

Appendix: Information and Climate (In)action

Contents

Proofs of Domestic Politics Model	A-1
Domestic Politics: Equilibrium	A-1
Domestic Politics: Results	A-5
Extension: Pro-Climate Interest Group	A-7
Extension: Politician and Interest Group Signal	A-10
Proofs of International Cooperation Model	A-12
International Cooperation: Equilibrium	A-12
International Cooperation: Results	A-22
Additional Figures	A-26

Proofs of Domestic Politics Model

Domestic Politics: Equilibrium

I prove Proposition 1 with a series of two lemmas. The first establishes equilibrium behavior in the climate policy subgame, and the second characterizes the optimal misreporting level given this equilibrium behavior.

Define $\hat{\sigma}(\theta, \omega)$ as the voter's belief that probability that the politician chooses $a = 1$ when she is of type θ and the state of the world is ω . Define $B(\theta, a, s)$ as proportional to the *ex ante* probability that a politician of type θ chooses action a and signal s is realized. Then we have

$$B(\theta, 1, s) = P(\theta) \left(\pi \hat{\sigma}(\theta, 1) + (1 - \pi) \hat{\sigma}(\theta, 0) \frac{P(s|s \neq \omega)}{P(s|s = \omega)} \right).$$

$$B(\theta, 0, s) = P(\theta) \left(\pi (1 - \hat{\sigma}(\theta, 1)) + (1 - \pi) (1 - \hat{\sigma}(\theta, 0)) \frac{P(s|s \neq \omega)}{P(s|s = \omega)} \right).$$

This means that the voter's posterior belief that the politician is competent, following policy choice a , is given by

$$\mu(a, s) = \frac{P(a, s|\theta = 1)P(\theta = 1)}{P(a, s|\theta = 1)P(\theta = 1) + P(a, s|\theta = 0)P(\theta = 0)} = \frac{B(1, a, s)}{B(1, a, s) + B(0, a, s)}.$$

Lemma A.1 *A unique cutoff \tilde{x}^* exists, admitting a unique perfect Bayesian equilibrium to the climate policy subgame. A politician of type θ chooses policy $a = 1$ given signal x^θ with probability $\sigma^*(\theta, x^\theta) \in [0, 1]$. These probabilities are*

$$\sigma^*(1, x^1) = x^1 = \omega.$$

$$\sigma^*(0, x^0) = 1 - G(\tilde{x}^*; \omega).$$

Upon observing policy a and signal s , the voter reelects the politician with probability $F(\mu^*(a, s; \tilde{x}^*)$.

Proof of Lemma A.1: It is straightforward that following any history in which the politician chooses policy a and the voter observes signal s the voter has posterior belief $P(\theta = 1|a, s) = \mu(a, s)$,

the voter reelects the politician if and only if $\mu(a, s) \geq \varepsilon$, which occurs with probability $F(\mu(a, s))$.

The competent politician, whose signal of ω is perfect, always chooses $a = 1$ following signal $x^1 = 1$:

$$1 + \beta F(\mu(1, 0)) + (1 - \beta)F(\mu(1, 1)) \geq \beta F(\mu(0, 0)) + (1 - \beta)F(\mu(0, 1)) \Leftrightarrow 1 \geq -\beta\Delta(0) - (1 - \beta)\Delta(1).$$

Similarly, she never chooses $a = 1$ following signal $x^1 = 0$:

$$F(\mu(1, 0)) \leq 1 + F(\mu(0, 0)) \Leftrightarrow \Delta(0) \leq 1.$$

Given the value of her private signal $x^0 = x$, the incompetent politician's posterior belief about the state is $\eta(x) = P(\omega = 1|x) = \frac{\pi g(x; 1)}{\pi g(x; 1) + (1 - \pi)g(x; 0)}$. Write $\Delta(s) = F(\mu(1, s)) - F(\mu(0, s))$. The incompetent type therefore chooses $a = 1$ if and only if

$$\begin{aligned} & \eta(x) + \beta\eta(x)F(\mu(1, 0)) + (1 - \beta)\eta(x)F(\mu(1, 1)) + (1 - \eta(x))F(\mu(1, 0)) \geq \\ & (1 - \eta(x)) + \beta\eta(x)F(\mu(0, 0)) + (1 - \beta)\eta(x)F(\mu(0, 1)) + (1 - \eta(x))F(\mu(0, 0)) \\ \Leftrightarrow & \eta(x) \geq \frac{1 - \Delta(0)}{2 + (1 - \beta)(\Delta(1) - \Delta(0))}. \end{aligned}$$

Define \tilde{x} as the signal that solves

$$2\eta(\tilde{x}) - 1 + (1 - \beta)\eta(\tilde{x})\Delta(1; \tilde{x}) + (1 - \eta(\tilde{x}) + \beta\eta(\tilde{x}))\Delta(0; \tilde{x}) = 0, \quad (1)$$

where the cutoff \tilde{x} induces voter posterior beliefs

$$\begin{aligned} \mu^*(1, 0; \tilde{x}) &= \frac{\tau\pi}{\tau\pi + (1 - \tau)\pi(1 - G(\tilde{x}; 1)) + (1 - \tau)(1 - \pi)\frac{\beta}{1 - \beta}(1 - G(\tilde{x}; 0))}. \\ \mu^*(1, 1; \tilde{x}) &= \frac{\tau}{\tau + (1 - \tau)(1 - G(\tilde{x}; 1))}. \\ \mu^*(0, 0; \tilde{x}) &= \frac{\tau(1 - \pi)\frac{\beta}{1 - \beta}}{\tau(1 - \pi)\frac{\beta}{1 - \beta} + (1 - \tau)(\pi G(\tilde{x}; 1) + (1 - \pi)\frac{\beta}{1 - \beta}G(\tilde{x}; 0))}. \\ \mu^*(0, 1; \tilde{x}) &= 0. \end{aligned}$$

Differentiating Equation 1 with respect to \tilde{x} yields

$$2\frac{\partial\eta(\tilde{x})}{\partial\tilde{x}} + (1-\beta)\frac{\partial\eta(\tilde{x})}{\partial\tilde{x}}(\Delta(1;\tilde{x}) - \Delta(0;\tilde{x})) + (1-\beta)\eta(\tilde{x})\frac{\partial\Delta(1;\tilde{x})}{\partial\tilde{x}} + (1-\eta(\tilde{x})\beta\eta(\tilde{x}))\frac{\partial\Delta(0;\tilde{x})}{\partial\tilde{x}}.$$

Since $g(\cdot)$ has the monotone likelihood ratio property, $\eta(\tilde{x})$ is increasing in \tilde{x} . Now observe that $\mu^*(1,0;\tilde{x})$ is increasing in \tilde{x} and $\mu^*(0,0;\tilde{x})$ is decreasing in \tilde{x} , which means that $\Delta(0)$ is increasing in \tilde{x} . Moreover, $\mu^*(1,1;\tilde{x})$ is increasing in \tilde{x} so $\Delta(1)$ is increasing in \tilde{x} . Further, by definition of posterior beliefs we have $\Delta(1;\tilde{x}) \geq \Delta(0;\tilde{x})$ so this expression is increasing in \tilde{x} . Hence by the intermediate value theorem there is a unique \tilde{x}^* solving Equation 1 such that the incompetent politician plays $a = 1$ when $x^0 > \tilde{x}^*$ and plays $a = 0$ when $x^0 \leq \tilde{x}^*$. ■

Corollary A.1 *The equilibrium cutoff \tilde{x}^* is increasing in β .*

Proof of Corollary A.1: Using the definition of the cutoff \tilde{x}^* , define the function $I(\tilde{x})$ as

$$I(\tilde{x}) := 2\eta(\tilde{x}) - 1 + (1-\beta)\eta(\tilde{x})\Delta(1;\tilde{x}) + (1-\eta(\tilde{x}) + \beta\eta(\tilde{x}))\Delta(0;\tilde{x}),$$

and note that the equilibrium cutoff is defined by the value \tilde{x}^* such that $I(\tilde{x}^*) = 0$. Further observe that, by definition of the existence of the equilibrium cutoff, $\frac{\partial I(\tilde{x})}{\partial \tilde{x}} > 0$. By the implicit function theorem,

$$\frac{d\tilde{x}^*}{d\beta} = -\frac{\partial I(\tilde{x})/\partial\beta}{\partial I(\tilde{x})/\partial\tilde{x}}.$$

Partially differentiating with respect to β yields

$$\frac{\partial I(\tilde{x})}{\partial\beta} = -\eta(\tilde{x})\left(\Delta(1;\tilde{x}) - \Delta(0;\tilde{x})\right) + (1-\eta(\tilde{x}) + \beta\eta(\tilde{x}))\frac{\partial\Delta(0;\tilde{x})}{\partial\beta}.$$

Now observe that

$$\frac{\partial\mu^*(1,0;\tilde{x})}{\partial\beta} = -\frac{\tau\pi(1-\tau)(1-\pi)(1-G(\tilde{x};0))}{(\tau\pi + \beta(1-\pi)(1-\tau)(1-G(\tilde{x};0)) + \pi(1-\tau)(1-G(\tilde{x};1)))^2} < 0,$$

and

$$\frac{\partial \mu^*(0, 0; \tilde{x})}{\partial \beta} = \frac{\tau\pi(1-\pi)(1-\tau)G(\tilde{x}; 1)}{(\beta(1-\pi)(\tau + (1-\tau)G(\tilde{x}; 0) + \pi(1-\tau)G(\tilde{x}; 1))^2} > 0$$

. Therefore $\frac{\partial \Delta(0)}{\partial \beta} < 0$. Hence $\frac{\partial I(\tilde{x})}{\partial \beta} < 0$ so by the implicit function theorem, $\frac{d\tilde{x}^*}{d\beta} > 0$. ■

Lemma A.2 *Given an equilibrium cutoff \tilde{x}^* , there exists an optimal $\beta^* \in [0, 1]$.*

Proof of Lemma A.2: The special interest group's objective function is

$$\max_{\beta \in [0, 1]} 1 - \tau\pi - (1 - \tau)\pi(1 - G(\tilde{x}^*(\beta); 1)) - (1 - \tau)(1 - \pi)(1 - G(\tilde{x}^*(\beta); 0)) - c(\beta).$$

Differentiating with respect to β yields the first-order condition

$$(1 - \tau)\pi g(\tilde{x}^*(\beta); 1) \frac{d\tilde{x}^*}{d\beta} + (1 - \tau)(1 - \pi)g(\tilde{x}^*(\beta); 0) \frac{d\tilde{x}^*}{d\beta} - c'(\beta) = 0.$$

Since the objective function is continuous and β is maximized along a compact interval, it must have both a maximum and a minimum. It is clear that the first-order condition must have at least one solution, as rearranging gives

$$(1 - \tau) \frac{d\tilde{x}^*}{d\beta} \left(\pi g(\tilde{x}^*; 1) + (1 - \pi)g(\tilde{x}^*; 0) \right) = c'(\beta),$$

but this solution may characterize either a maximum or a minimum. A maximum is characterized

whenever the second-order condition is negative at the solution to the above first-order condition.

The second order condition is

$$\begin{aligned} SOC &= (1 - \tau)\pi g(\tilde{x}^*; 1) \frac{d^2\tilde{x}^*}{d\beta^2} + (1 - \tau)\pi g'(\tilde{x}^*; 1) \left(\frac{d\tilde{x}^*}{d\beta} \right)^2 + (1 - \tau)(1 - \pi)g(\tilde{x}^*; 0) \frac{d^2\tilde{x}^*}{d\beta^2} \\ &\quad + (1 - \tau)(1 - \pi)g'(\tilde{x}^*; 0) \left(\frac{d\tilde{x}^*}{d\beta} \right)^2 - c''(\beta). \\ &= (1 - \tau) \left(\frac{d\tilde{x}^*}{d\beta} \right)^2 (\pi g'(\tilde{x}^*; 1) + (1 - \pi)g'(\tilde{x}^*; 0)) + \frac{d^2\tilde{x}^*}{d\beta^2} \left(\frac{d\tilde{x}^*}{d\beta} \right)^{-1} c'(\beta) - c''(\beta), \end{aligned}$$

where the simplification follows from substituting from the first-order condition that $\pi g(\tilde{x}^*; 1) +$

$$(1 - \pi)g(\tilde{x}^*; 0) = \frac{c'(\beta)}{1-\tau} \left(\frac{d\tilde{x}^*}{d\beta} \right)^{-1}.$$

The second-order condition is not readily globally concave: the sign of the first term depends on the value of \tilde{x}^* by log-concavity of $g(\cdot)$, the second term depends on the sign of $\frac{d^2\tilde{x}^*}{d\beta^2}$, and the third term is negative. But note that if the second-order condition fails at the critical point, the maximum of the objective function must be on the corner. Further, from the first-order condition, observe that if $c'(\beta) \rightarrow 0$, the LHS is strictly positive and so the optimal solution is a corner solution at $\beta^* = 1$. If $c'(\beta)$ is relatively large, the LHS is strictly negative and the optimal solution is a corner solution at $\beta^* = 0$. ■

Proof of Proposition 1: Immediate from Lemmas A.1 and A.2. ■

Domestic Politics: Results

This section proves Results 1 and 2.

Recall from the main text that the probability of climate action is written as

$$A(\tilde{x}^*) = \tau\pi + (1 - \tau)\pi(1 - G(\tilde{x}^*; 1)) + (1 - \tau)(1 - \pi)(1 - G(\tilde{x}^*; 0)).$$

Proof of Result 1: Differentiating with respect to β yields

$$\frac{dA(\tilde{x}^*)}{d\beta} = -(1 - \tau)\pi g(\tilde{x}^*; 1) \frac{d\tilde{x}^*}{d\beta} - (1 - \tau)(1 - \pi)g(\tilde{x}^*; 0) \frac{d\tilde{x}^*}{d\beta} < 0.$$

■

Before proving Result 2, I prove a result about the cutoff \tilde{x}^* .

Lemma A.3 *The following are true about the incompetent politician's equilibrium cutoff:*

$$1. \lim_{\pi \rightarrow 0} \tilde{x}^* = \infty.$$

$$2. \lim_{\pi \rightarrow 1} \tilde{x}^* = -\infty.$$

Proof of Lemma A.3:

1. It is immediate that when $\pi \rightarrow 0$, we have $\eta(x) \rightarrow 0$ for any x . Then

$$\lim_{\pi \rightarrow 0} I(\tilde{x}) = -1 + \lim_{\pi \rightarrow 0} \Delta(0; \tilde{x}),$$

where the second term is less than 1 given the definition of the posterior beliefs induced by any \tilde{x} . Hence $\lim_{\pi \rightarrow 0} I(\tilde{x}) < 0$, which means it is never optimal for the incompetent politician to choose $a = 1$, meaning $\tilde{x}^* \rightarrow \infty$.

2. It is immediate that when $\pi \rightarrow 1$, we have $\eta(x) \rightarrow 1$ for any x . Then

$$\lim_{\pi \rightarrow 1} I(\tilde{x}) = 1 + (1 - \beta)\Delta(1; \tilde{x}) + \beta\Delta(0; \tilde{x}),$$

where the first two terms are positive and the third term is at most -1 given the definition of the posterior beliefs induced by any \tilde{x} . Hence $\lim_{\pi \rightarrow 1} I(\tilde{x}) > 0$, which means it is always optimal for the incompetent politician to choose $a = 1$, meaning $\tilde{x}^* \rightarrow -\infty$.

■

Proof of Result 2: Define the function $I_\beta(\beta)$ as

$$I_\beta(\beta) := (1 - \tau)\pi g(\tilde{x}^*(\beta); 1) \frac{d\tilde{x}^*}{d\beta} + (1 - \tau)(1 - \pi)g(\tilde{x}^*(\beta); 0) \frac{d\tilde{x}^*}{d\beta} - c'(\beta) = 0.$$

Observe that, by Lemma A.3, at $\pi = 0$ and $\pi = 1$, $I_\beta < 0$ for any $\beta > 0$ and $I_\beta = 0$ for $\beta = 0$ so it is optimal for the special interest group to be truthful, $\beta^* = 0$. Further by Rolle's theorem there must be a $\hat{\pi} \in (0, 1)$ where $\frac{\partial I_\beta(\beta)}{\partial \pi} = 0$, meaning that β^* is nonmonotonic in π .

Partially differentiating yields

$$\begin{aligned} \frac{\partial I_\beta(\beta)}{\partial \pi} &= (1 - \tau) \left[g(\tilde{x}^*; 1) \frac{d\tilde{x}^*}{d\beta} + \pi g'(\tilde{x}^*; 1) \frac{d\tilde{x}^*}{d\pi} \frac{d\tilde{x}^*}{d\beta} + \pi g(\tilde{x}^*; 1) \frac{d^2\tilde{x}^*}{d\beta d\pi} \right. \\ &\quad \left. - g(\tilde{x}^*; 0) \frac{d\tilde{x}^*}{d\beta} + (1 - \pi)g'(\tilde{x}^*; 0) \frac{d\tilde{x}^*}{d\pi} \frac{d\tilde{x}^*}{d\beta} + (1 - \pi)g(\tilde{x}^*; 0) \frac{d^2\tilde{x}^*}{d\beta d\pi} \right]. \end{aligned}$$

$$\Leftrightarrow \frac{\partial I_\beta(\beta)}{\partial \pi} = (1 - \tau) \left[\left(g(\tilde{x}^*; 1) - g(\tilde{x}^*; 0) \right) \frac{d\tilde{x}^*}{d\beta} + \left(\pi g'(\tilde{x}^*; 1) + (1 - \pi)g'(\tilde{x}^*; 0) \right) \frac{d\tilde{x}^*}{d\pi} \frac{d\tilde{x}^*}{d\beta} \right. \\ \left. + \left(\pi g(\tilde{x}^*; 1) + (1 - \pi)g(\tilde{x}^*; 0) \right) \frac{d^2\tilde{x}^*}{d\beta d\pi} \right].$$

Observe that at $\pi = 0$ and $\pi = 1$, $\frac{\partial I_\beta(\beta)}{\partial \pi} = 0$, implying that such points are extrema, and we know that $\beta^* = 0$ in these cases. But because $\beta \in [0, 1]$, these must be minima. Then the point $\hat{\pi}$ which is defined by Rolle's theorem must be an interior maximum such that β^* is increasing when $\pi < \hat{\pi}$ and decreasing when $\pi > \hat{\pi}$. Such a $\hat{\pi}$ is characterized by $\frac{\partial I_\beta(\beta)}{\partial \pi} = 0$ and $\frac{\partial^2 I_\beta(\beta)}{\partial \pi^2} \leq 0$. ■

Extension: Pro-Climate Interest Group

Suppose that instead of a special interest group biased against climate action, the group that disseminates information to the voter is in favor of ambitious climate policies. Specifically, the group designs a signal $s \in \{0, 1\}$ according to the experiment

$$\mathcal{E}(s = 0, \omega = 0) = 1 - \gamma. \quad \mathcal{E}(s = 1, \omega = 0) = \gamma.$$

$$\mathcal{E}(s = 0, \omega = 1) = 0. \quad \mathcal{E}(s = 1, \omega = 1) = 1.$$

The interest group therefore chooses the parameter $\gamma \in [0, 1]$. All of the analysis remains as before. I characterize the equilibrium of the climate policy subgame and show that the special interest's optimal choice of γ exists, as in the main text for an anti-climate interest group.

Lemma A.4 *A unique cutoff \tilde{x}^* exists, admitting a unique perfect Bayesian equilibrium to the climate policy subgame with a pro-climate interest group. A politician of type θ chooses policy $a = 1$ given signal x^θ with probability $\sigma^*(\theta, x^\theta) \in [0, 1]$. These probabilities are*

$$\sigma^*(1, x^1) = x^1 = \omega.$$

$$\sigma^*(0, x^0) = 1 - G(\tilde{x}^*; \omega).$$

Upon observing policy a and signal s , the voter reelects the politician with probability $F(\mu^*(a, s; \tilde{x}^*))$.

Proof of Lemma A.4: The voter observes (a, s) and retains the politician when $\mu(a, s) \geq \varepsilon$, occurring with probability $F(\mu(a, s))$.

The competent politician always follows her signal. If $x^1 = 1$, playing $a = 1$ is optimal:

$$1 + F(\mu(1, 1)) \geq F(\mu(0, 1)) \Leftrightarrow 1 \geq -\Delta(1).$$

Similarly, if $x^1 = 0$, the competent politician chooses $a = 0$:

$$\gamma F(\mu(1, 1)) + (1 - \gamma)F(\mu(1, 0)) \leq 1 + \gamma F(\mu(0, 1)) + (1 - \gamma)F(\mu(0, 0)) \Leftrightarrow \gamma\Delta(1) + (1 - \gamma)\Delta(0) \leq 1.$$

Given the signal $x^0 = x$, the incompetent type chooses $a = 1$ iff

$$\begin{aligned} & \eta(x) + \gamma(1 - \eta(x))F(\mu(1, 1)) + (1 - \gamma)(1 - \eta(x))F(\mu(1, 0)) + \eta(x)F(\mu(1, 1)) \geq \\ & (1 - \eta(x)) + \gamma(1 - \eta(x))F(\mu(0, 1)) + (1 - \gamma)(1 - \eta(x))F(\mu(0, 0)) + \eta(x)F(\mu(0, 1)) \\ \Leftrightarrow & 2\eta(x) - 1 + (\gamma - \gamma\eta(x) + \eta(x))\Delta(1) + (1 - \gamma)(1 - \eta(x))\Delta(0) \geq 0. \end{aligned}$$

Let \tilde{x} be the value of x that solves this at equality. The posterior beliefs induced by these strategies are

$$\begin{aligned} \mu(1, 0) &= 0. \\ \mu(1, 1) &= \frac{\tau\pi\frac{\gamma}{1-\gamma}}{\pi\frac{\gamma}{1-\gamma}(\tau + (1 - \tau)(1 - G(\tilde{x}; 1))) + (1 - \pi)(1 - G(\tilde{x}; 0))}. \\ \mu(0, 0) &= \frac{\tau}{\tau + (1 - \tau)G(\tilde{x}; 0)}. \\ \mu(0, 1) &= \frac{\tau(1 - \pi)}{(1 - \pi)(\tau + (1 - \tau)G(\tilde{x}; 0)) + (1 - \tau)\pi\frac{\gamma}{1-\gamma}G(\tilde{x}; 1)}. \end{aligned}$$

Differentiating the incompetent type's constraint with respect to x yields

$$2 - \frac{\partial\eta(x)}{\partial x}(1 - \gamma)(\Delta(1) + \Delta(0)) + (\gamma(1 - \eta(x)) + \eta(x))\frac{\partial\Delta(1)}{\partial x} + (1 - \eta(x))(1 - \gamma)\frac{\partial\Delta(0)}{\partial x}.$$

Since $\mu(0, 0)$ is decreasing in \tilde{x} , $\Delta(0)$ is increasing in \tilde{x} . Similarly, $\mu(1, 1)$ is increasing in \tilde{x} and $\mu(0, 1)$ is decreasing in \tilde{x} . Hence by the intermediate value theorem there is a \tilde{x}^* such that the incompetent type plays $a = 1$ iff $x^0 \geq \tilde{x}^*$. ■

Corollary A.2 *The equilibrium signal cutoff \tilde{x} is decreasing in γ in the model with a pro-climate interest group.*

Proof of Corollary A.2: Define the function

$$I_\gamma(\tilde{x}) := 2\eta(\tilde{x}) - 1 + (\gamma - \gamma\eta(\tilde{x}) + \eta(\tilde{x}))\Delta(1; \tilde{x}) + (1 - \gamma)(1 - \eta(\tilde{x}))\Delta(0; \tilde{x}).$$

Clearly, $I_\gamma(\tilde{x})$ is increasing in \tilde{x} and the point \tilde{x}^* is defined by $I_\gamma(\tilde{x}^*) = 0$. By the implicit function theorem,

$$\frac{d\tilde{x}^*}{d\gamma} = -\frac{\partial I_\gamma(\tilde{x})/\partial\gamma}{\partial I_\gamma(\tilde{x})/\partial\tilde{x}}.$$

Differentiating with respect to γ yields

$$\frac{\partial I_\gamma(\tilde{x})}{\partial\gamma} = (1 - \eta(\tilde{x}))(\Delta(1; \tilde{x}) - \Delta(0; \tilde{x})) + (\gamma - \gamma\eta(\tilde{x}) + \eta(\tilde{x}))\frac{\partial\Delta(1; \tilde{x})}{\partial\gamma}.$$

Now, $\mu(1, 1)$ is increasing in γ and $\mu(1, 0)$ is decreasing in γ so $\frac{\partial\Delta(1; \tilde{x})}{\partial\gamma} > 0$. Hence $\frac{\partial I_\gamma(\tilde{x})}{\partial\gamma} > 0$ so by the implicit function theorem $\frac{d\tilde{x}^*}{d\gamma} < 0$. ■

Lemma A.5 *Given equilibrium behavior in the climate policy subgame with a pro-climate interest group, there exists an optimal $\gamma^* \in [0, 1]$.*

Proof of Lemma A.5: The special interest then chooses γ to maximize the probability of climate action, given by the objective function

$$\max_{\gamma \in [0, 1]} \tau\pi + (1 - \tau)\pi(1 - G(\tilde{x}^*(\gamma); 1)) + (1 - \tau)(1 - \pi)(1 - G(\tilde{x}^*(\gamma); 0)) - c(\gamma).$$

Differentiating with respect to γ yields the (rearranged) first-order condition

$$-(1 - \tau)\pi g(\tilde{x}^*; 1) \frac{d\tilde{x}^*}{d\gamma} - (1 - \tau)(1 - \pi)g(\tilde{x}^*; 0) \frac{d\tilde{x}^*}{d\gamma} = c'(\gamma)$$

and second-order condition

$$-(1 - \tau) \frac{d^2\tilde{x}^*}{d\gamma^2} \left(\pi g(\tilde{x}^*; 1) + (1 - \pi)g(\tilde{x}^*; 0) \right) - (1 - \tau) \left(\frac{d\tilde{x}^*}{d\gamma} \right)^2 \left(\pi g'(\tilde{x}^*; 1) + (1 - \pi)g'(\tilde{x}^*; 0) \right) - c''(\gamma),$$

with characterization analogous to the proof in Lemma A.2. ■

Extension: Politician and Interest Group Signal

In the main model, the politician is unable to condition her strategy on the signal s sent by the interest group. I now relax that assumption. This means that the politician's strategy is now a function of her type θ , her private signal x^θ , as well as the public signal s .

It is straightforward to observe that the interest group's signal has no effect on the competent type: since she knows ω perfectly already, there is no incentive to deviate from her equilibrium strategy as posited in the main text. Hence, $\sigma^*(1, x^1, s) = x^1 = \omega$.

Now consider the incompetent type. Define $\rho(x^0, s; \beta) = P(\omega = 1 | x^0, s; \beta)$ to be the incompetent type's posterior belief that $\omega = 1$ given her private signal x^0 and the realization of the interest group's message s given β . Since $s = 1$ is a truthful message, $\rho(x^0, 1) = 1$ for any value of x^0 . Hence in the subgame following $s = 1$, the incompetent type chooses $a = 1$ iff

$$1 + F(\mu(1, 1)) \geq F(\mu(0, 1)),$$

which is always satisfied, so $\sigma^*(0, x^0, 1) = 1$. Hence following $s = 1$, there is a pooling equilibrium on $a = 1$. Off path, $\mu(0, 1) = 0$ as it is the incompetent type who would possibly deviate.

Following $s = 0$, the incompetent type does not know if the special interest is truthful reporting $\omega = 0$ or if with some probability β it misreported. Then the incompetent type's problem is to

choose $a = 1$ whenever

$$\rho(x^0, 0; \beta) + F(\mu(1, 0)) \geq (1 - \rho(x^0, 0; \beta)) + F(\mu(0, 0)) \Leftrightarrow 2\rho(x^0, 0; \beta) - 1 + \Delta(0) \geq 0.$$

It is clear that $\mu(1, 0) = 0$ but $\mu(0, 0)$ is decreasing in the probability that the incompetent type takes action (analogous to proof of Lemma A.1). Then there is a cutoff \tilde{x}^* such that the incompetent type plays $a = 1$ iff $x^0 \geq \tilde{x}^*$. Hence $\sigma^*(0, x^0, 0) = 1 - G(\tilde{x}^*; \omega)$.

Proofs of International Cooperation Model

International Cooperation: Equilibrium

I prove Proposition 2 in a series of lemmas. To prove equilibrium existence in the subgame, I proceed in several steps. First I assume that competent types are willing to follow their signal, $a_i = x_i^1$ to prove that incompetent types have equilibrium strategies that are cutoffs: incompetent types play a_i iff their signal x_i^0 exceeds some cutoff k_i , holding fixed the behavior in country j and the beliefs of voter i (Lemma A.7). I then characterize the conditions needed for competent types to follow their signal in equilibrium, namely when τ_i is greater than some threshold $\bar{\tau}_i$ (Lemma A.8). I make this assumption for the rest of the analysis (Assumption A.1). I then endogenize the behavior of politician j into incompetent politician i 's cutoff to show that there are cutoffs that are mutual best responses (Lemma A.9). Finally, I endogenize voter i 's posterior beliefs as a function of the cutoff strategies (Lemma A.10). I then state existence of the optimal misreporting levels in Lemmas A.12 and A.13.

Recall that $\hat{\sigma}_i(\theta_i, \omega)$ is voter i 's belief about the probability that politician i chooses $a_i = 1$ when she is of type θ and the state of the world is ω . Define $B(\theta_i, a_i, s_i, a_j)$ as proportional to the *ex ante* probability that a politician i of type θ chooses action a_i and signal s_i is realized by the special interest group in country i and politician j chooses action a_j .

$$B(\theta_i, 1, s_i, a_j) = P(\theta_i) \left(\pi \hat{\sigma}_i(\theta_i, 1) P(a_j | \omega = 1) + (1 - \pi) \hat{\sigma}_i(\theta_i, 0) \frac{P(s_i | s_i \neq \omega)}{P(s_i | s_i = \omega)} P(a_j | \omega = 0) \right).$$

$$B(\theta_i, 0, s_i, a_j) = P(\theta_i) \left(\pi (1 - \hat{\sigma}_i(\theta_i, 1)) P(a_j | \omega = 1) + (1 - \pi) (1 - \hat{\sigma}_i(\theta_i, 0)) \frac{P(s_i | s_i \neq \omega)}{P(s_i | s_i = \omega)} P(a_j | \omega = 0) \right).$$

Upon observing politician i 's policy a_i , the special interest's signal in country i s_i , and politician j 's policy a_j , voter i has a posterior belief about politician i 's competence $\mu_i(a_i, s_i, a_j) = P(\theta_i = 1 | a_i, s_i, a_j)$,

$$\mu_i(a_i, s_i, a_j) = \frac{P(a_i, s_i, a_j | \theta_i = 1) P(\theta_i = 1)}{P(a_i, s_i, a_j | \theta_i = 1) P(\theta_i = 1) + P(a_i, s_i, a_j | \theta_i = 0) P(\theta_i = 0)} = \frac{B(1, a_i, s_i, a_j)}{B(1, a_i, s_i, a_j) + B(0, a_i, s_i, a_j)}.$$

Lemma A.6 *The following statements are true regarding the ordering of voter i 's posterior beliefs:*

- $\mu_i(1, 1, a_j) \geq \mu_i(0, 1, a_j) \Leftrightarrow \hat{\sigma}_i(1, 1) \geq \hat{\sigma}_i(0, 1)$.
- $\mu_i(1, 0, 1) \geq \mu_i(0, 0, 1) \Leftrightarrow \frac{\beta_i}{1-\beta_i} \frac{\pi}{1-\pi} \geq \frac{\tau_j \hat{\sigma}_j(1, 1) + (1-\tau_j) \hat{\sigma}_j(0, 1)}{\tau_j \hat{\sigma}_j(1, 0) + (1-\tau_j) \hat{\sigma}_j(0, 0)} \frac{\hat{\sigma}_i(0, 1) - \hat{\sigma}_i(1, 1)}{\hat{\sigma}_i(1, 0) - \hat{\sigma}_i(0, 0)}$.
- $\mu_i(1, 0, 0) \geq \mu_i(0, 0, 0) \Leftrightarrow \frac{\beta_i}{1-\beta_i} \frac{\pi}{1-\pi} \geq \frac{\tau_j (1 - \hat{\sigma}_j(1, 1)) + (1 - \tau_j) (1 - \hat{\sigma}_j(0, 1))}{\tau_j (1 - \hat{\sigma}_j(1, 0)) + (1 - \tau_j) (1 - \hat{\sigma}_j(0, 0))} \frac{\hat{\sigma}_i(0, 1) - \hat{\sigma}_i(1, 1)}{\hat{\sigma}_i(1, 0) - \hat{\sigma}_i(0, 0)}$.
- $\mu_i(1, 0, 1) \geq \mu_i(1, 0, 0) \Leftrightarrow \frac{\hat{\sigma}_i(1, 1)}{\hat{\sigma}_i(0, 1)} \geq \frac{\hat{\sigma}_i(1, 0)}{\hat{\sigma}_i(0, 0)}$.
- $\mu_i(1, 1, a_j) \geq \mu_i(1, 0, a_j) \Leftrightarrow \frac{\hat{\sigma}_i(1, 1)}{\hat{\sigma}_i(0, 1)} \geq \frac{\hat{\sigma}_i(1, 0)}{\hat{\sigma}_i(0, 0)}$.
- $\mu_i(0, 1, a_j) \geq \mu_i(0, 0, a_j) \Leftrightarrow \frac{1 - \hat{\sigma}_i(1, 1)}{1 - \hat{\sigma}_i(0, 1)} \geq \frac{1 - \hat{\sigma}_i(1, 0)}{1 - \hat{\sigma}_i(0, 0)}$.
- $\mu_i(0, 1, 1) \geq \mu_i(0, 1, 0) \Leftrightarrow \frac{\hat{\sigma}_i(1, 1)}{\hat{\sigma}_i(0, 1)} \geq \frac{\hat{\sigma}_i(1, 0)}{\hat{\sigma}_i(0, 0)}$.
- $\mu_i(0, 0, 1) \geq \mu_i(0, 0, 0) \Leftrightarrow \frac{1 - \hat{\sigma}_i(1, 1)}{1 - \hat{\sigma}_i(0, 1)} \geq \frac{1 - \hat{\sigma}_i(1, 0)}{1 - \hat{\sigma}_i(0, 0)}$.
- $\mu_i(a_i, 1, 1) = \mu_i(a_i, 1, 0)$.

Proof of Lemma A.6: Straightforward from definition of posterior beliefs. ■

Write $\Delta_i(s_i, a_j) = F(\mu_i(1, s_i, a_j)) - F(\mu_i(0, s_i, a_j))$ as the difference in politician i 's reelection probabilities from playing $a_i = 1$ and $a_i = 0$ when interest group i generates signal s_i and politician j plays a_j .

Corollary A.3 Suppose competent politicians follow their signal, $\hat{\sigma}_i(1, 1) = 1$ and $\hat{\sigma}_i(1, 0) = 0$.
The following statements are true:

- $\Delta_i(1, a_j) \geq 0$.
- $\Delta_i(1, a_j) \geq \Delta_i(0, a_j)$.
- $\Delta_i(s_i, 1) \geq \Delta_i(s_i, 0)$.

Proof of Corollary A.3: Immediate from Lemma A.6 and the definition of $\Delta_i(s_i, a_j)$. ■

Define the set of domestic fundamentals, which is the set of country-specific electoral returns in the climate policy subgame, as $\Lambda_i = (\Delta_i(1, 1), \Delta_i(1, 0), \Delta_i(0, 1), \Delta_i(0, 0))$.

Lemma A.7 Fix Λ_i and assume that competent politicians follow their signal. Politician i 's best response is in cutoff strategies: there exists a cutoff k_i such that the incompetent politician chooses $a_i = 1$ iff $x_i^0 \geq k_i$.

Proof of Lemma A.7: Let $y_j = P(a_j = 1|x_i)$ be the probability that politician j chooses $a_j = 1$ given what politician i knows about the state of the world from her realized signal $x_i^0 = x_i$. Then, $y_j = \tau_j \eta(x_i) + (1 - \tau_j)\eta(x_i)\hat{\sigma}_j(0, 1) + (1 - \tau_j)(1 - \eta(x_i))\hat{\sigma}_j(0, 0)$. Observe that y_j is increasing in $\eta(x_i)$ (and hence in x_i by the monotone likelihood ratio property): $\frac{\partial y_j}{\partial \eta(x_i)} = \tau_j + (1 - \tau_j)(\hat{\sigma}_j(0, 1) - \hat{\sigma}_j(0, 0)) \geq 0$, which follows from monotonicity of strategies in the state of the world.

Given Λ_i , the incompetent politician plays $a_i = 1$ following signal x_i iff

$$\begin{aligned} & \eta(x_i) \left[y_j \left[1 + \beta_i F(\mu_i(1, 0, 1)) + (1 - \beta_i)F(\mu_i(1, 1, 1)) \right] + (1 - y_j) \left[\beta_i F(\mu_i(1, 0, 0)) + (1 - \beta_i)F(\mu_i(1, 1, 0)) \right] \right] \\ & + (1 - \eta(x_i)) \left[y_j \left[1 + F(\mu_i(1, 0, 1)) \right] + (1 - y_j)F(\mu_i(1, 0, 0)) \right] \geq \\ & \eta(x_i) \left[y_j \left[\beta_i F(\mu_i(0, 0, 1)) + (1 - \beta_i)F(\mu_i(0, 1, 1)) \right] + (1 - y_j) \left[1 + \beta_i F(\mu_i(0, 0, 0)) + (1 - \beta_i)F(\mu_i(0, 1, 0)) \right] \right] \\ & + (1 - \eta(x_i)) \left[y_j F(\mu_i(0, 0, 1)) + (1 - y_j) \left[1 + F(\mu_i(0, 0, 0)) \right] \right]. \\ \Leftrightarrow & 2y_j - 1 + (1 - \eta(x_i) + \eta(x_i)\beta_i) \left(y_j \Delta_i(0, 1) + (1 - y_j) \Delta_i(0, 0) \right) + \eta(x_i)(1 - \beta_i) \left(y_j \Delta_i(1, 1) + (1 - y_j) \Delta_i(1, 0) \right) \geq 0. \end{aligned} \tag{2}$$

Differentiating with respect to $\eta(x_i)$ yields

$$2 \frac{\partial y_j}{\partial \eta(x_i)} + (1 - \beta_i) \left(y_j \Delta_i(1, 1) - y_j \Delta_i(0, 1) + (1 - y_j) \Delta_i(1, 0) - (1 - y_j) \Delta_i(0, 0) \right) + (1 - \eta(x_i) + \eta(x_i)\beta_i) \frac{\partial y_j}{\partial \eta(x_i)} \left(\Delta_i(0, 1) - \Delta_i(0, 0) \right) > 0.$$

Hence, incompetent politician i 's net gain from playing $a_i = 1$ is increasing in x_i such that by the intermediate value theorem she adopts a cutoff strategy and plays $a_i = 1$ iff $x_i^0 \geq k_i$. ■

Lemma A.8 Assume $\tau_j \geq \bar{\tau}_j$. The competent politician i always follows her signal.

Proof of Lemma A.8: Proof is analogous for politician j . Let $y_{j\omega} = P(a_j = 1|\omega)$ be the competent politician's updated beliefs about politician j 's behavior given that she knows the state

of the world perfectly.

Suppose a competent politician i observes $x_i = 1$. She plays $a_i = 1$ iff

$$\begin{aligned} & y_{j1} \left[1 + \beta_i F(\mu_i(1, 0, 1)) + (1 - \beta_i) F(\mu_i(1, 1, 1)) \right] + (1 - y_{j1}) \left[\beta_i F(\mu_i(1, 0, 0)) + (1 - \beta_i) F(\mu_i(1, 1, 0)) \right] \geq \\ & y_{j1} \left[\beta_i F(\mu_i(0, 0, 1)) + (1 - \beta_i) F(\mu_i(0, 1, 1)) \right] + (1 - y_{j1}) \left[\beta_i F(\mu_i(0, 0, 0)) + (1 - \beta_i) F(\mu_i(0, 1, 0)) \right]. \\ \Leftrightarrow & y_{j1} + \beta_i \left(y_{j1} \Delta_i(0, 1) + (1 - y_{j1}) \Delta_i(0, 0) \right) + (1 - \beta_i) \left(y_{j1} \Delta_i(1, 1) + (1 - y_{j1}) \Delta_i(1, 0) \right) \geq 0. \end{aligned}$$

By following her signal, $\Delta_i(1, 1) = \Delta_i(1, 0)$ and $\Delta_i(0, 1) \geq \Delta_i(0, 0)$ by Corollary A.3; the inequality holds.

Similarly, suppose a competent politician i observes $x_i = 0$. She plays $a_i = 0$ iff

$$\begin{aligned} & y_{j0} F(\mu_i(0, 0, 1)) + (1 - y_{j0}) \left[1 + F(\mu_i(0, 0, 0)) \right] \geq y_{j0} F(\mu_i(1, 0, 1)) + (1 - y_{j0}) F(\mu_i(1, 0, 0)) \\ \Leftrightarrow & (1 - y_{j0})(1 - \Delta_i(0, 0)) - y_{j0} \Delta_i(0, 1) \geq 0. \end{aligned}$$

This inequality need not hold; by way of contradiction, suppose it doesn't hold. Then this means that the competent type plays $a_i = 1$ regardless of her signal. Therefore, $\mu_i(0, s_i, a_j) = 0$ because any $a_i = 0$ must be played by the incompetent type.

Consider the incentives for the incompetent type. Suppose the incompetent type receives signal $x_i^0 = x_i$ and has beliefs $y_j = P(a_j = 1 | x_i)$. The incompetent type plays $a_i = 1$ iff Equation 2 is satisfied, which in this case reduces to

$$2y_j - 1 - F(0) + (\eta(x_i)\beta_i y_j + (1 - \eta(x_i))y_j)F(\mu_i(1, 0, 1)) + \eta(x_i)(1 - \beta_i)F(\mu_i(1, 1, 1)) + (\eta(x_i)\beta_i(1 - y_j) + (1 - \eta(x_i))(1 - y_j))F(\mu_i(1, 0, 0)) \geq 0,$$

where the simplification comes from the fact that $\mu_i(0, s_i, a_j) = 0$ and that by Lemma A.6, $\mu_i(1, 1, 1) = \mu_i(1, 1, 0)$. In a pooling equilibrium, it would also be true that $\mu_i(1, s_i, a_j) = \tau_i$, meaning the voter would learn nothing about the competent politician's type from $a_i = 1$. Substituting this into the incompetent politician's incentive constraint yields

$$2y_j - 1 - F(0) + F(\tau_i) \geq 0,$$

however, by the intermediate value theorem, there are some values of x_i where this constraint holds and some where it does not (because y_j is increasing in x_i). Hence pooling on $a_i = 1$ is not always optimal: there exists a cutoff \hat{x}_i such that the incompetent politician plays $a_i = 1$ iff $x_i \geq \hat{x}_i$ and $a_i = 0$ otherwise. Then we know that in such an equilibrium, $\sigma(1, 1) = \sigma(1, 0) = 1$, $\sigma(0, 1) = 1 - G(\hat{x}_i; 1)$, and $\sigma(0, 0) = 1 - G(\hat{x}_i; 0)$. Further, by first-order stochastic dominance, $G(\hat{x}_i; 0) \geq G(\hat{x}_i; 1) \implies \sigma(0, 1) \geq \sigma(0, 0)$ so by Lemma A.6 we have $\mu_i(1, 0, 0; \hat{x}_i) \geq \mu_i(1, 0, 1; \hat{x}_i)$.

Returning the competent politician's constraint, recall that she plays $a_i = 1$ following $x_i^1 = 0$ iff

$$(1 - y_{j0})(1 - F(\mu_i(1, 0, 0; \hat{x}_i))) - y_{j0}F(\mu_i(1, 0, 1; \hat{x}_i)) + F(0) \leq 0.$$

Note that if $x_i \geq \hat{x}_i$, then the incompetent politician is pooling, so $\mu_i(1, 0, 0; \hat{x}_i) = \mu_i(1, 0, 1; \hat{x}_i) = \tau_i$. But if $x_i \leq \hat{x}_i$, there is separation between the competent and the incompetent types, so posterior beliefs are bounded below by τ_i , $\mu_i(1, 0, 0; \hat{x}_i) \geq \mu_i(1, 0, 1; \hat{x}_i) \geq \tau_i$. Clearly this is hardest to satisfy at the lower bound, yielding

$$1 - y_{j0} - F(\tau_i) + F(0) \leq 0.$$

Since the LHS is increasing in τ_j and the RHS is constant, there is a value $\bar{\tau}_j$ such that when $\tau_j \leq \bar{\tau}_j$ the constraint is satisfied, but that contradicts the hypothesis that $\tau_j \geq \bar{\tau}_j$. ■

To continue with the analysis, maintain the following assumption such that Lemma A.8 holds.

Assumption A.1 *Both politicians are sufficiently likely to be competent: $\tau_i \geq \bar{\tau}_i$ and $\tau_j \geq \bar{\tau}_j$.*

Now we endogenize the behavior of politician j into politician i 's best response (and vice versa).

Lemma A.9 *Fix Λ_i . There exist cutoffs $(\tilde{x}_i, \tilde{x}_j)$ that are mutual best responses.*

Proof of Lemma A.9: By Lemma A.7, the incompetent politician in both countries has a well-defined cutoff k_i such that i plays $a_i = 1$ iff $x_i^0 \geq k_i$ holding fixed the strategy of politician j . Since politician j is playing a cutoff strategy, we know that $y_j = \tau_j \eta(x_i) + (1 - \tau_j) \eta(x_i)(1 - G(k_j; 1)) + (1 - \tau_j)(1 - \eta(x_i))(1 - G(k_j; 0))$ given that $x_i^0 = x_i$. Observe that $\frac{\partial y_j}{\partial k_j} = -(1 - \tau_j) \left(\eta(x_i)g(k_j; 1) + (1 - \eta(x_i))g(k_j; 0) \right) < 0$.

Define $\hat{I}(k_i, k_j; \Lambda_i)$ as the incompetent politician i 's indifference condition between playing $a_i = 1$ and $a_i = 0$ that endogenizes the cutoff of the incompetent politician j :

$$\begin{aligned}\hat{I}(k_i, k_j; \Lambda_i) := & 2y_j(k_i, k_j) - 1 + (1 - \eta(k_i) + \eta(k_i)\beta_i)(y_j(k_i, k_j)\Delta_i(0, 1) + (1 - y_j(k_i, k_j))\Delta_i(0, 0)) \\ & + \eta(k_i)(1 - \beta_i)(y_j(k_i, k_j)\Delta_i(1, 1) + (1 - y_j(k_i, k_j))\Delta_i(1, 0)).\end{aligned}$$

Hence, the cutoffs $(\tilde{x}_i, \tilde{x}_j)$ therefore solve the system

$$\hat{I}(\tilde{x}_i, \tilde{x}_j; \Lambda_i) = 0 \quad \text{and} \quad \hat{I}(\tilde{x}_j, \tilde{x}_i; \Lambda_j) = 0.$$

To show the system has a unique solution, I use the implicit function theorem. The Jacobian matrix is

$$\mathbf{J} = \begin{bmatrix} \frac{\partial \hat{I}(k_i, k_j; \Lambda_i)}{\partial k_i} & \frac{\partial \hat{I}(k_i, k_j; \Lambda_i)}{\partial k_j} \\ \frac{\partial \hat{I}(k_j, k_i; \Lambda_j)}{\partial k_i} & \frac{\partial \hat{I}(k_j, k_i; \Lambda_j)}{\partial k_j} \end{bmatrix}.$$

Differentiating $\hat{I}(k_i, k_j; \Lambda_i)$ with respect to k_j yields

$$\frac{\partial \hat{I}(k_i, k_j; \Lambda_i)}{\partial k_j} = 2\frac{\partial y_j}{\partial k_j} + (1 - \eta(k_i) + \eta(k_i)\beta_i)\frac{\partial y_j}{\partial k_j}(\Delta_i(0, 1) - \Delta_i(0, 0)) + \eta(k_i)(1 - \beta_i)\frac{\partial y_j}{\partial k_j}(\Delta_i(1, 1) - \Delta_i(1, 0)) < 0.$$

Since the determinant $|\mathbf{J}| = \frac{\partial \hat{I}(k_i, k_j; \Lambda_i)}{\partial k_i} \frac{\partial \hat{I}(k_j, k_i; \Lambda_j)}{\partial k_j} - \frac{\partial \hat{I}(k_i, k_j; \Lambda_i)}{\partial k_j} \frac{\partial \hat{I}(k_j, k_i; \Lambda_j)}{\partial k_i} > 0$, the system has a unique solution at the cutoffs $(\tilde{x}_i, \tilde{x}_j)$ are well-defined. ■

Now we need to endogenize voter i 's beliefs by writing $\Delta_i(s_i, a_j)$ as a function of equilibrium strategies. By Lemma A.9, there exists a pair of cutoffs $(\tilde{x}_i, \tilde{x}_j)$ such that incompetent politician i plays $a_i = 1$ iff $x_i^0 \geq \tilde{x}_i$ (same for incompetent politician j), and that competent politicians always follow their signals. Moreover, given \tilde{x}_j , we can write $\tilde{y}_{j1} = P(a_j = 1 | \omega = 1, \tilde{x}_j) = \tau_j + (1 - \tau_j)(1 - G(\tilde{x}_j; 1))$ and $\tilde{y}_{j0} = P(a_j = 1 | \omega = 0, \tilde{x}_j) = (1 - \tau_j)(1 - G(\tilde{x}_j; 0))$. This induces the following posterior beliefs for voter i :

$$\mu_i(1, 0, 1; \tilde{x}_i, \tilde{x}_j) = \frac{\tau_i \pi \tilde{y}_{j1}}{\pi \tilde{y}_{j1}(\tau_i + (1 - \tau_i)(1 - G(\tilde{x}_i; 1))) + (1 - \tau_i)(1 - \pi) \frac{\beta_i}{1 - \beta_i} (1 - G(\tilde{x}_i; 0)) \tilde{y}_{j0}}.$$

$$\begin{aligned}
\mu_i(1, 1, 1; \tilde{x}_i, \tilde{x}_j) &= \frac{\tau_i}{\tau_i + (1 - \tau_i)(1 - G(\tilde{x}_i; 1))}. \\
\mu_i(1, 0, 0; \tilde{x}_i, \tilde{x}_j) &= \frac{\tau_i \pi (1 - \tilde{y}_{j1})}{\pi (1 - \tilde{y}_{j1})(\tau_i + (1 - \tau_i)(1 - G(\tilde{x}_i; 1))) + (1 - \tau_i)(1 - \pi) \frac{\beta_i}{1 - \beta_i} (1 - G(\tilde{x}_i; 0))(1 - \tilde{y}_{j0})}. \\
\mu_i(1, 1, 0; \tilde{x}_i, \tilde{x}_j) &= \frac{\tau_i}{\tau_i + (1 - \tau_i)(1 - G(\tilde{x}_i; 1))}. \\
\mu_i(0, 0, 1; \tilde{x}_i, \tilde{x}_j) &= \frac{\tau_i (1 - \pi) \frac{\beta_i}{1 - \beta_i} \tilde{y}_{j0}}{(1 - \pi) \frac{\beta_i}{1 - \beta_i} \tilde{y}_{j0} (\tau_i + (1 - \tau_i)G(\tilde{x}_i; 0)) + (1 - \tau_i)\pi G(\tilde{x}_i; 1)\tilde{y}_{j1}}. \\
\mu_i(0, 1, 1; \tilde{x}_i, \tilde{x}_j) &= 0. \\
\mu_i(0, 0, 0; \tilde{x}_i, \tilde{x}_j) &= \frac{\tau_i (1 - \pi) \frac{\beta_i}{1 - \beta_i} (1 - \tilde{y}_{j0})}{(1 - \pi) \frac{\beta_i}{1 - \beta_i} (1 - \tilde{y}_{j0})(\tau_i + (1 - \tau_i)G(\tilde{x}_i; 0)) + (1 - \tau_i)\pi G(\tilde{x}_i; 1)(1 - \tilde{y}_{j1})}. \\
\mu_i(0, 1, 0; \tilde{x}_i, \tilde{x}_j) &= 0.
\end{aligned}$$

The following table summarizes the sign of the derivative of voter i 's posterior beliefs with respect to the cutoffs \tilde{x}_i and \tilde{x}_j .

$\mu_i(a_i, s_i, a_j; \tilde{x}_i, \tilde{x}_j)$	$\frac{\partial \mu_i(a_i, s_i, a_j; \tilde{x}_i, \tilde{x}_j)}{\partial \tilde{x}_i}$	$\frac{\partial \mu_i(a_i, s_i, a_j; \tilde{x}_i, \tilde{x}_j)}{\partial \tilde{x}_j}$
$\mu_i(1, 1, 1)$	+	0
$\mu_i(1, 1, 0)$	+	0
$\mu_i(1, 0, 1)$	+	+
$\mu_i(1, 0, 0)$	+	-
$\mu_i(0, 1, 1)$	0	0
$\mu_i(0, 1, 0)$	0	0
$\mu_i(0, 0, 1)$	-	+
$\mu_i(0, 0, 0)$	-	-

Table A.1

Siging derivatives with respect to \tilde{x}_i follow analogously from the proof of Lemma A.1. Derivatives with respect to \tilde{x}_j can be signed because the monotone likelihood ratio property implies hazard rate ordering. From Table A.1, it is evident that all $\Delta(s_i, a_j)$ are increasing in \tilde{x}_i .

Lemma A.10 *There exist cutoffs $(\tilde{x}_i^*, \tilde{x}_j^*)$ that are mutual best responses.*

Proof of Lemma A.10: Define $\hat{I}^*(\tilde{x}_i, \tilde{x}_j, \Lambda_i)$ as the incompetent politician i 's indifference condition that endogenizes both the cutoff of the incompetent politician j \tilde{x}_j and the electoral returns

in country i Λ_i given equilibrium strategies defined by such cutoffs:

$$\hat{I}^*(\tilde{x}_i, \tilde{x}_j, \Lambda_i) = 2y(\tilde{x}_i, \tilde{x}_j) - 1 + (1 - \eta(\tilde{x}_i) + \eta(\tilde{x}_i)\beta_i) \left(y(\tilde{x}_i, \tilde{x}_j) \Delta_i(0, 1; \tilde{x}_i, \tilde{x}_j) + (1 - y(\tilde{x}_i, \tilde{x}_j)) \Delta_i(0, 0; \tilde{x}_i, \tilde{x}_j) \right) + \eta(\tilde{x}_i)(1 - \beta_i) \Delta_i(1, 0; \tilde{x}_i, \tilde{x}_j). \quad (3)$$

Differentiating with respect to \tilde{x}_i yields

$$\frac{\partial \hat{I}^*(\tilde{x}_i, \tilde{x}_j, \Lambda_i)}{\partial \tilde{x}_i} = \frac{\partial \hat{I}(\tilde{x}_i, \tilde{x}_j, \Lambda_i)}{\partial \tilde{x}_i} + (1 - \eta(\tilde{x}_i) - \eta(\tilde{x}_i)\beta_i) (y(\tilde{x}_i, \tilde{x}_j) \frac{\partial \Delta_i(0, 1)}{\partial \tilde{x}_i} + (1 - y(\tilde{x}_i, \tilde{x}_j)) \frac{\partial \Delta_i(0, 0)}{\partial \tilde{x}_i}) + \eta(\tilde{x}_i)(1 - \beta_i) \frac{\partial \Delta_i(1, 0)}{\partial \tilde{x}_i} > 0.$$

Hence endogenizing voter i 's beliefs preserves optimality of the cutoff strategy for incompetent politician i .

Finally, differentiating with respect to \tilde{x}_j yields

$$\frac{\partial \hat{I}^*(\tilde{x}_i, \tilde{x}_j, \Lambda_i)}{\partial \tilde{x}_j} = \frac{\partial \hat{I}(\tilde{x}_i, \tilde{x}_j, \Lambda_i)}{\partial \tilde{x}_j} + (1 - \eta(\tilde{x}_i) - \eta(\tilde{x}_i)\beta_i) (y(\tilde{x}_i, \tilde{x}_j) \frac{\partial \Delta_i(0, 1)}{\partial \tilde{x}_j} + (1 - y(\tilde{x}_i, \tilde{x}_j)) \frac{\partial \Delta_i(0, 0)}{\partial \tilde{x}_j}) < 0.$$

Therefore, there exist cutoffs $(\tilde{x}_i^*, \tilde{x}_j^*)$ solving the system

$$\hat{I}^*(\tilde{x}_i^*, \tilde{x}_j^*, \Lambda_i(\tilde{x}_i^*, \tilde{x}_j^*)) = 0 \quad \text{and} \quad \hat{I}^*(\tilde{x}_j^*, \tilde{x}_i^*, \Lambda_j(\tilde{x}_j^*, \tilde{x}_i^*)) = 0.$$

Analogous to Lemma A.9, the solution to the system is unique by the implicit function theorem by constructing the Jacobian matrix \mathbf{J} and demonstrating that $|\mathbf{J}| > 0$. ■

Lemma A.11 *A unique pair of cutoffs $(\tilde{x}_i^*, \tilde{x}_j^*)$ exists, admitting a unique perfect Bayesian equilibrium to the international climate policy subgame. A politician of type θ in country i chooses policy $a_i = 1$ given signal x_i^θ with probability $\sigma^*(\theta_i, x_i^\theta) \in [0, 1]$. These probabilities are*

$$\sigma^*(1, x_i^1) = x_i^1 = \omega.$$

$$\sigma^*(0, x_i^0) = 1 - G(\tilde{x}_i^*; \omega).$$

Upon observing policies a_i and a_j and signal s_i , the voter in country i reelects the politician with probability $F(\mu_i^*(a_i, s_i, a_j; \tilde{x}_i^*, \tilde{x}_j^*))$.

Proof Lemma A.11: Following any history in which politician i chooses policy a_i , voter i ob-

serves signal s_i , and politician j chooses policy a_j , the voter has posterior belief $P(\theta_i = 1 | a_i, s_i, a_j) = \mu(a_i, s_i, a_j)$ as defined above, and reelects politician i iff $\mu(a_i, s_i, a_j) \geq \varepsilon_i$, which occurs with probability $F(\mu(a_i, s_i, a_j))$.

By Lemma A.8, the competent politician always follows her signal. By Lemma A.10, the incompetent politician plays a cutoff strategy such that she plays $a_i = 1$ iff $x_i^0 \geq \tilde{x}_i^*$, where \tilde{x}_i^* exists and is a best response to both politician j 's behavior and voter i 's posterior beliefs. ■

Corollary A.4 *Politician i 's cutoff \tilde{x}_i^* is increasing in β_i .*

Proof of Corollary A.4: By the implicit function theorem,

$$\frac{d\tilde{x}_i^*}{d\beta_i} = - \frac{\begin{bmatrix} \frac{\partial \hat{I}^*(\tilde{x}_i, \tilde{x}_j, \Lambda_i)}{\partial \beta_i} & \frac{\partial \hat{I}^*(\tilde{x}_i, \tilde{x}_j, \Lambda_i)}{\partial k_j} \\ \frac{\partial \hat{I}^*(\tilde{x}_j, \tilde{x}_i, \Lambda_j)}{\partial \beta_i} & \frac{\partial \hat{I}^*(\tilde{x}_j, \tilde{x}_i, \Lambda_j)}{\partial k_j} \end{bmatrix}}{|\mathbf{J}|}.$$

It is clear that $\frac{\partial \hat{I}^*(\tilde{x}_j, \tilde{x}_i, \Lambda_j)}{\partial \beta_i} = 0$. Now differentiate $\hat{I}^*(\tilde{x}_i, \tilde{x}_j, \Lambda_i)$ with respect to β_i to get

$$\frac{\partial \hat{I}^*(\tilde{x}_i, \tilde{x}_j, \Lambda_i)}{\partial \beta_i} = \eta(\tilde{x}_i)(y\Delta_i(0, 1) + (1-y)\Delta_i(0, 0) - \Delta_i(1, 0)) + (1 - \eta(\tilde{x}_i) + \eta(\tilde{x}_i)\beta_i)(y\frac{\partial \Delta_i(0, 1)}{\partial \beta_i} + (1-y)\frac{\partial \Delta_i(0, 0)}{\partial \beta_i}).$$

Now, $\mu_i(1, 0, 1; \tilde{x}_i, \tilde{x}_j)$ is decreasing in β_i and $\mu_i(0, 0, 1; \tilde{x}_i, \tilde{x}_j)$ is increasing in β_i so $\Delta_i(0, 1)$ is decreasing in β_i . Similarly, $\mu_i(1, 0, 0; \tilde{x}_i, \tilde{x}_j)$ is decreasing in β_i and $\mu_i(0, 0, 0; \tilde{x}_i, \tilde{x}_j)$ is increasing in β_i so $\Delta_i(0, 0)$ is also decreasing in β_i . Hence $\frac{\partial \hat{I}^*(\tilde{x}_i, \tilde{x}_j, \Lambda_i)}{\partial \beta_i} < 0$ so the determinant of the matrix in the numerator is negative; by the implicit function theorem, $\frac{d\tilde{x}_i^*}{d\beta_i} > 0$. ■

Lemma A.12 *Fix β_j . Given equilibrium behavior in the international coordination game, special interest i 's best response $\hat{\beta}_i(\beta_j) \in [0, 1]$ exists.*

Proof of Lemma A.12: Fix β_j (the proof is analogous for special interest j fixing β_i). Since β_j is a parameter, this proof is identical to Lemma A.2 albeit that the incompetent politician's cutoff is \tilde{x}_i^* and not \tilde{x}^* (although these cutoffs have the same relevant properties).

Special interest i has the objective function

$$\max_{\beta_i \in [0,1]} 1 - A_i(\tilde{x}_i^*(\beta_i, \beta_j)) - c(\beta_i).$$

Differentiating with respect to β_i yields the first-order condition

$$-\frac{dA_i}{d\beta_i} - c'(\beta_i) = 0,$$

and second-order condition

$$SOC = -\frac{d^2 A_i}{d\beta_i^2} - c''(\beta_i),$$

where $\frac{d^2 A_i}{d\beta_i^2} = -(1-\tau_i) \frac{d^2 \tilde{x}_i^*}{d\beta_i^2} (\pi g(\tilde{x}_i^*(\beta_i, \beta_j); 1) + (1-\pi)g(\tilde{x}_i^*(\beta_i, \beta_j); 0)) - (1-\tau_i)(\frac{d\tilde{x}_i^*}{d\beta_i})^2 (\pi g'(\tilde{x}_i^*(\beta_i, \beta_j); 1) + (1-\pi)g'(\tilde{x}_i^*(\beta_i, \beta_j); 0))$. Similar to the argument made in the proof of Lemma A.2, a solution $\hat{\beta}_i(\beta_j)$ exists, either as the solution to the first-order condition or on the corner. ■

Lemma A.13 *Given equilibrium behavior in the international climate policy subgame, there exists an optimal pair $(\beta_i^*, \beta_j^*) \in [0, 1]^2$.*

Proof of Lemma A.13: Since each interest group's best response is well-defined as shown in Lemma A.12, we now endogenize the behavior of the other interest group. Define the function $Z(\beta_i, \beta_j)$ as (analogous for group j):

$$Z(\beta_i, \beta_j) := (1 - \tau_i) \frac{d\tilde{x}_i^*}{d\beta_i} (\pi g(\tilde{x}_i^*(\beta_i, \beta_j); 1) + (1 - \pi)g(\tilde{x}_i^*(\beta_i, \beta_j); 0)) - c'(\beta_i),$$

where $\hat{\beta}_i(\beta_j)$ is the solution to $Z(\hat{\beta}_i, \beta_j) = 0$ for a fixed β_j , and $\frac{\partial Z(\hat{\beta}_i, \beta_j)}{\partial \beta_i} < 0$, by definition of $\hat{\beta}_i(\beta_j)$ being utility maximizing. The equilibrium levels of misreporting (β_i^*, β_j^*) are defined as the solution to the system

$$Z(\beta_i^*, \beta_j^*) = 0 \text{ and } Z(\beta_j^*, \beta_i^*) = 0.$$

To show that this system has a unique solution, define the Jacobian matrix as

$$\mathbf{J} = \begin{bmatrix} \frac{\partial Z(\beta_i^*, \beta_j^*)}{\partial \beta_i} & \frac{\partial Z(\beta_i^*, \beta_j^*)}{\partial \beta_j} \\ \frac{\partial Z(\beta_j^*, \beta_i^*)}{\partial \beta_i} & \frac{\partial Z(\beta_j^*, \beta_i^*)}{\partial \beta_j} \end{bmatrix}.$$

We know that $\frac{\partial Z(\beta_i^*, \beta_j^*)}{\partial \beta_i} < 0$ and $\frac{\partial Z(\beta_j^*, \beta_i^*)}{\partial \beta_j} < 0$. Differentiating with respect to β_j yields

$$\begin{aligned} \frac{\partial Z(\beta_i, \beta_j)}{\partial \beta_j} &= (1 - \tau_i) \frac{d^2 \tilde{x}_i^*}{d \beta_i d \beta_j} \left(\pi g(\tilde{x}_i^*(\beta_i, \beta_j); 1) + (1 - \pi)g(\tilde{x}_i^*(\beta_i, \beta_j); 0) \right) \\ &\quad + (1 - \tau_i) \frac{d \tilde{x}_i^*}{d \beta_i} \frac{d \tilde{x}_i^*}{d \beta_j} \left(\pi g'(\tilde{x}_i^*(\beta_i, \beta_j); 1) + (1 - \pi)g'(\tilde{x}_i^*(\beta_i, \beta_j); 0) \right). \end{aligned}$$

While $\frac{\partial Z(\beta_i, \beta_j)}{\partial \beta_j}$ is not readily signed, observe that by symmetry, $sgn \frac{\partial Z(\beta_i, \beta_j)}{\partial \beta_j} = sgn \frac{\partial Z(\beta_j, \beta_i)}{\partial \beta_i}$. Then it is apparent that $|\mathbf{J}| \neq 0$, and hence nonsingular, so a solution to the system exists. ■

Proof of Proposition 2: Immediate from Lemmas A.11 and A.13. ■

International Cooperation: Results

This section proves Results 3, 4, 5, 6, and 7.

Proof of Result 3: Immediate from Lemma A.10 and the implicit function theorem,

$$\frac{d \tilde{x}_i^*}{d \tilde{x}_j} = -\frac{\partial \hat{I}^*(k_i, \tilde{x}_j, \Lambda_i) / \partial \tilde{x}_j}{\partial \hat{I}^*(k_i; \tilde{x}_j, \Lambda_i) / \partial k_i} > 0.$$

■

Proof of Result 4: By the implicit function theorem,

$$\frac{d \tilde{x}_j^*}{d \beta_i} = -\frac{\begin{bmatrix} \frac{\partial \hat{I}^*(\tilde{x}_i, \tilde{x}_j, \Lambda_i)}{\partial \tilde{x}_i} & \frac{\partial \hat{I}^*(\tilde{x}_i, \tilde{x}_j, \Lambda_i)}{\partial \beta_i} \\ \frac{\partial \hat{I}^*(\tilde{x}_j, \tilde{x}_i, \Lambda_j)}{\partial \tilde{x}_i} & \frac{\partial \hat{I}^*(\tilde{x}_j, \tilde{x}_i, \Lambda_j)}{\partial \beta_i} \end{bmatrix}}{|\mathbf{J}|}.$$

It is clear that $\frac{\partial \hat{I}^*(\tilde{x}_j, \tilde{x}_i, \Lambda_j)}{\partial \beta_i} = 0$. From Corollary A.4, $\frac{\partial \hat{I}^*(\tilde{x}_i, \tilde{x}_j, \Lambda_i)}{\partial \beta_i} < 0$ so the determinant of the

matrix in the numerator is negative (as $\frac{\partial \hat{I}^*(\tilde{x}_j, \tilde{x}_i, \Lambda_j)}{\partial \tilde{x}_i} < 0$). Then $\frac{d\tilde{x}_j^*}{d\beta_i} > 0$. ■

Proof of Result 5: The probability of climate action for country i (analogous for country j) is defined as

$$A_i(\tilde{x}_i^*) = \tau_i \pi + (1 - \tau_i) \pi (1 - G(\tilde{x}_i^*; 1)) + (1 - \tau_i)(1 - \pi) (1 - G(\tilde{x}_i^*; 0)).$$

Differentiating with respect to β_i yields

$$\begin{aligned} \frac{dA_i}{d\beta_i} &= -(1 - \tau_i) \frac{d\tilde{x}_i^*}{d\beta_i} (\pi g(\tilde{x}_i^*; 1) + (1 - \pi)g(\tilde{x}_i^*; 0)) < 0. \\ \frac{dA_j}{d\beta_i} &= -(1 - \tau_j) \frac{d\tilde{x}_j^*}{d\beta_i} (\pi g(\tilde{x}_j^*; 1) + (1 - \pi)g(\tilde{x}_j^*; 0)) < 0. \end{aligned}$$

Then, using the definitions of coordinated climate action, unilateral climate action, and coordinated climate inaction from the text, differentiating with respect to β_i yields

$$\begin{aligned} \text{coordinated climate action: } & A_i \frac{dA_j}{d\beta_i} + \frac{dA_i}{d\beta_i} A_j < 0. \\ \text{unilateral climate action: } & \frac{dA_i}{d\beta_i} (1 - 2A_j) + \frac{dA_j}{d\beta_i} (1 - 2A_i). \\ \text{coordinated climate inaction: } & - (1 - A_i) \frac{dA_j}{d\beta_i} - \frac{dA_i}{d\beta_i} (1 - A_j) > 0. \end{aligned}$$

Clearly, coordinated climate action is decreasing in β_i and coordinated climate inaction is increasing in β_i . A sufficient condition that unilateral climate action is increasing in β_i is thus if $A_i > \frac{1}{2}$ and $A_j > \frac{1}{2}$. ■

Before proving Result 6, I prove a result about the cutoffs \tilde{x}_i^* and \tilde{x}_j^* (analogous to Lemma A.3).

Lemma A.14 *The following are true about the incompetent politician i 's equilibrium cutoff (analogous for j):*

1. $\lim_{\pi \rightarrow 0} \tilde{x}_i^* = \infty$.

2. $\lim_{\pi \rightarrow 1} \tilde{x}_i^* = -\infty$.

Proof of Lemma A.14:

1. It is immediate that when $\pi \rightarrow 0$, we have $\eta(x) \rightarrow 0$ for any x , which also implies that

$$y(\tilde{x}_i, \tilde{x}_j) = (1 - \tau_j)(1 - G(\tilde{x}_j; 0)). \text{ Then}$$

$$\lim_{\pi \rightarrow 0} \hat{I}^*(\tilde{x}_i, \tilde{x}_j, \Lambda_i) = 2y(\tilde{x}_i, \tilde{x}_j) - 1 + y(\tilde{x}_i, \tilde{x}_j)\Delta_i(0, 1; \tilde{x}_i, \tilde{x}_j) + (1 - y(\tilde{x}_i, \tilde{x}_j))\Delta_i(0, 0; \tilde{x}_i, \tilde{x}_j).$$

From the definition of the posterior beliefs induced by the cutoff, we know that $\Delta_i(0, 1; \tilde{x}_i, \tilde{x}_j) < 0$ and $\Delta_i(0, 0; \tilde{x}_i, \tilde{x}_j) < 0$. Hence $\lim_{\pi \rightarrow 0} \hat{I}^*(\tilde{x}_i, \tilde{x}_j, \Lambda_i) < 0$, which means it is never optimal for the incompetent politician to choose $a = 1$, meaning $\tilde{x}_i^* \rightarrow \infty$.

2. It is immediate that when $\pi \rightarrow 1$, we have $\eta(x) \rightarrow 1$ for any x , which also implies that

$$y(\tilde{x}_i, \tilde{x}_j) = \tau_j + (1 - \tau_j)(1 - G(\tilde{x}_j; 1)). \text{ Then}$$

$$\lim_{\pi \rightarrow 1} \hat{I}^*(\tilde{x}_i, \tilde{x}_j, \Lambda_i) = 2y(\tilde{x}_i, \tilde{x}_j) - 1 + \beta_i y(\tilde{x}_i, \tilde{x}_j)\Delta_i(0, 1; \tilde{x}_i, \tilde{x}_j) + \beta_i(1 - y(\tilde{x}_i, \tilde{x}_j))\Delta_i(0, 0; \tilde{x}_i, \tilde{x}_j) + (1 - \beta_i)\Delta_i(1, 0; \tilde{x}_i, \tilde{x}_j).$$

Now, given the posterior beliefs induced by the cutoffs, $\Delta_i(1, 0; \tilde{x}_i, \tilde{x}_j)$ is constant in π , but $\Delta_i(0, 1; \tilde{x}_i, \tilde{x}_j) > 0$ and $\Delta_i(0, 0; \tilde{x}_i, \tilde{x}_j) > 0$. Hence $\lim_{\pi \rightarrow 1} \hat{I}^*(\tilde{x}_i, \tilde{x}_j, \Lambda_i) > 0$, which means it is always optimal for the incompetent politician to choose $a = 1$, meaning $\tilde{x}_i^* \rightarrow -\infty$.

■

Proof of Result 6: Recall that (β_i^*, β_j^*) is the solution to the system of equations

$$\begin{aligned} Z(\beta_i, \beta_j) &= (1 - \tau_i) \frac{d\tilde{x}_i^*}{d\beta_i} \left(\pi g(\tilde{x}_i^*(\beta_i, \beta_j); 1) + (1 - \pi)g(\tilde{x}_i^*(\beta_i, \beta_j); 0) \right) - c'(\beta_i) = 0. \\ Z(\beta_j, \beta_i) &= (1 - \tau_j) \frac{d\tilde{x}_j^*}{d\beta_j} \left(\pi g(\tilde{x}_j^*(\beta_j, \beta_i); 1) + (1 - \pi)g(\tilde{x}_j^*(\beta_j, \beta_i); 0) \right) - c'(\beta_j) = 0. \end{aligned}$$

Observe that, by Lemma A.14, at $\pi = 0$ and $\pi = 1$, $Z(\beta_i, \beta_j) < 0$ for any $\beta_i > 0$ and any β_j , and $Z(\beta_j, \beta_i) < 0$ for any $\beta_j > 0$ and any β_i . Furthermore, $Z(\beta_i, \beta_j) = 0$ for $\beta_i = 0$ and $Z(\beta_j, \beta_i) = 0$ for $\beta_j = 0$. Hence $(\beta_i^*, \beta_j^*) = (0, 0)$ is an equilibrium.

Further by Rolle's theorem there must be a $\hat{\pi}_i \in (0, 1)$ where $\frac{\partial Z(\beta_i, \beta_j)}{\partial \pi} = 0$, and there must be a $\hat{\pi}_j \in (0, 1)$ where $\frac{\partial Z(\beta_j, \beta_i)}{\partial \pi} = 0$, meaning that β_i^* and β_j^* are nonmonotonic in π . Note that it need not be the case that $\hat{\pi}_i = \hat{\pi}_j$.

Consider β_i^* (analogous for β_j^*). Partially differentiating yields

$$\begin{aligned}\frac{\partial Z(\beta_i, \beta_j)}{\partial \pi} &= (1 - \tau) \left[g(\tilde{x}_i^*; 1) \frac{d\tilde{x}_i^*}{d\beta_i} + \pi g'(\tilde{x}_i^*; 1) \frac{d\tilde{x}_i^*}{d\pi} \frac{d\tilde{x}_i^*}{d\beta} + \pi g(\tilde{x}_i^*; 1) \frac{d^2\tilde{x}_i^*}{d\beta_i d\pi} \right. \\ &\quad \left. - g(\tilde{x}_i^*; 0) \frac{d\tilde{x}_i^*}{d\beta_i} + (1 - \pi) g'(\tilde{x}_i^*; 0) \frac{d\tilde{x}_i^*}{d\pi} \frac{d\tilde{x}_i^*}{d\beta_i} + (1 - \pi) g(\tilde{x}_i^*; 0) \frac{d^2\tilde{x}_i^*}{d\beta_i d\pi} \right].\end{aligned}$$

Observe that at $\pi = 0$ and $\pi = 1$, $\frac{\partial Z(\beta_i, \beta_j)}{\partial \pi} = 0$, implying that such points are extrema, and we know that $\beta_i^* = 0$ in these cases. But because $\beta_i \in [0, 1]$, these must be minima. Then the point $\hat{\pi}_i$ which is defined by Rolle's theorem must be an interior maximum such that β_i^* is increasing when $\pi < \hat{\pi}_i$ and decreasing when $\pi > \hat{\pi}_i$. Such a $\hat{\pi}_i$ is characterized by $\frac{\partial Z(\beta_i, \beta_j)}{\partial \pi} = 0$ and $\frac{\partial^2 Z(\beta_i, \beta_j)}{\partial \pi^2} \leq 0$. ■

Proof of Result 7: Given the definitions from the main text of $A_i(\tilde{x}_i^*)$ and $R_i(\tilde{x}_i^*)$:

$$R_i(\tilde{x}_i^*) - A_i(\tilde{x}_i^*) = \tau_i(1 - \pi) + (1 - \tau_i)(1 - \pi)(2G(\tilde{x}_i^*; 0) - 1).$$

Differentiating with respect to β_i and β_j yields

$$\begin{aligned}\frac{d(R_i(\tilde{x}_i^*) - A_i(\tilde{x}_i^*))}{d\beta_i} &= 2(1 - \tau_i)(1 - \pi)g(\tilde{x}_i^*; 0) \frac{d\tilde{x}_i^*}{d\beta_i} > 0. \\ \frac{d(R_i(\tilde{x}_i^*) - A_i(\tilde{x}_i^*))}{d\beta_j} &= 2(1 - \tau_i)(1 - \pi)g(\tilde{x}_i^*; 0) \frac{d\tilde{x}_i^*}{d\tilde{x}_j^*} \frac{d\tilde{x}_j^*}{d\beta_i} > 0.\end{aligned}$$

■

Additional Figures

Figure A.1 demonstrates that the lion's share of these laws are related to climate mitigation. The growth of mitigation laws over time is notable, especially as nearly all NDCs under the Paris framework include mitigation measures. Moreover, as mitigation is nationally costly but provides global benefits, theories of collective action would predict a stagnation or underprovision of mitigation laws. Other laws aim to address adaptation, disaster risk management, and loss and damages. These policies, while much more difficult to measure, are also increasing in frequency as climate change's effects become more pronounced, especially in the Global South.

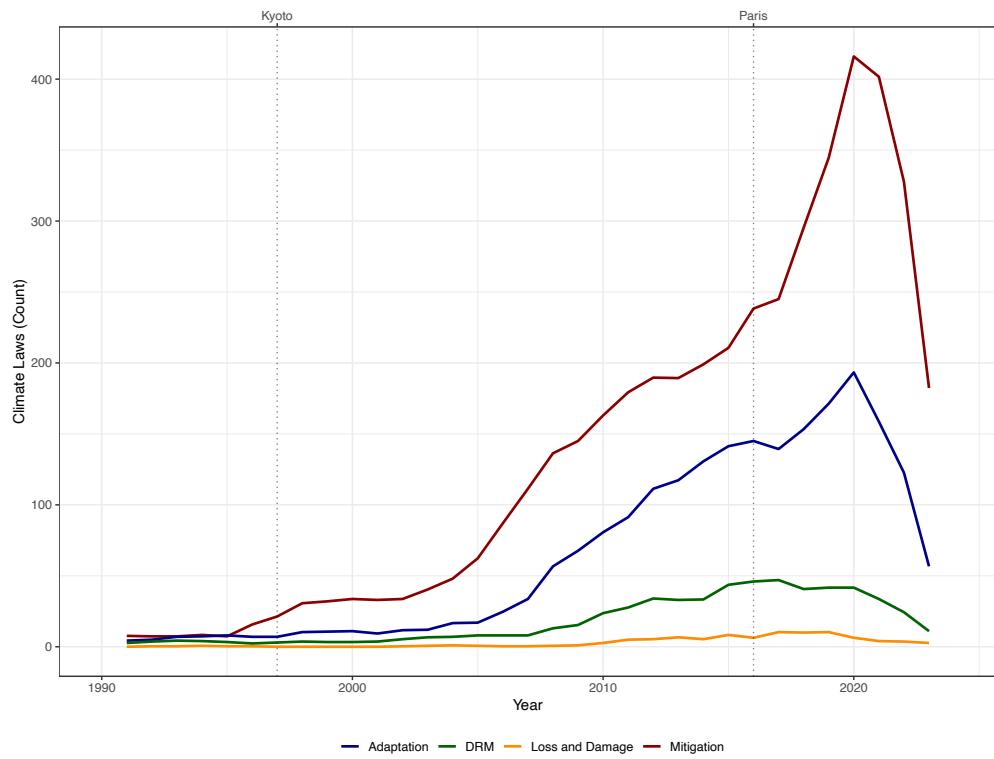


Figure A.1: Climate Laws by Type

Unsurprisingly, many of the laws enacted address reforms to the energy industry, as shown in Figure A.2 where laws are graphed by sector. The passage of these laws demonstrate how fossil fuel companies or other firms with “climate-forcing assets” ([Colgan, Green and Hale 2021](#)) have become increasingly at risk over time. While energy laws are consistently the most commonly passed climate law, there has been a spike in economy-wide initiatives in the 2020s; these laws intend to cut across sectors, representing large-scale societal investments like the Inflation Reduction Act in the United States or the European Union’s European Green Deal.

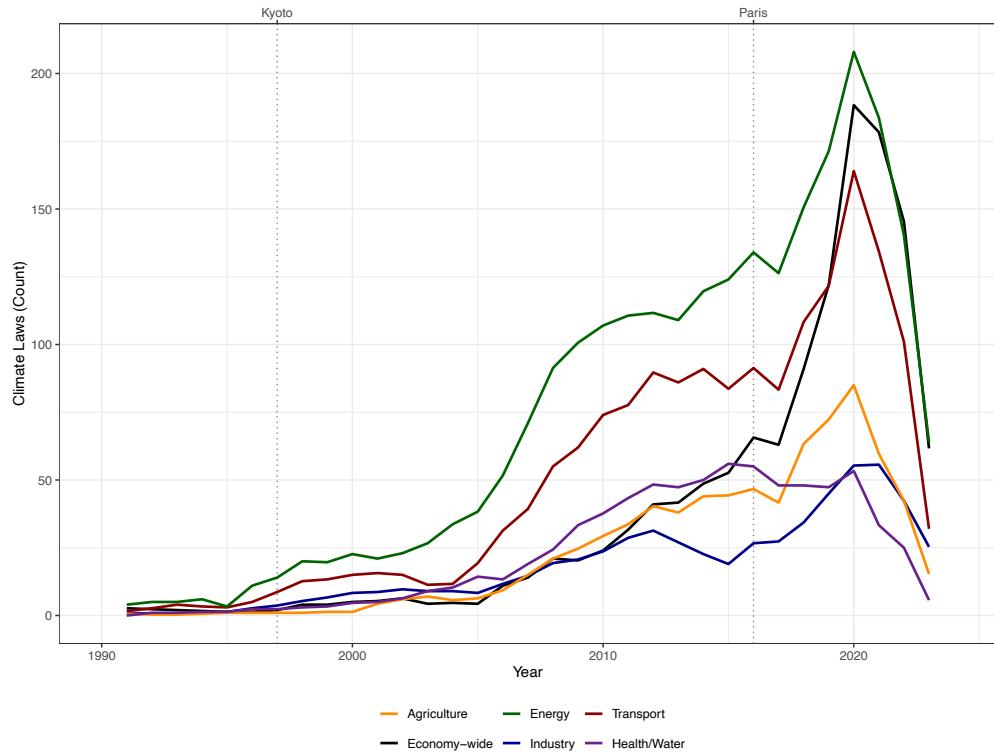


Figure A.2: Climate Laws by Sector

Figure A.3 of the figure examines the evolution of policy instruments used to address climate change. While initial efforts predominantly relied on command-and-control regulations, the early 2010s marked a shift toward the adoption of subsidies and incentives as central tools. Subsidies, in particular, play a pivotal role in fostering domestic industries to accelerate the green transition. Their increasing use is noteworthy, especially in light of the temptations to free-ride, as predicted by collective action theories, as these policy instruments aim to lessen the burden of costly abatement or adjustment. Also notable is the steady growth in laws that provided for climate change research, contributing to the accumulation of knowledge about the severity of global warming. These investments and the subsequent accumulation of knowledge have contributed to the scientific understanding which ultimately facilitates more climate policymaking and pushes back on the ability for special interests to misreport, as will be detailed in the theoretical argument.

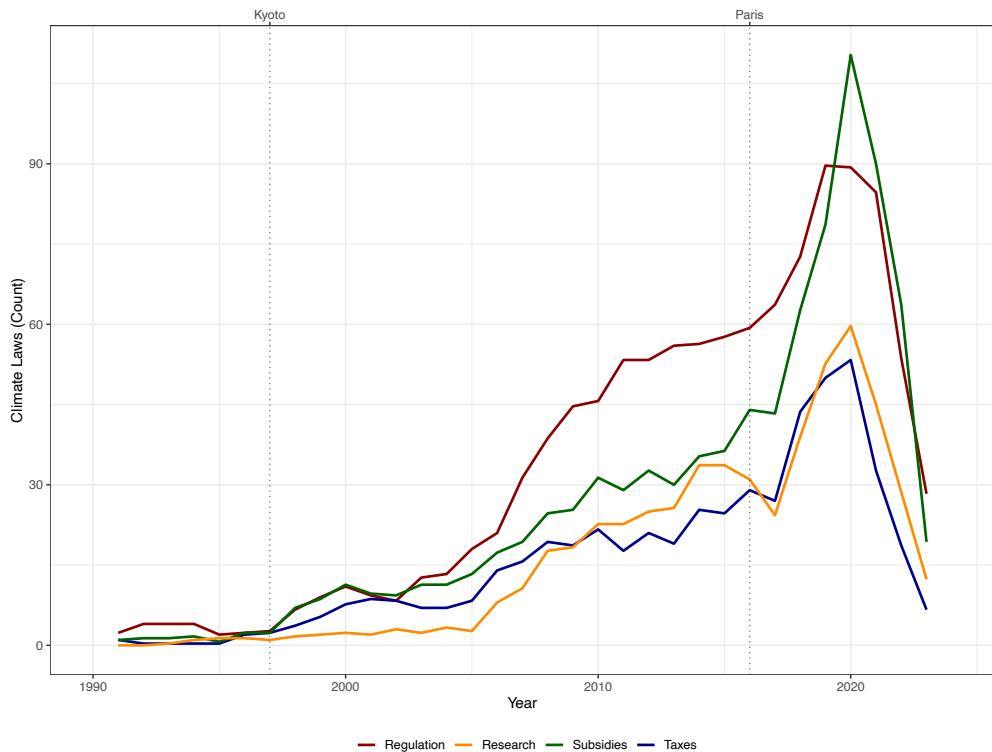


Figure A.3: Climate Laws by Policy Instrument

Figure A.4 displays the number of climate laws normalized by the number of adopting countries in each year. The increasing trend in law adoption over time is robust to this normalization.

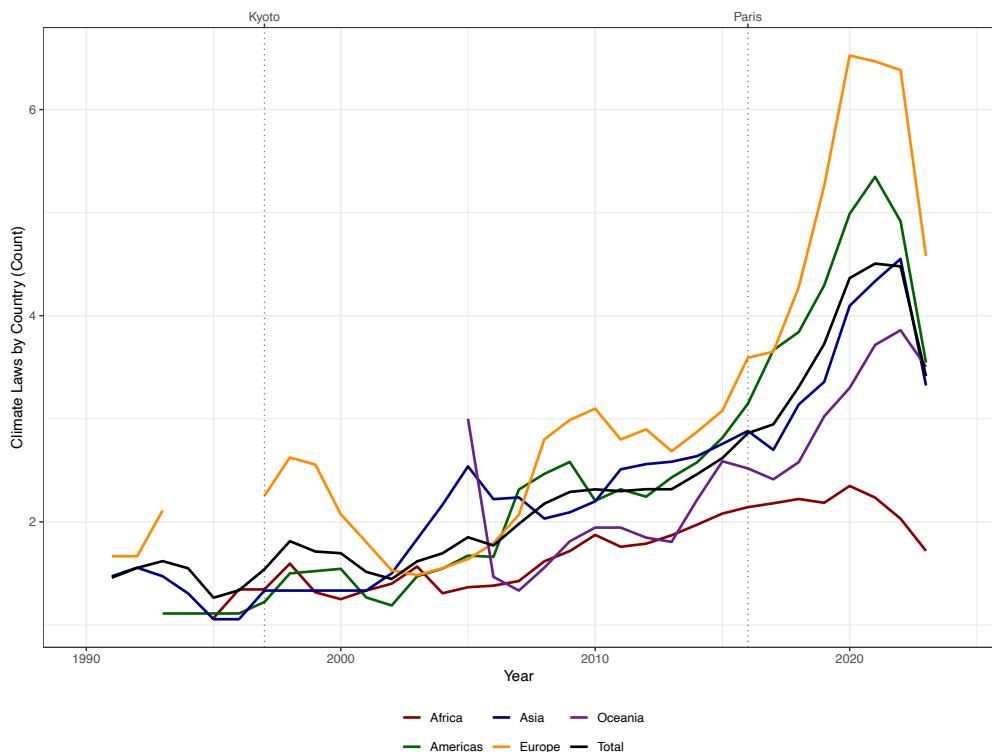


Figure A.4: Climate Laws Normalized by Country

Figure A.5 shows the correlation in the OECD Environmental Policy Stringency Index across countries. The figure shows that all cross-country correlations of environmental policy stringency are positive, and almost all of the are statistically distinguishable from zero (those that are not are in red). These positive correlations are meaningful because they suggest that increases in climate ambitions across countries are complementary, not substitutable, as theories based in free-riding would predict.

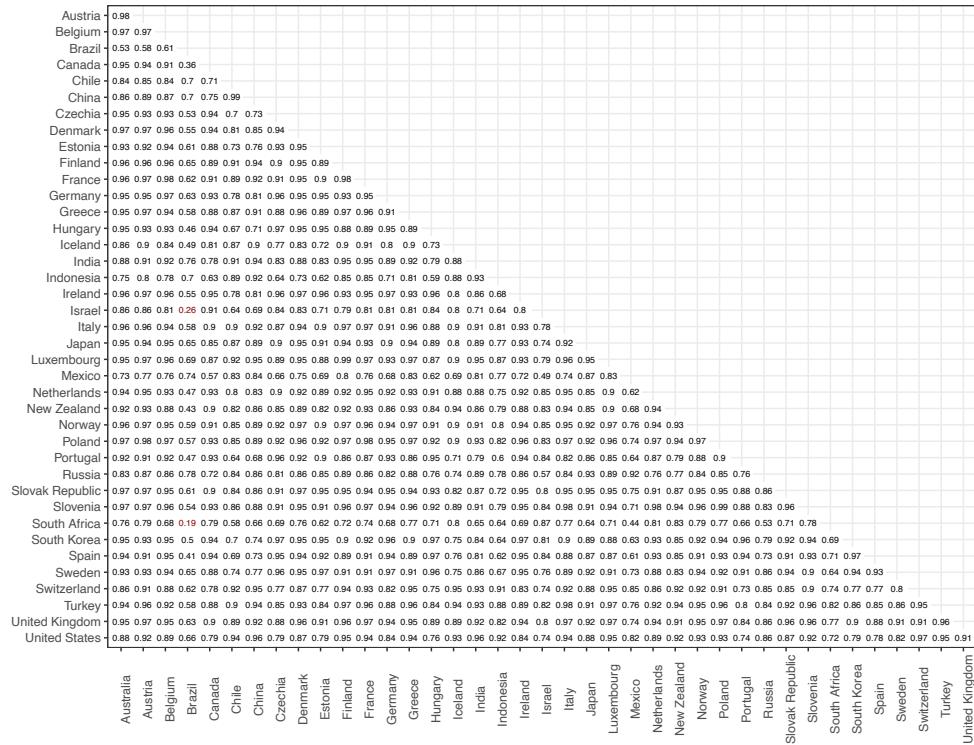


Figure A.5: Correlation Between Countries' Environmental Policy Stringency, 1990-2020

The Climate Actions and Policies Measurement Framework (CAPMF) by [Nachtigall et al. \(2024\)](#) presents an alternative approach to measuring policy stringency than the OECD's EPS. It is constructed similarly to the EPS, but relies on more policy instruments and also factors in international policy commitments. Rather than aggregate to a single index, the CAPMF aggregates up to the levels of sectoral policies, cross-sectoral policies, and international policies. Figure A.6 thus illustrates these measures for 49 countries between 1990 and 2022. Similar to the EPS in Figure 3, countries' policy stringencies are increasing over time.

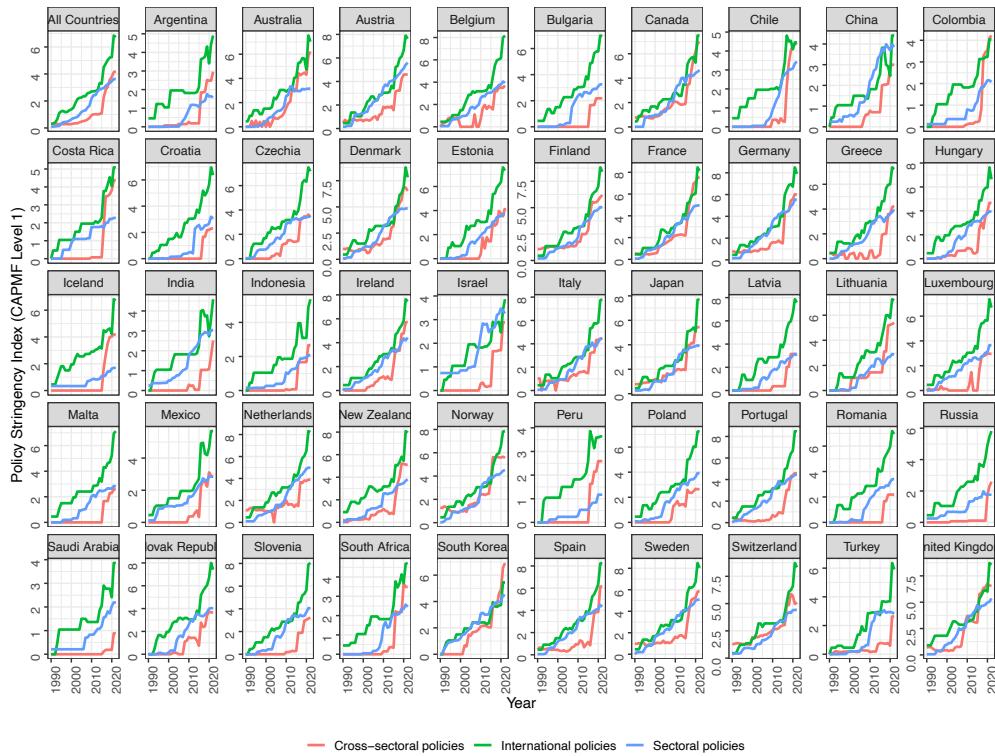


Figure A.6: Environmental Policy Stringency over Time using CAPMF

The evolution of climate policymaking in the United States comports with the status of the informational environment as fostered by firms like Exxon. Figure A.7 illustrates the near absence of climate policy in the United States during the 1990s and early 2000s, a period coinciding with Exxon's public campaigns denying climate change. Notably, following Exxon's reduction in funding for climate denial efforts around 2007, the implementation of climate policies began to gain traction. Furthermore, Exxon's eventual acknowledgment of climate change's severity marks the onset of a new phase in U.S. climate policymaking. Although some climate legislation was enacted during the Trump administration, the Biden administration oversaw the most significant expansion of climate policy, culminating in the passage of the Inflation Reduction Act, the largest clean energy investment in history.

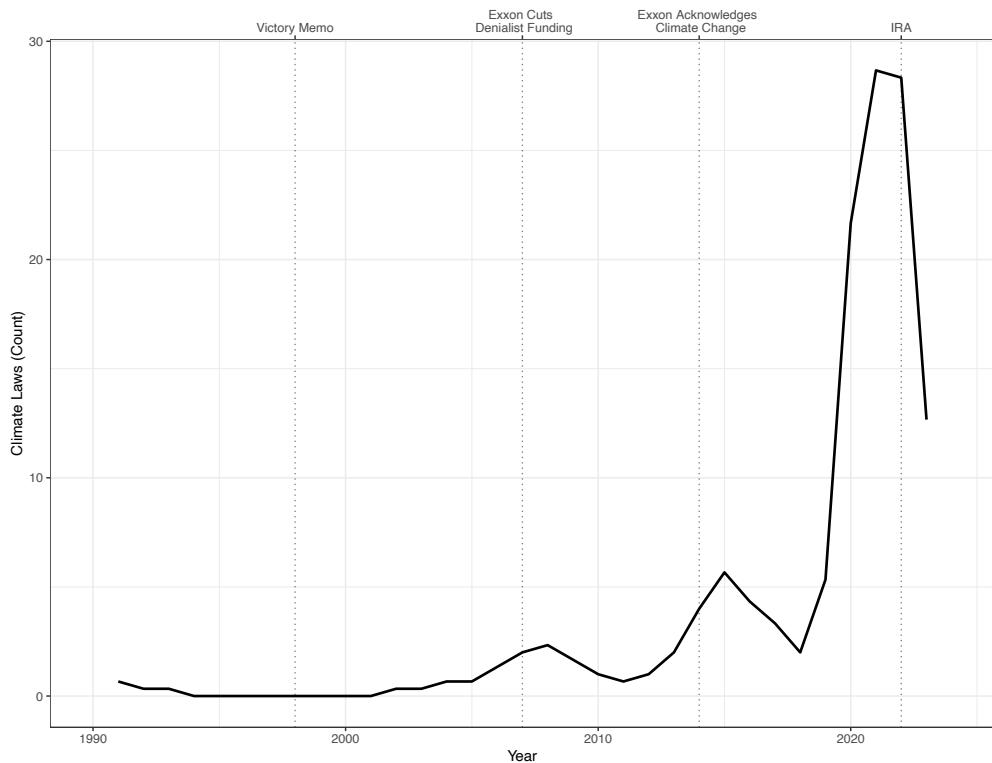


Figure A.7: Variation in U.S. Climate Policy over Time

Exxon scientist James Black's 1978 memo notes the scientific consensus that the climate is affected by fossil fuels. Notably, he writes that "present thinking holds that man has a time window of five to ten years before the need for hard decisions regarding changes in energy strategies might become critical." The summary section of the memo is presented in Figure A.8. The entire document is available at <https://climateintegrity.org/uploads/deception/1978-Exxon-BlackMemo.pdf>.

THE GREENHOUSE EFFECT

J. F. Black, Products Research Division
Exxon Research and Engineering Co.

SUMMARY

The earth's atmosphere presently contains about 330 ppm of CO₂. This gas does not absorb an appreciable amount of the incoming solar energy but it can absorb and return part of the infrared radiation which the earth radiates toward space. CO₂, therefore, contributes to warming the lower atmosphere by what has been called the "Greenhouse Effect."

The CO₂ content of the atmosphere has been monitored since 1957 at two locations, the Mauna Loa Observatory, Hawaii and the South Pole. These and other shorter studies show that CO₂ is increasing. If the increase is attributed to the combustion of fossil fuels, it can be calculated that the CO₂ content of the atmosphere has already been raised by about 10 to 15% and that slightly more than half of the CO₂ released by fossil fuel combustion remains in the atmosphere. Assuming that the percentage of the CO₂ remaining in the atmosphere will stay at 53% as fossil fuel consumption increases, one recent study predicts that in 2075 A.D., CO₂ concentration will peak at a level about twice what could be considered normal. This prediction assumes that fossil fuel consumption will grow at a rate of 2% per year until 2025 A.D. after which it will follow a symmetrical decrease. This growth curve is close to that predicted by Exxon's Corporate Planning Department.

Mathematical models for predicting the climatic effect of a CO₂ increase have not progressed to the point at which all the feedback interactions which can be important to the outcome can be included. What is considered the best presently available climate model for treating the Greenhouse Effect predicts that a doubling of the CO₂ concentration in the atmosphere would produce a mean temperature increase of about 2°C to 3°C over most of the earth. The model also predicts that the temperature increase near the poles may be two to three times this value.

The CO₂ increase measured to date is not capable of producing an effect large enough to be distinguished from normal climate variations. An example of normal variations is provided by a study of meteorological and historical records in England indicate that the average temperature has varied over a range of about 10.7°C in the past 1000 years. A study of past climates suggests that if the earth becomes warmer, more rainfall should result. But an increase as large as 2°C would probably also affect the distribution of the rainfall. A possible result might be a shift of both the desert and the fertile areas of the globe toward higher latitudes. Some countries would benefit but others could have their agricultural output reduced or destroyed. The picture is too unclear to predict which countries might be affected favorably or unfavorably.

It seems likely that any general temperature increase would be accentuated in the polar regions, possibly as much as two- or three-fold as mentioned above. Any large temperature increase at high latitudes would be associated with a reduction in snow cover and a melting of the great icecap. Present thinking suggests that there would be little or no melting of the polar ice-caps in response to warmer temperatures on a time scale over which the Greenhouse Effect is predicted to apply.

A number of assumptions and uncertainties are involved in the predictions of the Greenhouse Effect. The first is the assumption that the observed CO₂ increase can be attributed entirely to fossil fuel combustion. At present, meteorologists have little evidence that the incremental CO₂ in the atmosphere comes from fossil sources. The increase could be at least partly due to changes in the natural balance. There is considerable uncertainty regarding what controls the exchange of atmospheric CO₂ with the oceans and with carbonaceous materials on the continents.

Models which predict the climatic effects of a CO₂ increase are in a primitive stage of development. The atmosphere is a very complicated system, particularly on a global scale. In existing models, important interactions are neglected, either because they are not completely understood or because their proper mathematical treatment is too cumbersome. Substantial efforts are being expended to improve existing models. But there is no guarantee that better knowledge will lessen rather than augment the severity of the predictions.

The Greenhouse Effect has been the subject of a number of international scientific conferences during the past two years. These meetings have identified the information needed to definitely establish the source and ultimate significance of the CO₂ increase in the atmosphere. Present thinking suggests that man has a time window of five to ten years before the need for hard decisions regarding changes in energy strategies might become critical. The DOE is presently seeking Congressional support for a research program which will produce the necessary information in the required time. This program is described.

Figure A.8: James Black's Memo to Exxon Executives, 1978

Exxon scientist Roger Cohen's 1982 memo summarizes findings about Exxon's internal climate modeling. It documents the projected relationship between increased carbon dioxide in the atmosphere and changes in the Earth's climate. It further discusses the scientific consensus around this result. The first two pages of the memo are displayed in Figure A.9. The entire document is available at <https://www.climatefiles.com/exxonmobil/1982-exxon-memo-summarizing-climate-modeling-and-co2-greenhouse-effect-research/>.

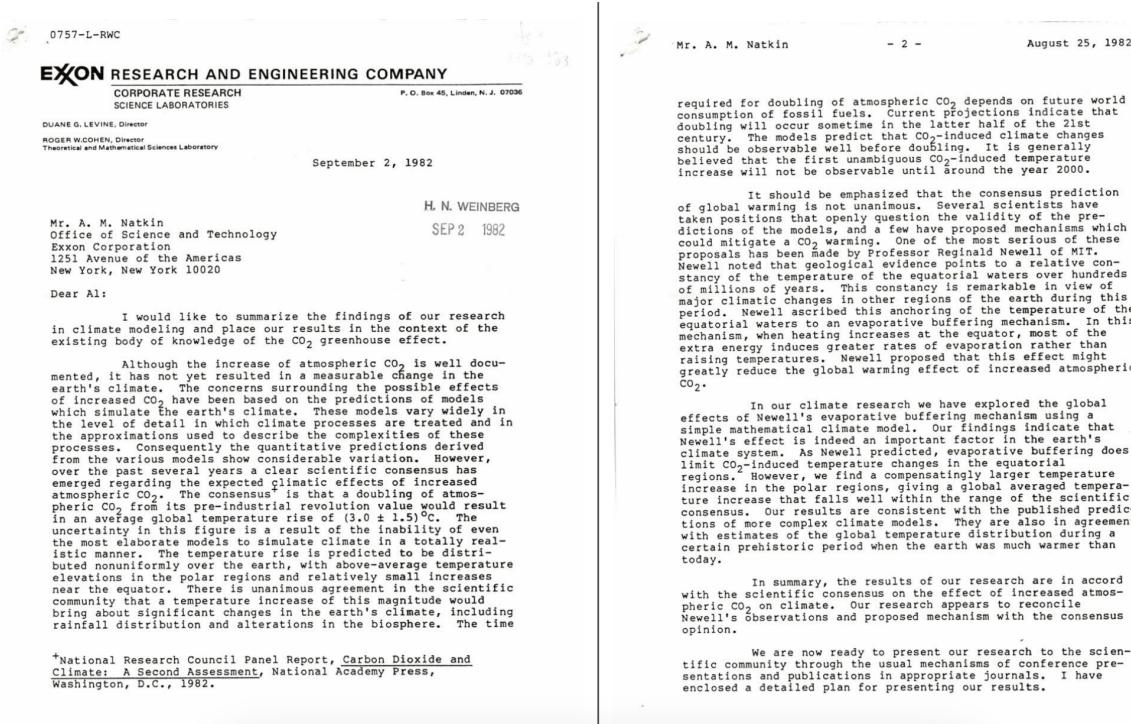


Figure A.9: Roger Cohen's Memo on Exxon Climate Science, 1982

In 1996 and 1998, Exxon released pamphlets to the masses that sought to inject doubt into the public discourse about the validity of climate science and the subsequent need for policy action. Figure A.10 displays the introductory letter from Exxon Chairman Lee Raymond to the document “Global climate change: everyone’s debate.” The full document is available at <https://www.climatefiles.com/exxonmobil/1998-exxon-pamphlet-global-climate-change-everyones-debate/>. The pamphlet “Global warming: who’s right?” admonishes readers not to “ignore the facts” about climate change and is available at <https://climateintegrity.org/uploads/deception/1996-Exxon-Global-Warming-Whos-Right.pdf>.

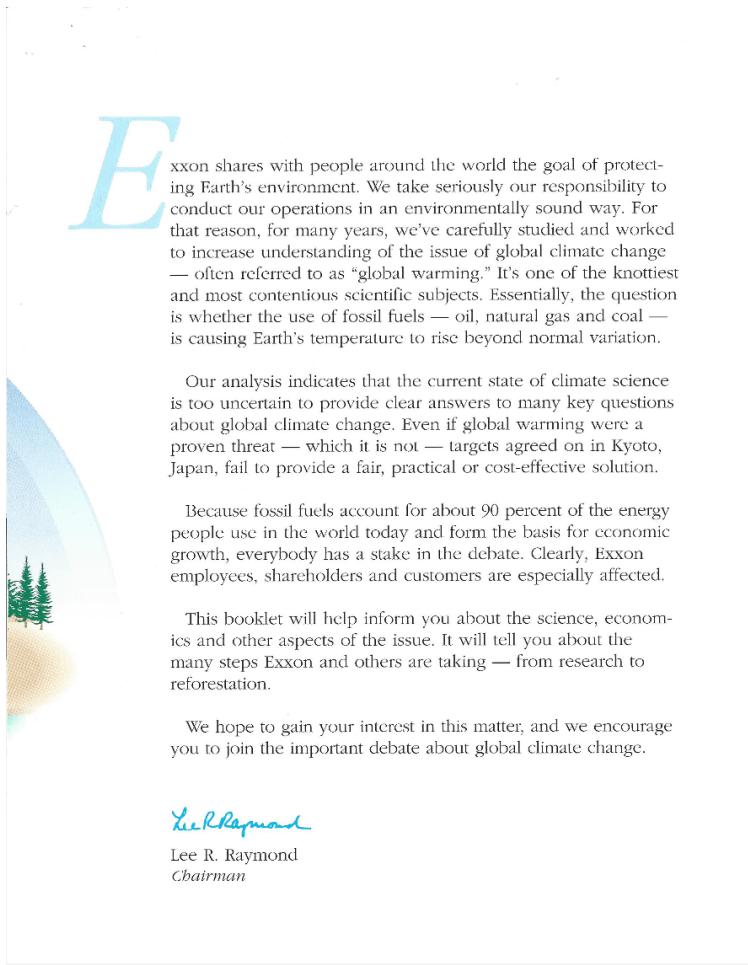


Figure A.10: “Global climate change: everyone’s debate,” 1996

The “Victory Memo” of 1998 makes the goal to inject uncertainty into the public sphere clear: “victory will be achieved when average citizens ‘understand’ (recognize) uncertainties in climate science,” and “recognition of uncertainty becomes part of the ‘conventional wisdom.’” Figure A.11 provides an excerpt of the memo describing the goals of the public informational campaign, the entire memo can be found at <https://www.climatefiles.com/trade-group/american-petroleum-institute/1998-global-climate-science-communications-team-action-plan/>.

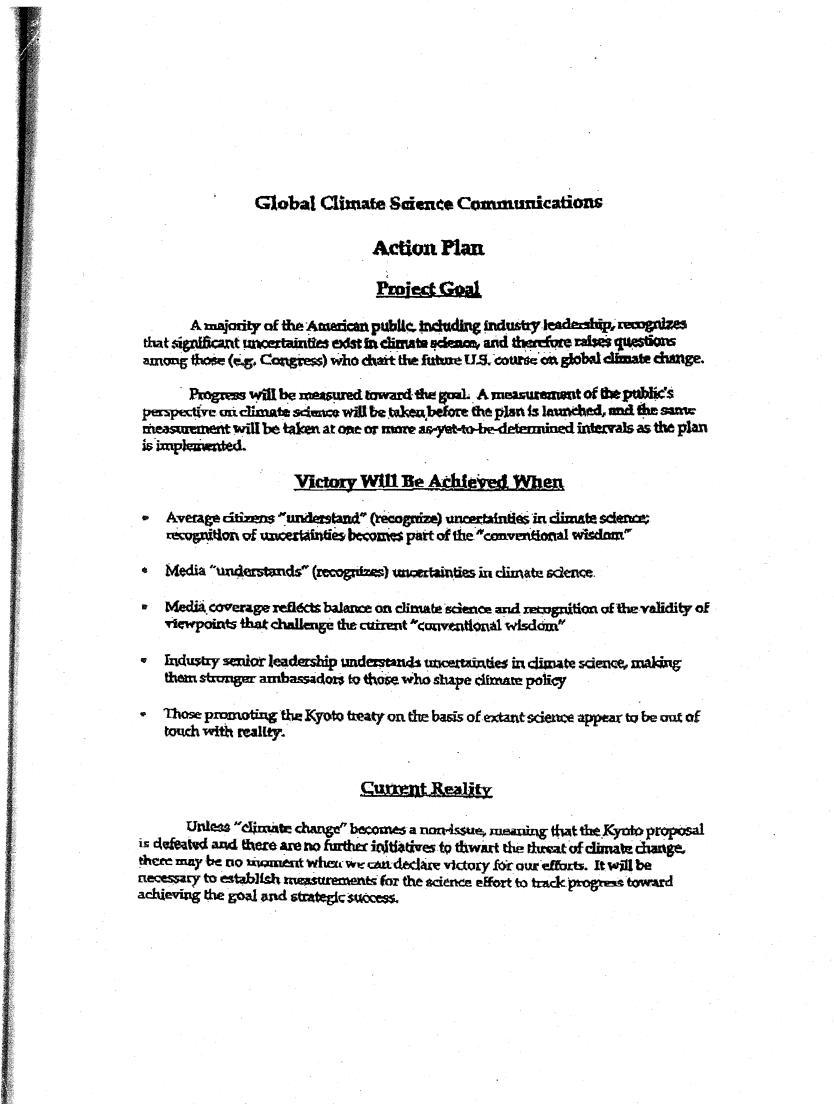


Figure A.11: Victory Memo, 1998

“The Greenhouse Effect” is a report published by a working group of Shell scientists in 1988 documents potential climate impacts, including rising sea levels, ocean acidification, and human migration, from continued fossil fuel production. The document’s summary is shown in Figure A.12; the full document is available at <https://www.documentcloud.org/documents/4411090-Dокумент3.html>.

CONFIDENTIAL

- 1 -

SUMMARY

Man-made carbon dioxide, released into and accumulated in the atmosphere, is believed to warm the earth through the so-called greenhouse effect. The gas acts like the transparent walls of a greenhouse and traps heat in the atmosphere that would normally be radiated back into space. Mainly due to fossil fuel burning and deforestation, the atmospheric CO₂ concentration has increased some 15% in the present century to a level of about 340 ppm. If this trend continues, the concentration will be doubled by the third quarter of the next century. The most sophisticated geophysical computer models predict that such a doubling could increase the global mean temperature by 1.3-3.3°C. The release of other (trace) gases, notably chlorofluorocarbons, methane, ozone and nitrous oxide, which have the same effect, may amplify the warming by predicted factors ranging from 1.5 to 3.5°C.

Mathematical models of the earth's climate indicate that if this warming occurs then it could create significant changes in sea level, ocean currents, precipitation patterns, regional temperature and weather. These changes could be larger than any that have occurred over the last 12,000 years. Such relatively fast and dramatic changes would impact on the human environment, future living standards and food supplies, and could have major social, economic and political consequences.

There is reasonable scientific agreement that increased levels of greenhouse gases would cause a global warming. However, there is no consensus about the degree of warming and no very good understanding what the specific effects of warming might be. But as long as man continues to release greenhouse gases into the atmosphere, participation in such a global "experiment" is guaranteed. Many scientists believe that a real increase in the global temperature will be detectable towards the end of this century or early next century. In the meanwhile, greater sophistication both in modelling and monitoring will improve the understanding and likely outcomes. However, by the time the global warming becomes detectable it could be too late to take effective countermeasures to reduce the effects or even to stabilise the situation.

The likely time scale of possible change does not necessitate immediate remedial action. However, the potential impacts are sufficiently serious for research to be directed more to the analysis of policy and energy options than to studies of what we will be facing exactly. Anticipation of climatic change is new, preventing undue change is a challenge which requires international cooperation.

With fossil fuel combustion being the major source of CO₂ in the atmosphere, a forward looking approach by the energy industry is clearly desirable, seeking to play its part with governments and others in the development of appropriate measures to tackle the problem.

Figure A.12: “The Greenhouse Effect,” 1988

The Global Climate Coalition was a lobbying group of several large oil and gas companies that operated between 1989 and 2001. Its primary function was to coordinate messaging against global climate action like the ratification of the Kyoto Protocol. In 1995, the GCC internally circulated *Predicting Future Climate Change: A Primer*, which summarized the state of climate science. Notably, it reads, “The scientific basis for the Greenhouse Effect and the potential impact of human emissions of greenhouse gases such as CO₂ on climate is well established and cannot be denied.” Figure A.13 displays the introduction to the primer. The full document is available at https://www.ucsusa.org/sites/default/files/attach/2015/07/Climate-Deception-Dossier-7_GCC-Climate-Primer.pdf

<p>APPROVAL DRAFT</p> <p><u>Predicting Future Climate Change: A Primer</u></p> <p>In its recently approved Summary for Policymakers for its contribution to the IPCC's Second Assessment Report, Working Group I stated:</p> <p>...the balance of evidence suggests that there is a discernable human influence on global climate.</p> <p>The Global Climate Coalition's Science and Technical Advisory Committee believes that the IPCC statement goes beyond what can be justified by current scientific knowledge.</p> <p>This paper presents an assessment of those issues in the science of climate change which relate to the ability to predict whether human emissions of greenhouse gases have had an effect on current climate or will have a significant impact on future climate. It is a primer on these issues, not an exhaustive analysis. Complex issues have been simplified, hopefully without any loss of accuracy. Also, since it is a primer, it uses the terminology which has become popular in the climate change debate, even in those cases where the popular terminology is not technically accurate.</p> <p>Introduction and Summary</p> <p>Since the beginning of the industrial revolution, human activities have increased the atmospheric concentration of CO₂ by more than 25%. Atmospheric concentrations of other greenhouse gases have also risen. Over the past 120 years, global average temperature has risen by 0.3 - 0.6°C. Since the Greenhouse Effect can be used to relate atmospheric concentration of greenhouse gases to global average temperature, claims have been made that at least part of the temperature rise experienced to date is due to human activities, and that the projected future increase in atmospheric concentrations of greenhouse gases (from human activities) will lead to even larger increases in future temperature. Additionally, it is claimed that these increases in temperature will lead to an array of climate changes (rainfall patterns, storm frequency and intensity, etc.) that could have severe environmental and economic impacts.</p> <p>This primer addresses the following questions concerning climate change:</p> <ol style="list-style-type: none"> 1) Can human activities affect climate? 2) Can future climate be accurately predicted? <p>The climate models which are being used to predict the increases in temperature which might occur with increased atmospheric concentrations of greenhouse gases are limited at present both by incomplete scientific understanding of the factors which affect climate and</p>	<p>APPROVAL DRAFT</p> <p>by inadequate computational power. Improvements in both are likely, and in the next decade it may be possible to make fairly accurate statements about the impact that increased greenhouse gas concentrations could have on climate. However, these improvements may still not translate into an ability to predict future climate for at least two reasons:</p> <ul style="list-style-type: none"> - limited understanding of the natural variability of climate, and - inability to predict future atmospheric concentrations of greenhouse gases. <p>The smaller the geographic area considered, the poorer the quality of climate prediction. This is a critical limitation in our ability to predict the impacts of climate change, most of which would result from changes in a local or regional area.</p> <ol style="list-style-type: none"> 3) Have human activities over the last 120 years affected climate, i.e. has the change been greater than natural variability? 4) Are there alternate explanations for the climate change which has occurred over the last 120 years? <p>Given the limitations of climate models and other information on this question, current climate and human induced climate change has already been detected, are unjustified. However, assessment of whether human activities have already affected climate may be possible when improved climate models are available. Alternatively, a large, short term change in climate consistent with model predictions could be taken as proof of a human component of climate change.</p> <p>Explanations based on solar variability, anomalies in ice temperatures record, etc. are valid to the extent that they help to support a conclusion that we understand current climate or can detect a human component in the change in climate that has occurred over the past 120 years. However, these alternative hypotheses do not address what would happen if atmospheric concentrations of greenhouse gases continue to rise at projected rates.</p> <p>Can Human Activities Affect Climate?</p> <p>The Sun warms the Earth and is the source of energy for the climate system. However, as shown in Figure 1, the process by which this occurs is complicated. Only about half of the incoming radiation from the Sun is absorbed by the Earth's surface. About a quarter is absorbed by the atmosphere, and the remainder is reflected back into space by clouds, dust and other particulates without being absorbed, either by the surface or atmosphere.</p>
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Figure A.13: *Predicting Future Climate Change: A Primer*, 1995

While the GCC internally circulated *Predicting Future Climate Change: A Primer*, its public-facing publications of the time were very different. In 1995, it also published “Climate Change: Your Passport To The Facts,” a booklet allegedly intended to introduce readers to essential facts about climate change. Facts include that “the notion that scientists have reached consensus that man-made emissions of greenhouse gases are leading to a dangerous level of global warming is not true” and “computer climate models, which are the basis for ”predictions” of global climate change, suffer from severe flaws.” Figure A.14 shows an excerpt of the booklet, with the full document available at <https://www.worthingtoncaron.com/documents/1995-CLIMATE-CHANGE-YOUR-PASSPORT.pdf>

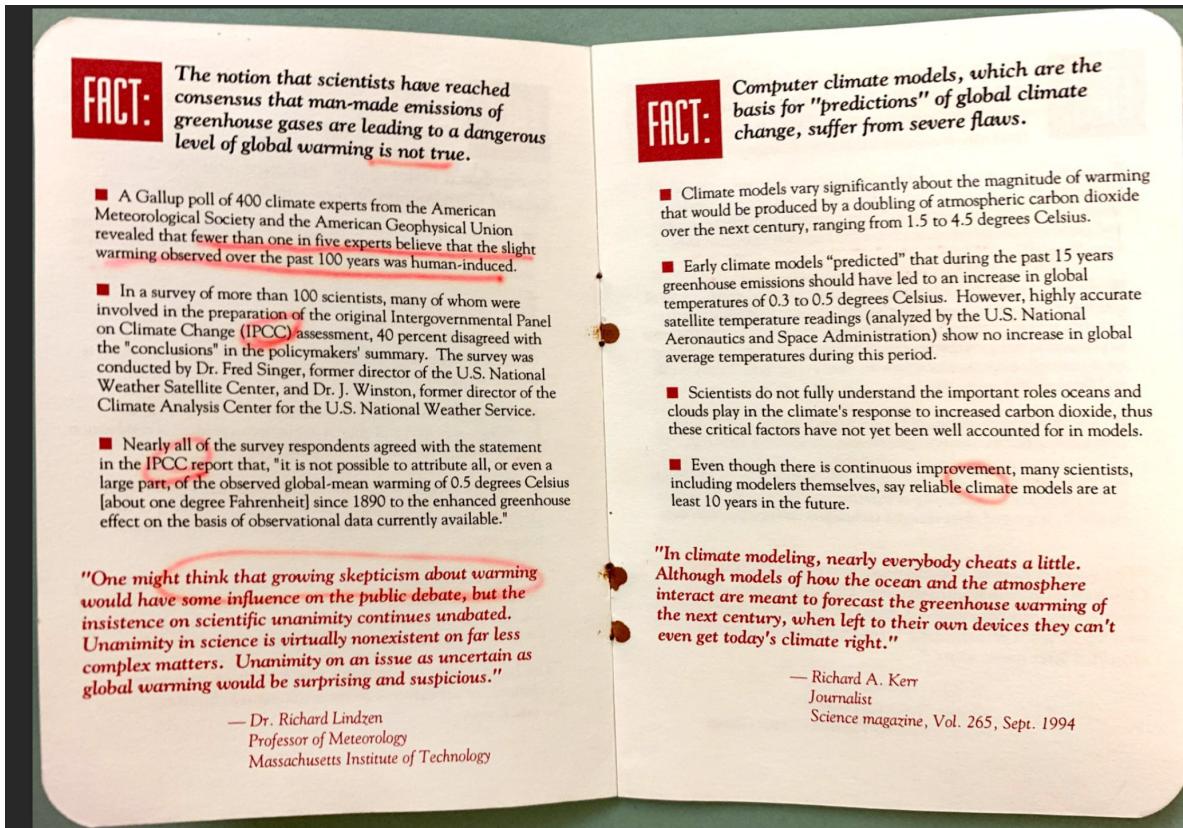


Figure A.14: “Climate Change: Your Passport To The Facts,” 1995

ExxonMobil published a series of newspaper ads in order to sow doubt into the public about climate science. In the spring of 2000, ExxonMobil ran the ad “Unsettled Science” in major news outlets (e.g., the *New York Times*), displayed in Figure A.15. These ads also tried to discredit climate scientists. Scientists like Lloyd Keigwin later responded in the *Wall Street Journal* complaining that ExxonMobil had distorted his work by suggesting it supported the notion that global warming was just a natural cycle.¹

Unsettled Science

Knowing that weather forecasts are reliable for a few days at best, we should recognize the enormous challenge facing scientists seeking to predict climate change and its impact over the next century. In spite of everyone's desire for clear answers, it is not surprising that fundamental gaps in knowledge leave scientists unable to make reliable predictions about future changes.

A recent report from the National Research Council (NRC) raises important issues, including these still-unanswered questions: (1) Has human activity already begun to change temperature and the climate, and (2) How significant will future change be?

The NRC report confirms that Earth's surface temperature has risen by about 1 degree Fahrenheit over the past 150 years. Some use this result to claim that humans are causing global warming, and they point to storms or floods to say that dangerous impacts are already underway. Yet scientists remain unable to confirm either contention.

Geological evidence indicates that climate and greenhouse gas levels experience significant natural variability for reasons having nothing to do with human activity. Historical records and current scientific evidence show that Europe and North America experienced a *medieval warm period* one thousand years ago, followed centuries later by a *little ice age*. The geological record shows even larger changes throughout Earth's history. Against this backdrop of large, poorly understood natural variability, it is impossible for scientists to attribute the recent small surface temperature increase to human causes.

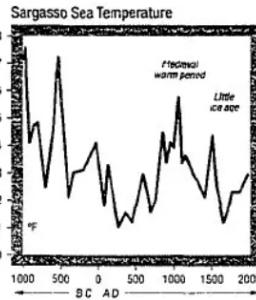
Moreover, computer models relied upon by climate scientists predict that lower atmospheric temperatures will rise as fast as or faster than temperatures at the surface. However, only within the last 20 years have reliable global measurements of temperatures in the lower atmosphere been available through the use of satellite technology. These measurements show little if any warming.

Even less is known about the potential positive or negative impacts of climate change. In fact, many academic studies and field experiments have demonstrated that increased levels of carbon dioxide can promote crop and forest growth.

So, while some argue that the science debate is settled and governments should focus only on near-term policies—that is empty rhetoric. Inevitably, future scientific research will help us understand how human actions and natural climate change may affect the world and will help determine what actions may be desirable to address the long-term.

Science has given us enough information to know that climate changes may pose long-term risks. Natural variability and human activity may lead to climate change that could be significant and perhaps both positive and negative. Consequently, people, companies and governments should take responsible actions now to address the issue.

One essential step is to encourage development of lower-emission technologies to meet our future needs for energy. We'll next look at the promise of technology and what is being done today.



ExxonMobil

Figure A.15: “Unsettled Science,” 2000

¹<https://insideclimatenews.org/news/22102015/exxon-sowed-doubt-about-climate-science-for-decades-by-stressing-uncertainty/>