. Competitor Costs (Coal Reserves) is share of competitors in high adjustment cost zip codes as measured by local coal reserves. * indicates significance at $p < 0.05$.

Table 6: Interaction with Trade Exposure and Production Stage Characteristics

	Model 1	Model 2	Model 3	Model 4	Model 5
(Intercept)	-5.27^*	-5.28^*	-5.03^*	-4.46^*	-5.18^*
	(0.37)	(0.40)	(0.45)	(0.61)	(0.38)
Comp. Costs (Coal Reserves)	4.41^*	3.63^*	4.80^*		3.42^*
	(1.45)	(1.25)	(1.62)		(0.99)
Own Costs (Coal Reserves)	0.24	0.17	0.13	0.47	0.26
	(0.39)	(0.41)	(0.41)	(0.36)	(0.43)
Comp. Costs (Coal Reliance)				24.16^*	
				(8.43)	
Market Share	0.60	0.30	0.81	0.81	0.57
	(1.55)	(1.76)	(1.17)	(1.25)	(0.99)
Productivity	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Net PP&E	0.00^*	0.00^*	0.00^*	0.00^*	0.00^*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Market Cap	−0.02	−0.02	−0.02	−0.03	−0.01
	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)
Energy Intensive Manuf.	1.56	1.14	1.35	−0.67	1.94^*
	(0.86)	(1.22)	(0.88)	(0.83)	(0.90)
Electricity Provider	3.63^*	3.71^*	3.36^*	2.69^*	3.58^*
	(0.47)	(0.53)	(0.47)	(0.65)	(0.41)
(Log) Import Penetration	−31.83				
	(47.24)				
(Log) Imp. Pen. × Comp. Share (Coal Reserves)	−86.85				
	(73.13)				
Trade Exposed, Energy Intensive (TEEI)		1.58^*			
		(0.61)			
TEEI × Comp. Costs (Coal Reliance)		−3.26			
		(3.92)			
(Log) Exports			−0.05	−0.11	
			(0.05)	(0.06)	
(Log) Exports × Comp. Costs (Coal Reserves)			−0.23		
			(0.18)		
(Log) Exports × Comp. Costs (Coal Reliance)				−0.36	
				(0.92)	
Multinationals	0.56^*	0.48	0.55^*	0.48	0.46
	(0.25)	(0.26)	(0.25)	(0.25)	(0.34)
Final Good					−0.01
					(1.43)
Final Good × Multinational					0.22
					(1.56)
N	2724	2724	2724	2724	2724

Logistic regression with standard errors clustered by industry. Dependent variable is support for H.R. 5424 The American Clean Energy and Security Act of 2009. Competitor Costs (Coal Reliance) is share of competitors located in high adjustment cost zip codes as measured by coal usage in electricity generation. Competitor Costs (Coal Reserves) is share of competitors in high adjustment cost zip codes as measured by local coal reserves. * indicates significance at $p < 0.05$.

Appendix B2: Further Details of Event Study

The event study presented in the main text considers the impact of passage of the H.R. 2454 The American Clean Energy and Security Act on the market returns to all manufacturing firms listed on the New York Stock Exchange. Event studies have been widely employed in the literature on corporate finance and, increasingly, the study of international institutions. In the context of corporate finance, event studies explore changes in firm stock returns in reaction to the disclosure of new information. The intuition behind these event studies is that the magnitude of unanticipated returns to equity provides a useful measure of the impact of events on shareholder wealth (Kothari and Warner, 2007).

More recently, within the study of international institutions, event studies have been employed to assess the credibility of negotiated outcomes. Wilf (2016) studies the impact of Basel III negotiations on regulated banks, finding evidence that international negotiations are viewed as credible and thus impact perceptions of banks' value. In a similar vein Kucik and Pelc (2016) demonstrate that dispute settlement rulings within the World Trade Organization impact the value of firms even in countries not party to specific disputes, evidence that investors anticipate systemic shifts in regulatory policy following novel judicial rulings. In parallel to these approaches I employ an event study to assess the expected impact of climate change legislation across firms, as measured by the abnormal returns observed following passage.

As noted in the text I calculate abnormal returns employing a "market model" in which a post-treatment counterfactual is generated for each firm by regressing that firm's pre-treatment returns on a chosen index and predicting post-treatment returns employing the resulting coefficient estimates (Kothari and Warner, 2007). As my index I employ the Dow Jones Industrial Average. I define pre-treatment and post-treatment periods as consisting of 25 days prior to and 10 days following the passage of H.R. 2454. Note that if market actors anticipated a successful outcome in the days immediately prior to passage then including the observed returns from these days could induce post treatment bias. For this reason I exclude the five days prior to treatment from my definition of the pre-treatment window.

Data on daily opening and closing prices for all manufacturing firms listed on the New York Stock Exchange are obtained from the CRSP database. Returns are defined as the normalized difference between opening and closing price. For each firm i denote daily observed return by, $Return_{i,t}$ where t denotes the day of observation. I normalize t so that $t = 0$ corresponds to the date of passage (i.e. the treatment date). The pre-treatment period is then defined as the set of days, $t \in [-30, -5)$. The post-treatment period is the set, $t \in [0, 5)$. Denote the daily observed Dow Jones Index by $Index_t$. For each firm in the sample I estimate the following market model via ordinary least squares employing only pre-treatment observations,

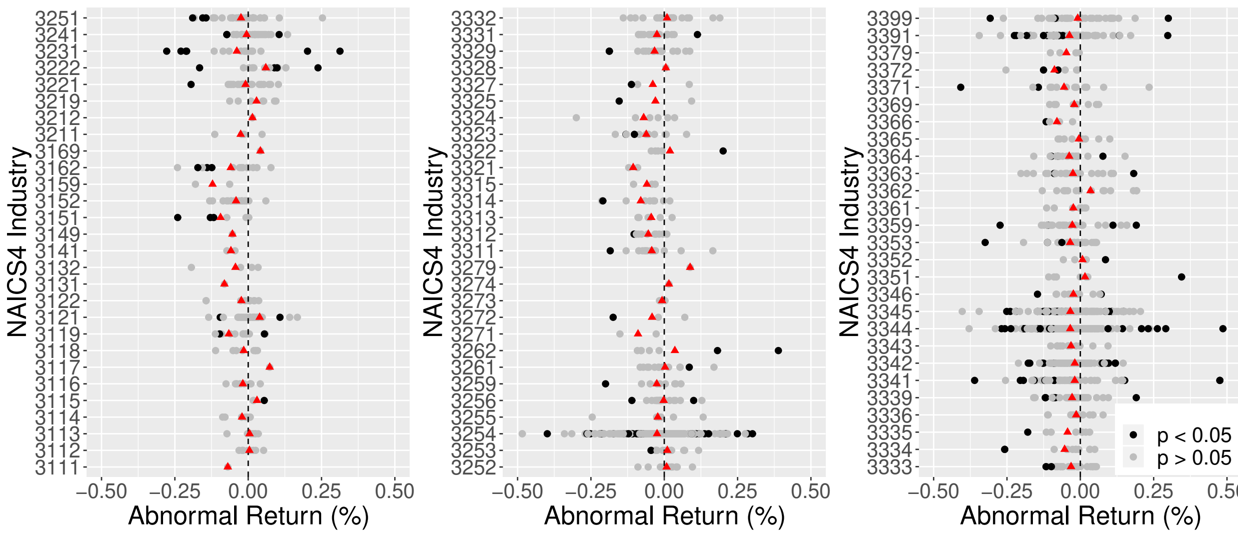
$$Return_{i,t} = \alpha_i + \beta_i Index_t + \epsilon_{i,t}$$

Employing the resulting parameter estimates, I predict returns for firm i for all post-treatment observations,

$$\widehat{Return}_{i,t} = \hat{\alpha}_i + \hat{\beta}_i Index_t$$

Firm i's abnormal return on day t is equal to the difference between the observed return $Return_{i,t}$ and the predicted return $\widehat{Return}_{i,t}$. Note that the abnormal return is equivalent to the shift in value plus a random error $\epsilon_{i,t}$, the latter of which is normally distributed by assumption (as is the cumulative abnormal return described below). I aggregate abnormal

Figure 13: Abnormal Returns to Manufacturing Industries Following Passage of H.R.2454



Firm-level abnormal returns for all publicly-traded manufacturers following House passage of H.R. 2454, the U.S. Clean Energy and Security Act on June 29, 2009. Abnormal returns plotted by 4-digit NAICS industry with estimates statistically significant at the 0.05 level in black and industry average abnormal return depicted in red.

returns across the post-treatment period to generate the cumulative abnormal returns for firm i,[3]

$$\widehat{CAR}_i = \sum_t \left(Return_{i,t} - \widehat{Return}_{i,t} \right)$$

One concern noted in the event-study literature is that events may impact not only the mean but also the variance of the distribution of abnormal returns. For this reason I calculate statistical significance employing the estimated variance of abnormal returns during the pre-treatment period only. The results of the event study are presented in the main text and included here again in Figure 13 for completeness.

Again, as noted in the main text the abnormal returns, aggregated across firms and across industries, are jointly significant and negative on average. This is consistent with the predicted overall economic costs of climate change regulation. Yet within industry there is much variation in investor perceptions of the legislation's firm-level impact. Most importantly, while the average abnormal return for nearly all industries is negative as expected,

[3] For discussion of various quantities of interest related to event studies as well as their associated variance see Dasgupta et al. (1998).

in many industries the abnormal returns to a minority of firms are estimated to be positive and statistically significant suggesting that some firms are expected to gain in profitability following the imposition of costly climate change legislation, and that this expected gain is unlikely to be driven simply by the usual stochasticity of equity returns.

Appendix B3: Measurement of Firm Location

An important concern regarding measurement of firms' energy-consumption (or production) locations is that firms may not necessarily produce in the same locations as their headquarters as reported in the balance sheet data used to construct the cost measures employed in the analyses above. To address this I report a number of additional robustness results relying on a range of approaches to the possibility of measurement error.

First, it is useful to note that if the measurement error described above were systematic is could bias coefficient estimates of the variables of interest in either direction. However provided the measurement error is uncorrelated with other variables then the bias should be towards zero, implying that the specifications in the text provide conservative estimates of the coefficients of interest. To probe a potential systematic relationship between headquarter locations and other firm characteristics I begin by plotting headquarter locations against the most likely firm- and industry-level characteristics: total assets, annual investment, and number of incumbents. These plots are included in Figures 14 and 15.

Next I explore the potential for unobserved confounders by reporting results of several additional specifications, controlling for firms' incentives to locate their headquarters in particular locations. In particular I include measures of the local business and tax environment. I also include a separate indicator for firms headquartered in the state of Delaware, given that state's widely recognized status as a domestic tax haven. Across specifications the main coefficients of interest remain substantively similar and maintain their statistical significance. The results are presented in Table 7.

Finally I qualitatively assess the potential for measurement error by comparing a randomly selected subset of firm headquarter locations (as reported in the data) with firms' own descriptions of their operations and properties from SEC filings. Unfortunately the data reported in these filings (10-k annual reports) is not sufficiently systematic to make more

Figure 14: Industry Characteristics and Adjustment Costs

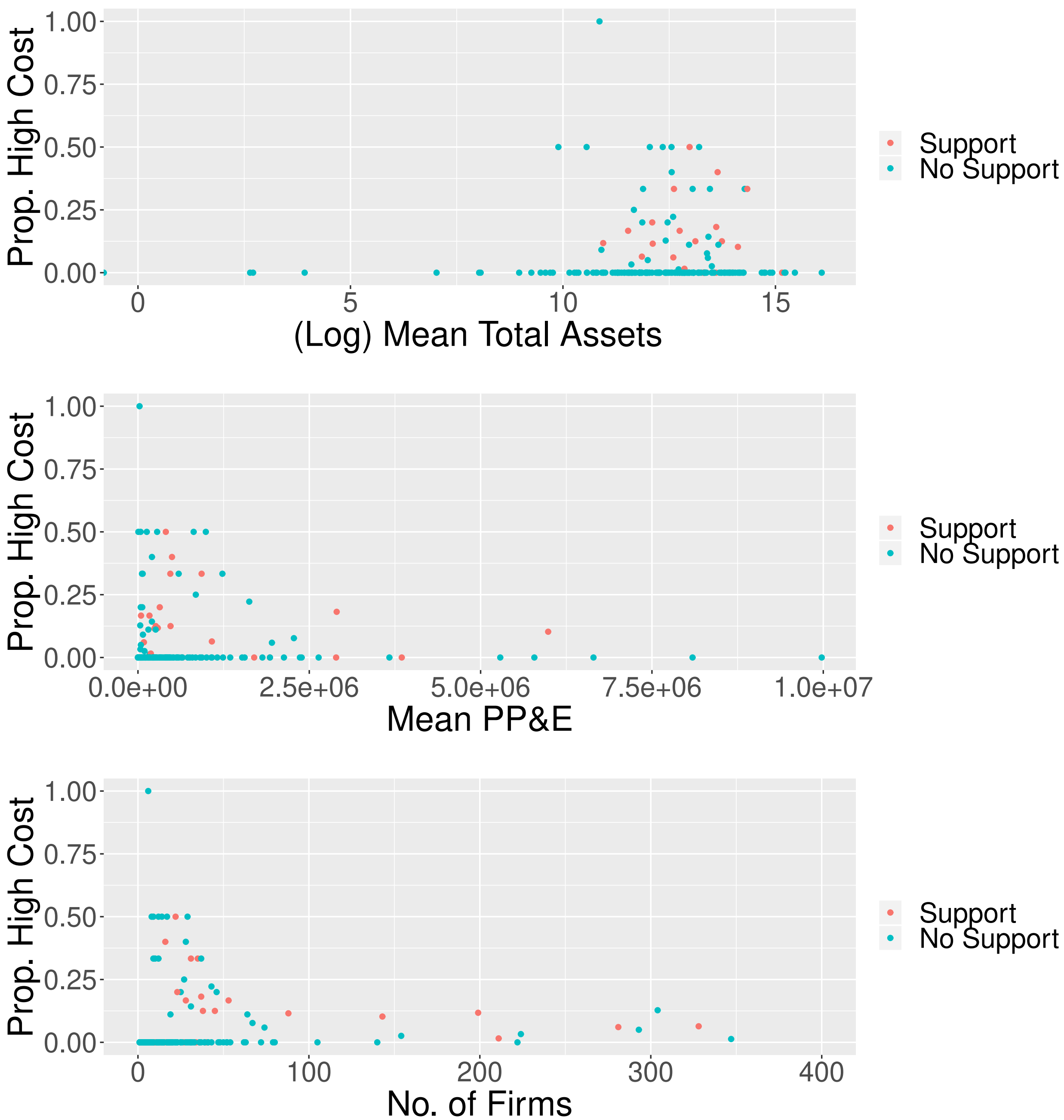


Figure 15: Firm Characteristics and Adjustment Costs

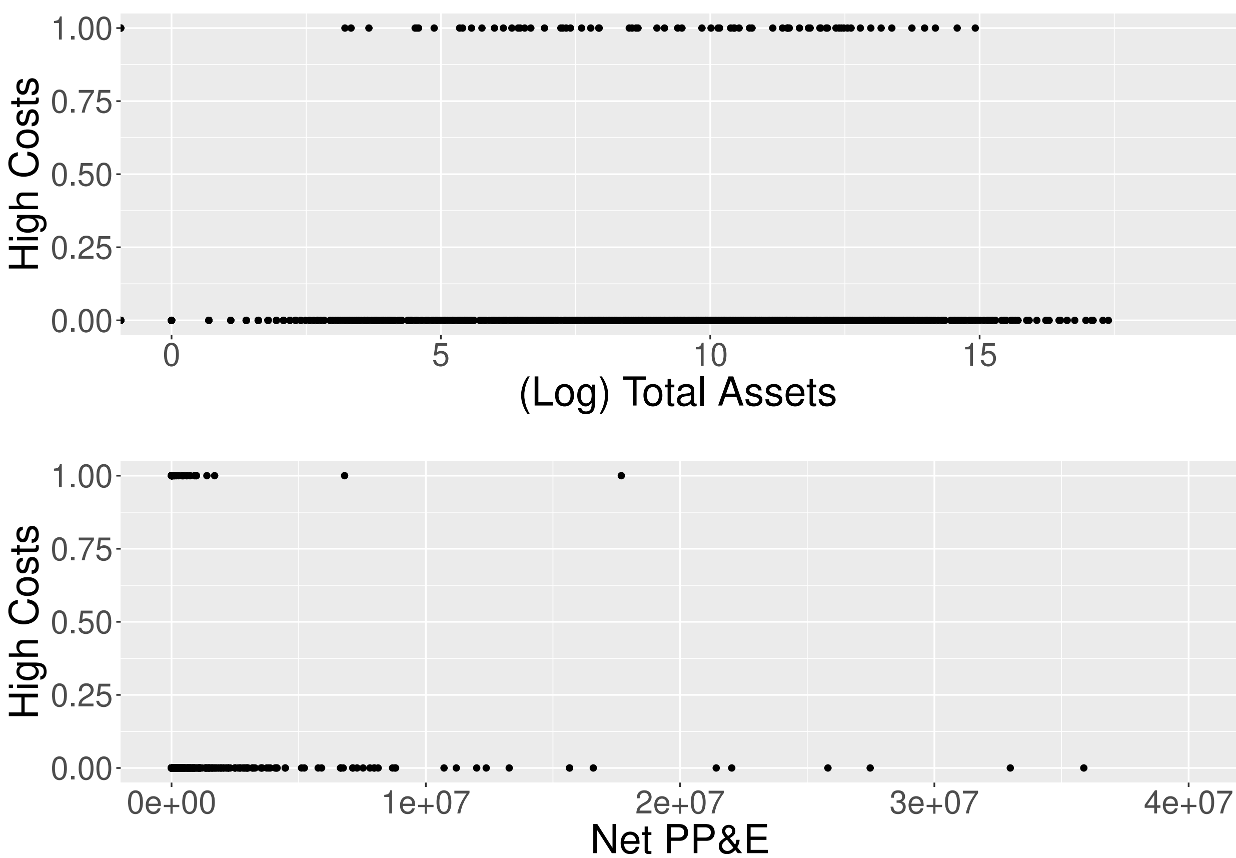


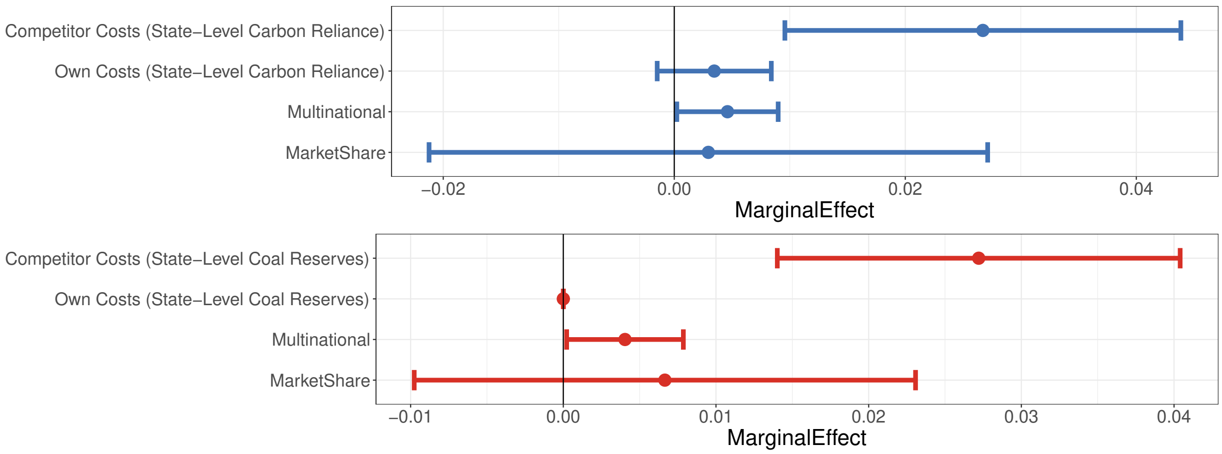
Table 7: Headquarter Incentives

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
(Intercept)	-5.75^*	-5.51^*	-5.33^*	-5.28^*	-5.31^*	-5.18^*
	(0.93)	(0.36)	(0.98)	(0.43)	(1.06)	(0.39)
Comp. Costs (Coal Reliance)	23.72^*		23.84^*		23.73^*	
	(9.01)		(8.70)		(8.82)	
Own Cost (Coal Reliance)	0.54		0.69		0.74	
	(0.97)		(0.84)		(0.85)	
Comp. Costs (Coal Reserves)		3.51^*		3.40^*		3.47^*
		(1.23)		(1.11)		(1.20)
Own Cost (Coal Reserves)		0.12		0.17		0.21
		(0.42)		(0.44)		(0.41)
Market Share	-1.18	0.21	-1.19	0.37	-1.19	0.34
	(4.47)	(1.75)	(4.98)	(1.67)	(4.66)	(1.72)
Productivity	0.00	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Net PP&E	0.00^*	0.00	0.00^*	0.00^*	0.00^*	0.00^*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
MarketvCap	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02
	(0.05)	(0.02)	(0.06)	(0.02)	(0.06)	(0.02)
Energy Intensive Manufacturing	-14.61^*	1.62	-14.49^*	1.72^*	-15.51^*	1.69^*
	(1.04)	(0.87)	(0.96)	(0.79)	(0.98)	(0.81)
Multinational	0.84	0.54^*	0.81	0.53^*	0.81	0.53^*
	(0.74)	(0.26)	(0.72)	(0.26)	(0.74)	(0.26)
Electricity Provider	0.86	3.59^*	0.86	3.64^*	0.84	3.63^*
	(1.30)	(0.51)	(1.37)	(0.51)	(1.37)	(0.51)
Business Index	0.02	0.02				
	(0.04)	(0.01)				
Tax Burden Index			0.00	0.00		
			(0.03)	(0.02)		
Delaware					-14.27^*	-11.87^*
					(0.83)	(0.58)
N	531	2712	531	2712	531	2724

Logistic regression with standard errors clustered by industry. Dependent variable is support for H.R. 5424 The American Clean Energy and Security Act of 2009. Competitor Costs (Coal Reliance) is share of competitors located in high adjustment cost zip codes as measured by coal usage in electricity generation. Competitor Costs (Coal Reserves) is share of competitors in high adjustment cost zip codes as measured by local coal reserves. * indicates significance at $p < 0.05$.

detailed coding of production locations possible. Firms differ in both the level and nature of details which they provide. Nonetheless this qualitative exploration yields two important insights which form the basis of additional robustness checks.

Figure 16: Locating Firms by State

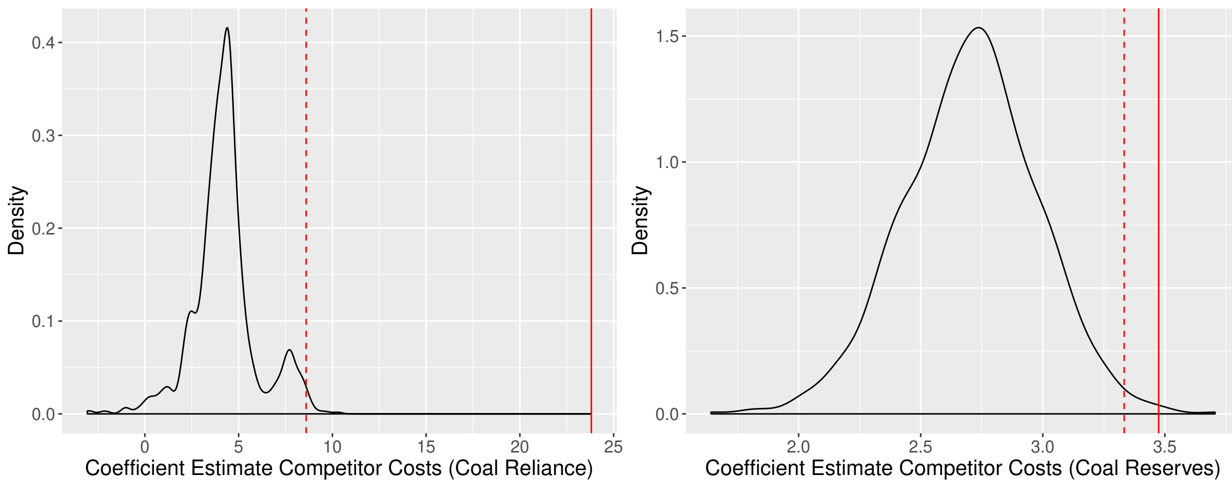


Average marginal effects with 95% confidence intervals. Logistic regression with standard errors clustered by industry. Dependent variable is support for H.R. 5424 The American Clean Energy and Security Act of 2009. Competitor Costs (State-Level Coal Reliance) is share of competitors located in high adjustment cost states as measured by per capita carbon emissions from in electricity generation. Competitor Costs (State-Level Coal Reserves) is share of competitors in high adjustment states as measured by in-state coal reserves. Omitted covariates include Productivity, Net PP&E, Market Cap, Energy Intensive Manufacturing, and Electricity Provider. * indicates significance at $p < 0.05$. Full results available upon request.

First, a significant number of firms do undertake production in locations which differ from their headquarter locations as suggested by the reviewer. However the vast majority of these firms maintain a large portion of their operations within the same state as their headquarter locations. To take this possibility into account I re-estimate the main specification from the text again at the state-level (using both carbon-intensity of electricity generation and presence of coal reserves to mirror the zip-code level analysis) and present these results as an additional robustness check. The marginal effects of these specifications are presented in Figure 16.

Second, using a randomly selected subset of one hundred firms I estimate the error rate, that is the number of firms for which production does not coincide with headquarter locations in any way. I estimate this rate to be around 15%. Taking this rate into account enables me to perform one last robustness exercise which should re-assure readers that the results could not have occurred by chanced. To do so I randomly select 15% of firms in the sample and randomize their headquarter locations according to the empirical distribution of headquarter locations in the data. I then re-estimate both main specifications in the text and repeat the

Figure 17: Random Assignment of Errors



procedure 1,000 times in order to generate a distribution of coefficient estimates given the specified error rate.

Comparing the true coefficient estimates from the text with these distributions I find in each case that the coefficient estimate exceeds 95% of those generated via the randomization procedure. This confirms that it is highly unlikely that the coefficients estimated in the main text could simply be an artifact of measurement error in the headquarter locations. Figure 17 depicts the distribution and 95th percentile for the resulting coefficient estimates.

Taken collectively these various checks provide overall support for the argument that the results presented in the main text are unlikely to have arisen due either to systematic measurement error or by random chance.

Appendix C1: Endogenous Entry in a Closed Economy

Consider the baseline model in which $N = 2$. We maintain assumption **A1** from the main text and assume that there exists a lower bound on α, $\bar{\alpha}$ such that both incumbent firms optimally produce positive output in equilibrium.[4] Suppose that following the regulatory stage, a set of candidate firms may choose one at a time whether or not to enter the market. Index entrants by $k = 3, 4, ...$ Entrants pay a fixed cost, $f > 0$, and are *ex ante* uncertain of their level of green capital. Let green capital for entrant k be $F_k \in (0, \bar{F})$ for some $\bar{F} > 0$. Green capital is distributed symmetrically for all entrants according to CDF G with associated density g. Upon paying the fixed cost entrants learn their green capital and subsequently compete with the two incumbent firms for market share. I make the following assumption which implies that as variable costs approach zero all K entrants will optimally pay the fixed cost f,

$$\textbf{D1}. \quad \left(\frac{\alpha}{K+2}\right)^2 > f$$

The first potential entrant chooses to pay the fixed cost if and only if expected profits from doing so are strictly positive,

$$\int_0^{\bar{F}} \left[\left(\frac{\alpha + r\left(\sum_{i=1,2} \frac{1}{F_i} - \frac{3}{t}\right)}{4} \right)^2 - f \right] g(t)dt > 0$$

Denote by r_1 the level of regulation which renders the first potential entrant indifferent between paying the fixed cost and not. Setting expected profits above equal to zero and

[4] As in the main text this implies $\bar{\alpha} = R(\frac{2}{F_j} - \frac{1}{F_i})$ where firm j refers to the firm with lower green capital.

rearranging gives,

$$r_1 \int_0^{\bar{F}} \left(\sum_{i=1,2} \frac{1}{F_i} - \frac{3}{t} \right) g(t)dt = -\frac{1}{2\alpha} \left[\alpha^2 - f(N+2)^2 + r_1^2 \int_0^{\bar{F}} \left(\sum_{i=1,2} \frac{1}{F_i} - \frac{3}{t} \right)^2 g(t)dt \right]$$

Note that the right hand side is strictly less than zero by assumption $D1$. Since regulation is strictly positive, a necessary condition for r_1 to be well-defined is that the quantity under the integral on the left hand side is strictly negative. This is equivalent to,

$$\mathbb{E}\left[\frac{1}{F}\right] > \frac{1}{3} \sum_{i=1,2} \frac{1}{F_i}$$

Regulation acts as a barrier to entry only if the expected marginal cost of regulation for each potential entrant is high relative to the incumbents' own costs.

Next, suppose that r_1 is well-defined and consider firm j's profit under r_1 versus it's profit relative to a marginally lower level of regulation, $r^1 - \epsilon$ for $\epsilon > 0$. Firm j's marginal costs are continuously decreasing in the interval $(r^1 - \epsilon, r^1 + \epsilon)$. However profits increase discontinuously at r^1, given the potential entrant's decision not to compete. For $\epsilon \to 0$ the discreet increase in profits due to less competition will strictly dominate the marginal decrease due to higher costs of production. Thus in any equilibrium characterized by $r^* \in (r^1 - \epsilon, r^1)$ firm j strictly prefers r^1 to r^* and therefore lobbies in favor of more stringent regulation. Note that firm i always prefers r_1 to any lower level of regulation since profit for the relatively low cost firm is increasing in r even in the absence of new entry. The threat of entry only serves to intensify firm i's preference for higher levels of regulation.

Appendix C2: Microfoundations of Policy Maker Ideology

Consider the baseline model in which $N = 2$, again maintaining assumption that $\alpha > R(\frac{2}{F_j} - \frac{1}{F_i})$ where $F_i > F_j$. Suppose that policy maker preferences reflect the welfare of a representative voter rather than a fixed ideological stance. Regulation affects voters adversely by raising prices and reducing consumer surplus yet also provides a benefit by reducing future dangers of global climate change. Furthermore, let total profits to the economy be decreasing in the level of regulation, an assumption consistent with substantive predictions regarding climate change regulation.[5] I assume that the voter purchases only the good produced by the two firms and values it according to some strictly increasing but concave function, $v(\cdot)$. The value of regulation is given by $\delta(\cdot)$, also assumed to be strictly increasing and concave. Let q_v denote the voter's equilibrium quantity purchased. The voter's preferences are,

$$u_v(q, r) = v(q_v) - q_v P(q_i, q_j) + \delta(r)$$

Policy maker preferences now reflect the voter's implied welfare,

$$g(r|s_1(\cdot), s_2(\cdot), u_v(\cdot, \cdot)) = \lambda u_v(q, r) + (1 - \lambda)(s_1(r) + s_2(r))$$

Note that for λ sufficiently close to one, the policy maker's preferences are strictly concave by the assumptions on $v(\cdot)$ and $\delta(\cdot)$. The sequence is the same as in the baseline model with the addition of a final stage in which the voter selects a consumption quantity after regulation and production decisions have been made. Before analyzing how the presence of the representative voter affects regulatory levels, consider the voter's optimal consumption in the final period. From the analysis in the main text, for any regulatory outcome r, the

[5] That is $\frac{d\pi_1}{dr} + \frac{d\pi_2}{dr} < 0$. This implies an upper bound on γ_i. If firm i's productivity advantage is large enough then regulation may actually increase economic profit by forcing the inefficient firm to contract.

prevailing equilibrium price is $p(q_i^*, q_j^*) = \frac{1}{3}\left(\alpha + r\left[\frac{1}{F_i} + \frac{1}{F_j}\right]\right)$. In the final stage, the voter takes this price as given and optimally chooses q_v to satisfy the first order condition,

$$v'(q_v^*) - \frac{1}{3}\left(\alpha + r\left[\frac{1}{F_i} + \frac{1}{F_j}\right]\right) = 0$$

Next, consider the policy maker's incentives. By the envelope theorem, the optimal level of regulation satisfies,

$$\lambda\left(\delta'(r^*) - \frac{q_v^*}{3}\left[\frac{1}{F_i} + \frac{1}{F_j}\right]\right) + (1-\lambda)\frac{2}{9}\big([\alpha + r^*\gamma_i]\gamma_i + [\alpha + r^*\gamma_j]\gamma_j\big) = 0$$

Note that the right hand term is strictly less than zero implying that an interior solution requires $\delta'(r^*) > \bar{\delta}$ for some $\bar{\delta} > 0$. The voter's marginal value for regulation in equilibrium must balance the marginal social loss of lower consumption and firm profits.

Substantively this highlights an important explanation for the ultimate failure of the American Clean Energy and Security Act referenced in the text. Beginning in 2007 public support for climate change legislation among the Republican base declined sharply, eroding lawmakers' support for the legislation in spite of endorsement by high-profile members of the business community. Opposition to climate action was a key priority among both tea party activists and conservative elites, a trend largely overlooked by environmental activists who - according to one prominent account - failed to seriously engage in rallying what public support remained (Skocpol, 2013).[6]

The implication of the analysis overall is that pro-environmental lobbying by firms will support the emergence of climate change legislation (and be decisive in that emergence) only when public support reaches a certain threshold. Given the growing popular support for

[6]Though it is unclear to what extent diffuse public support could be effectively mobilized relative to those expected to bear concentrated costs in the form of higher electricity prices. See Stokes (2016) for a discussion of the distributional costs of climate policies across citizens.

climate action in nearly all countries outside the United States the likely future impact of this mechanism may be increasing over time.

Appendix C3: Investments in Energy Efficiency

Finally I consider the role of investment in green capital in the emergence or suppression of green lobbying. If high cost firms anticipate their competitors' strategy of lobbying in favor of climate change, they may find it optimal to invest additional resources in reducing their adjustment costs. Not only does this strategy reduce the costs of any future regulation, it undermines the benefits of green lobbying by competitor firms, making it less likely to emerge.

Consider again the model with only two firms. I analyze an extension in which each firm endogenously chooses whether and how much to invest in reducing future investment costs. Again I maintain assumption **A1** and assume that $\alpha >> 0$ so that both firms optimally produce in equilibrium for any endogenously chosen level of green capital and climate regulation. I assume that firms' green capital is equivalent to investments in energy efficiency. Climate change legislation is designed to reduce carbon emissions by increasing the cost of energy. Thus firms with a more energy efficient capital stock face lower adjustment costs than their competitors who invest fewer resources in efficiency. This interpretation of adjustment costs is not without loss of generality since I also assume that increasing energy efficiency reduces marginal production costs, holding all else equal.[7]

To incorporate investments in energy efficiency I assume that each firm may now choose to invest resources prior to engaging in market competition. Investment is costly *ex ante* but leads to lower marginal costs during the subsequent competition stage. Denote each firm's initial endowment of green capital by $\tilde{F}_i$. Costs are linear and given by,

$$h(F_i, \tilde{F}_i) = c_i(F_i - \tilde{F}_i)$$

for $c_i > 0$ for $i = 1, 2$. F_i can now be interpreted as firm i's green capital net investment.

[7] An implication of this is that firms benefit from their investments regardless of the regulatory outcome.

Firms pay no cost in order to maintain their initial level of efficiency (i.e. there is no depreciation). Once investments have been made, firms have the opportunity to participate in the political process and engage in market competition as before. The sequence of play and all other parameters of the model remain the same as in the baseline case.

Proposition 8. *If $c_i \neq c_j$ then levels of green capital never converge.*

Proof of Proposition 8

First we characterize equilibrium investments in the extended game. Conditional on firms behaving optimally, we can define the following function which maps each firm's green capital along with its competitor's to its expected profits,

$$\tilde{\pi}_i(q_i^*(F_i, F_j), F_i)$$

Similarly, firm i's campaign contribution, conditional on optimality, can be written as a function of both firms' green capital,

$$\tilde{s}_i(F_i, F_j)$$

We use these two functions to define the following value function,

$$V_i(F_i|F_j) = \tilde{\pi}_i(q_i^*(F_i, F_j), F_i) - \tilde{s}_i(F_i, F_j)$$

When choosing its optimal level of investment, firm i solves,

$$\underset{F_i}{Max} \quad V_i(F_i|F_j) - h(F_i, \tilde{F}_i)$$

and likewise for firm j. Applying the envelope theorem, the first order conditions yield the following system of equations,

$$h'(F_i, \tilde{F}_i) = \frac{\partial \tilde{\pi}_i(q_i^*(F_i, F_j), F_i)}{\partial F_i}$$
$$h'(F_j, \tilde{F}_i) = \frac{\partial \tilde{\pi}_j(q_j^*(F_j, F_i), F_j)}{\partial F_j}$$

Note that by the envelope theorem both q_i and q_j remain unchanged as does equilibrium price which is completely determined by those two quantities. Thus F_i affects profits directly only through its effect on marginal cost, that is through equilibrium regulation and through the direct effect of F_i. Equilibrium investments are a pair (F_i^*, F_j^*) defined by the following system of equations,

$$c_i = \frac{q_i^*(F_i, F_j)}{F_i^2}\left(r^* - \frac{1}{F_i}\left[\frac{\alpha\beta + 2r^*\beta(2\gamma_i - \gamma_j)}{1 - \beta(\gamma_i^2 + \gamma_j^2)}\right]\right)$$
$$c_j = \frac{q_j^*(F_j, F_i)}{F_j^2}\left(r^* - \frac{1}{F_j}\left[\frac{\alpha\beta + 2r^*\beta(2\gamma_j - \gamma_i)}{1 - \beta(\gamma_i^2 + \gamma_j^2)}\right]\right)$$

Let $f(F_i, F_j) = \frac{q_i^*(F_i,F_j)}{F_i^2}\left(r^* - \frac{1}{F_i}\left[\frac{\alpha\beta+2r^*\beta(2\gamma_i-\gamma_j)}{1-\beta(\gamma_i^2+\gamma_j^2)}\right]\right)$. Suppose that $c_i \neq c_j$, but $F_i^* = F_j^* = F^*$. Then $f(F_i, F_j) = f(F_j, F_i) = f(F^*, F^*)$. Without loss of generality, assume $c_i > c_j$. But then $c_i = f(F^*, F^*) = c_j$, a contradiction.

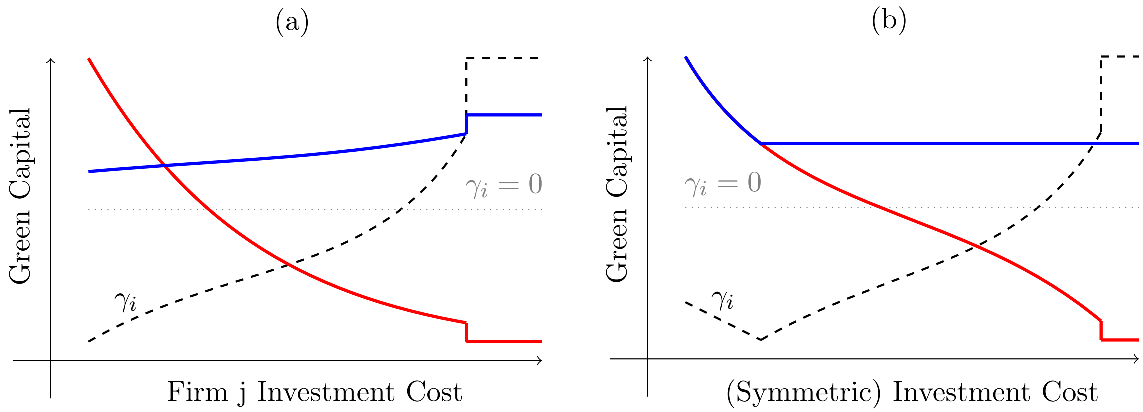
■

Proposition 8 establishes that except in the case in which firms face identical costs of investment, investments are unlikely to eradicate heterogeneity. Figure (18a) depicts equilibrium green capital (net of investment) for two firms facing heterogeneous costs. In the absence of investment firm i favors regulation and optimally lobbies in support. In the presence of investment, asymmetry of costs becomes a key determinant of heterogeneity. On the left hand side, when firm j's costs are low relative to those of firm i, firm j invests substantially in equilibrium, overtaking his competitor as the relatively low-cost firm. As firm j's per unit cost of investment increases, his investment falls while his opponent's investment rises moderately. The two converge only at the point at which $c_i = c_j = 2$. After this point firm i once again retains his position as the low-cost firm. When cost differentials are high, $\gamma_i > 0$ meaning that sufficient heterogeneity remains that firm i is willing to support climate change regulation in equilibrium.

Figure (18b) depicts the case in which firms face identical marginal costs of investment. When costs are sufficiently low (on the left hand side), equilibrium green capital converges exactly. Firm j invests at a faster rate than firm i, eliminating all heterogeneity. As costs increase, both firms invest lower amounts until firm i's investment is driven to zero. Beyond this point firm i's equilibrium green capital remains equal to its initial endowment. Firm j's investment continues to decline. Even in the case of symmetric costs then, when those costs are sufficiently high, heterogeneity persists.

Of course this analysis is limited to a one-shot policy making game. Climate change policy making and the investment choices which firms make in anticipation of that policy making is inherently dynamic. The results presented so far leave ambiguous how levels of investment might evolve in a dynamic version of the model. It seems possible that "virtuous cycles" might emerge in which green firms over time continue to invest, enhancing their advantage over the competition and leading to stricter climate change regulation over time. In contrast it is possible that the costs of climate change regulation spur additional investment by inferior firms, reducing the gap in adjustment costs between competitors and undermining incentives to support climate change legislation. Future work could explore these dynamic considerations in more detail.

Figure 18: Equilibrium Investments in Green Capital



Equilibrium green capital for firms i (blue) and j (red) when initial endowments are $\tilde{F}_i = 3$ and $\tilde{F}_j = 1$. In panel (a) firm i's investment cost is fixed at $c_i = 2$. In panel (b) firm investment costs are symmetric. Convergence occurs only when costs are symmetric and small (left side of panel (b)).

Appendix C4: Industries with Multiple Firms (Closed Economy)

In the benchmark analysis I restricted attention to the case in which only two firms compete for market share. How does the presence of multiple competitors within industry affect incentives to lobby for particular policies even in the absence of foreign competitors? Consider a variation of the original model in which a set of N firms with asymmetric costs compete for market share. Again, I assume that all firms produce a single homogeneous good and $\alpha > R(\frac{M}{F_j} - \sum_{k \neq j} \frac{1}{F_k})$ where $F_j = \min(F_1, ..., F_n)$. As in the original model, each firm $i \in \{1, ..., n\}$ has marginal cost $\frac{r}{F_i}$ where $F_i \neq F_j$ for all $i, j \in \{1, ..., n\}$. All other features of the model remain the same. In contrast to the competitive equilibrium with only two firms, in which one firm lobbied in favor of regulation and one firm lobbied against, in the case of N firms a competitive equilibrium will consist of some strict *subset* of firms lobbying in favor of regulation with the remaining firms lobbying against. Denote by F^H_{-i} the harmonic mean of green capital for all firms $j \neq i$.[8]

Proposition 9. *Let $\mathcal{G} \subset N$ be the subset of firms who lobby in favor of regulation in*

[8] That is, $\frac{1}{\frac{1}{N-1}\sum_{j \neq i} \frac{1}{F_j}}$

equilibrium. If,

$$F_i > \frac{N}{N-1} F_{-i}^H$$

for at least one firm, then $\mathcal{G}$ is non-empty.

Proof of Proposition 9 In the model with N firms, firm i solves

$$max_{q_i} q_i \left(\alpha - \sum_i q_i - \frac{r}{F_i} \right)$$

Firm i's best response is,

$$\tilde{q}_i = \frac{1}{2} \left(\alpha - \sum_{j \neq i} q_j - \frac{r}{F_i} \right)$$

Note that equilibrium price is given by $P(Q) = \alpha - Q$ where Q denotes total demand. Re-writing i's best response in terms of this equilibrium price yields,

$$\tilde{q}_i = P(Q) - \frac{r}{F_i} \tag{17}$$

Summing across all i and re-arranging we obtain the following expression for equilibrium price in terms of primitives, $P(Q) = \frac{\alpha + r \sum_j \frac{1}{F_j}}{N+1}$. Plugging this back into the best response gives i's optimal production level,

$$q_i^{*,N} = \frac{1}{N+1} \left[\alpha + r \left(\sum_{j \neq i} \frac{1}{F_j} - \frac{N}{F_i} \right) \right]$$

Note that (17) is also exactly equivalent to firm i's per unit net revenue. Thus equilibrium profits are,

$$\pi_i^N = \frac{1}{(N+1)^2} \left[\alpha + r \left(\sum_{j \neq i} \frac{1}{F_j} - \frac{N}{F_i} \right) \right]^2$$

Differentiating with respect to r and re-arranging yields,

$$\frac{d\pi_i}{dr} = \frac{2}{(N+1)^2}\left[\alpha + r\left(\sum_{j\neq i}\frac{1}{F_j} - \frac{N}{F_i}\right)\right]\cdot\left[\sum_{j\neq i}\frac{1}{F_j} - \frac{N}{F_i}\right]$$

Thus firm i's profits are increasing in r whenever $\gamma_i^N = \sum_{j\neq i}\frac{1}{F_j} - \frac{N}{F_i} > 0$ or,

$$F_i > \frac{N}{N-1}\cdot F_{-i}^H$$

where F_{-i}^H is the harmonic mean of green capital for all firms not including i.[9] Note that for $N = 2$ this condition reduces to the same condition as in the baseline model, $F_i > 2F_j$. The condition for non-emptiness of $\mathcal{G}$ then follows from the last expression. ■

In equilibrium, any firm whose green capital meets the condition above will lobby in favor of climate change policy. The harmonic mean in this context is equivalent to the reciprocal of the mean marginal adjustment cost for all competitor firms. In other words, if $F_i > F_{-i}^H$ then firm i's marginal adjustment cost is strictly less than the mean adjustment cost of its competitors. For i to lobby in favor of climate change legislation it must be the case that F_i exceeds the harmonic mean of competitor green capital by an amount which is decreasing in N. When $N = 2$ the required difference is at its greatest, and the condition simplifies to exactly that which obtained in the case of two firms, $F_i > 2F_j$. For N very large the required difference goes to zero and the condition reduces to $F_i > F_{-i}^H$. This is a far stronger result than that established earlier in the case of two firms (Proposition 2) in which competitive lobbying emerged for *some* parameter values. Here, for N sufficiently large, if firm costs are not perfectly symmetric then in *every* equilibrium there exists a non-empty subset of firms who optimally lobby in favor of higher regulation.

[9]That is, $F_{-i}^H = \frac{1}{\frac{1}{N-1}\sum_{j\neq i}\frac{1}{F_j}}$.

References

Susmita Dasgupta, Benôit Laplante, and Nlandu Mamingi. Capital market responses to environmental performance in developing countries. *World Bank Development Research Group*, 1998. URL http://web.worldbank.org/archive/website01004/WEB/IMAGES/12852832.PDF.

S.P. Kothari and Jerold B. Warner. Econometrics of event studies. In B. Espen Eckbo, editor, *Handbookd of Corporate Finance, Volume 1*. Elsevier B.V., 2007.

Jeffrey Kucik and Krzysztof J. Pelc. Do international rulings have spillover effects? the view from financial markets. *World Politics*, 68(4):713–751, 2016.

Theda Skocpol. Naming the problem: What it will take to counter extremism and engage americans in the fight against global warming. 2013.

Leah C Stokes. Electoral backlash against climate policy: A natural experiment on retrospective voting and local resistance to public policy. *American Journal of Political Science*, 60(4):958–974, 2016.

Leah C Stokes and Hanna L Breetz. Politics in the us energy transition: Case studies of solar, wind, biofuels and electric vehicles policy. *Energy Policy*, 113:76–86, 2018.

Meredith Wilf. Credibility and distributional effects of international banking regulations: Evidence from us bank stock returns. *International Organization*, 70:763–796, 2016.