Environmental Policy and the Size Distribution of Firms

Jessica Coria

Efthymia Kyriakopoulou

Motivation

- Different environmental policies impose different costs of compliance to firms and redistribute intra-industry rents differently.
  - Economies of scale in compliance might modify the optimal scale of firms and put small firms at a unit cost disadvantage.
  - Statutory and/or enforcement asymmetries might favor some establishments.
- Aim: to study the incidence of regulatory costs of different regulations across firm size.

Motivation

Why?

- Society may have an interest in preserving small businesses because of antitrust or other noneconomic reasons.

- The incidence of regulatory costs across firm size may also tell us something about the interest of certain groups of businesses in supporting alternative regulatory policies.

Preview of the Results

Emission taxes and performance standards reduce to a lower extent profits for larger firms than for smaller firms.

In contrast, emission standards create regulatory asymmetries as they distort the emission intensity and profits of large firms the most.

When the regulatory asymmetries created by emissions standards are taken into account, the profitability of emission saving biased technological change is higher under emission standards than under market-based instruments.

The Model

- Continuum of risk-neutral single-plant polluting firms of mass 1.
- Homogeneous good and two inputs: energy (e) and labor (l).
- Each unit of energy generates γ units of emissions $\xi = \gamma e$.
- Production function of firm i is $q_i = \theta[\varphi_i e_i]^{\alpha} l_i^{\beta}$.
- φ_i uniformly distributed on the interval $[\underline{\varphi}, \bar{\varphi}]$.
- w and z are the equilibrium wage rate and energy, and p is the output price.

Environment Regulation

- Regulatory goal is to limit aggregate emissions at some exogenously given level $\bar{E}$ by means of a per-unit emission tax τ, a uniform emission standard $\bar{\xi}$, and a uniform performance standard κ.

- In the case of emission taxes, firm i maximizes its profits $\pi_i(T)$

$$\pi_i(T) = p\theta[\varphi_i e_i]^{\alpha} l_i^{\beta} - w l_i - [z+\tau]e_i - F$$

Emission Taxes

- Individual and average emission intensity in the industry correspond to $p\alpha\gamma/z+\tau$.
- Let $\Delta\pi\downarrow i\uparrow\uparrow T=\pi\downarrow i\uparrow\uparrow NR-\pi\downarrow i\uparrow\uparrow T/\pi\downarrow i\uparrow\uparrow NR$ represent the percentage reduction in firm $i\uparrow$'s profits under emissions taxation vis-a-vis no regulation.

- **Proposition 1:** Emission taxes reduce by a larger percentage profits for smaller firms than for larger firms.

Emission Taxes

$$\partial \Delta \pi_{i\uparrow\uparrow T} / \partial \varphi_i = -[\alpha/1-\alpha-\beta\,]F/\varphi_i \; \Delta \pi_{i\uparrow\uparrow T} / \pi_{i\uparrow\uparrow NR} < 0.$$

The normalized fixed cost F/φ_i reflects the fact that the percentage reduction in profits of the larger firms is smaller since they can spread the fixed cost across a larger output.

Emission Standards

- Firm i maximizes profits given by the constraint $\xi\downarrow i \leq \bar{\xi}$.
- If the standard is binding, individual emissions intensity is equal to $\gamma\uparrow\alpha/1-\beta\ \bar{\xi}\uparrow 1-\alpha-\beta/1-\beta\ [p\uparrow\beta\ \beta\uparrow\beta\ w\uparrow-\beta\ \theta\varphi\downarrow i\uparrow\alpha\ ]\uparrow-1/1-\beta$.

- Let $\Delta\pi\downarrow i\uparrow\uparrow S=\pi\downarrow i\uparrow\uparrow NR-\pi\downarrow i\uparrow\uparrow S/\pi\downarrow i\uparrow\uparrow NR$ represent the percentage reduction in firm $i\uparrow$'s profits under emission standards vis-a-vis no regulation.

Emission Standards

Proposition 2: Emission standards reduce by a larger percentage profits for larger firms than for smaller firms.

RA

$$\partial \Delta \pi_{i\uparrow\uparrow S} / \partial \varphi_i = [\alpha/1-\alpha-\beta\,][\alpha[\pi_{i\uparrow\uparrow S} + F] - z[1-\alpha-\beta][\bar{\xi}\,\gamma_{\uparrow} - 1\,]/\varphi_i\,\pi_{i\uparrow\uparrow NR}\,[1-\beta]\,] - [\alpha/1-\alpha-\beta\,]F/\varphi_i\;\Delta\pi_{i\uparrow\uparrow T}/\pi_{i\uparrow\uparrow NR} > 0.$$

SE

Performance Standards

- Emission intensity is fixed by policy at $\xi\downarrow i / q\downarrow i \leq \kappa$.
- If the constraint is binding, the choice of the energy input is given by $e\downarrow i = \gamma\uparrow - 1 \ \kappa q\downarrow i$.

- **Proposition 3:** Performance standards reduce by a larger percentage profits for smaller firms than for larger firms.

Performance Standards

$$\partial \Delta \pi \downarrow i \uparrow \uparrow PS / \partial \varphi \downarrow i = -[\alpha / 1-\alpha-\beta\,] F / \varphi \downarrow i \;\Delta \pi \downarrow i \uparrow \uparrow PS / \pi \downarrow i \uparrow \uparrow NR < 0.$$

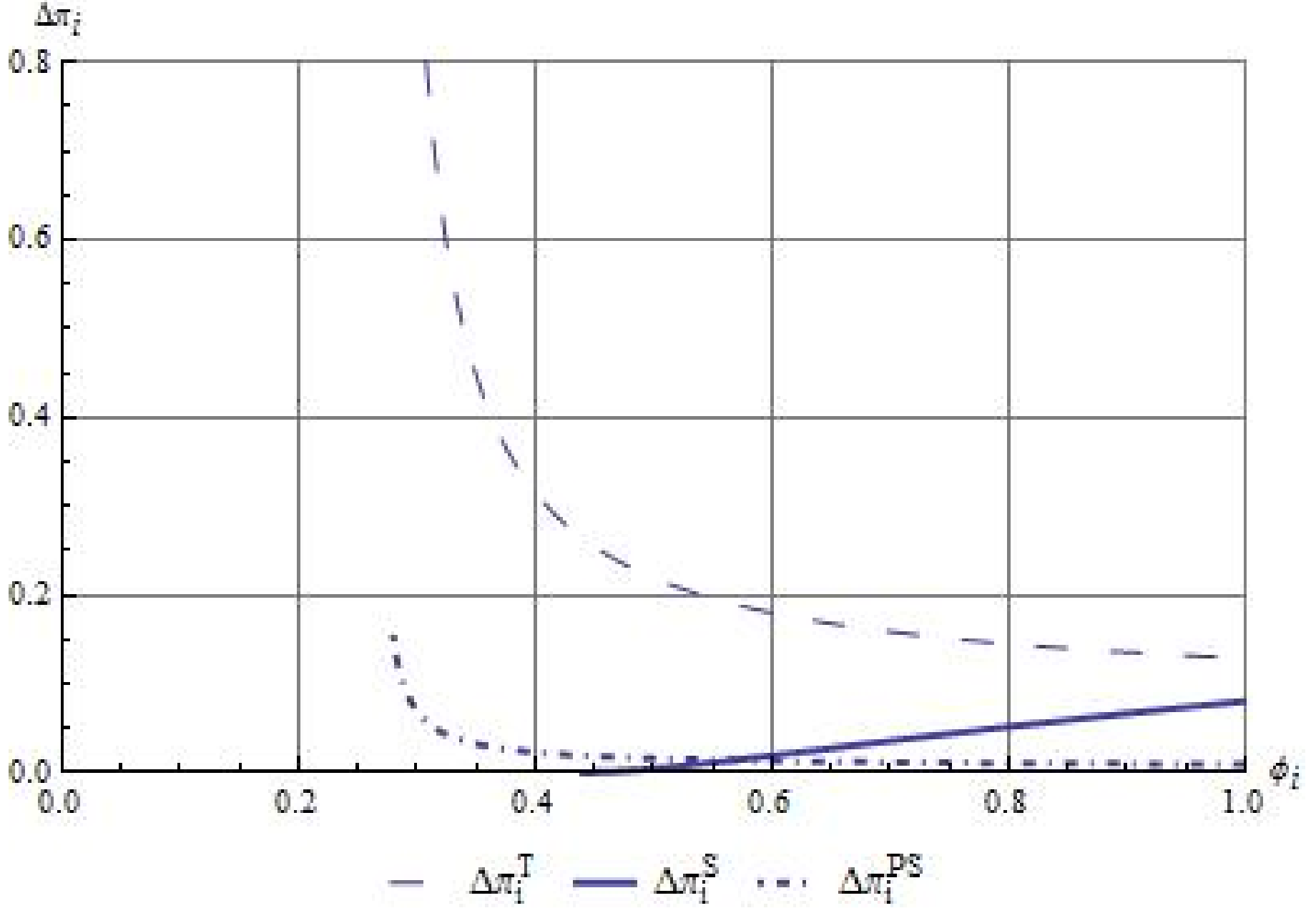
Proposition 4: Emission taxes reduce the profits of larger firms by a larger percentage than do performance standards.

Intuition: A restriction on emissions per unit of output is equivalent to a combination of a tax on emissions and subsidy to output.

Minimum Optimal Firm Size

- The minimum optimal firm size is larger under emission taxes and performance standards than under no regulation, $\varphi\downarrow 0\uparrow NR < \varphi\downarrow 0\uparrow PS < \varphi\downarrow 0\uparrow T$.

- There is a critical threshold $\varphi\downarrow 1$ that defines whether emission standards are binding. Since $\varphi\downarrow 1 > \varphi\downarrow 0\uparrow NR$, emission standards do not affect the minimum optimal firm size.

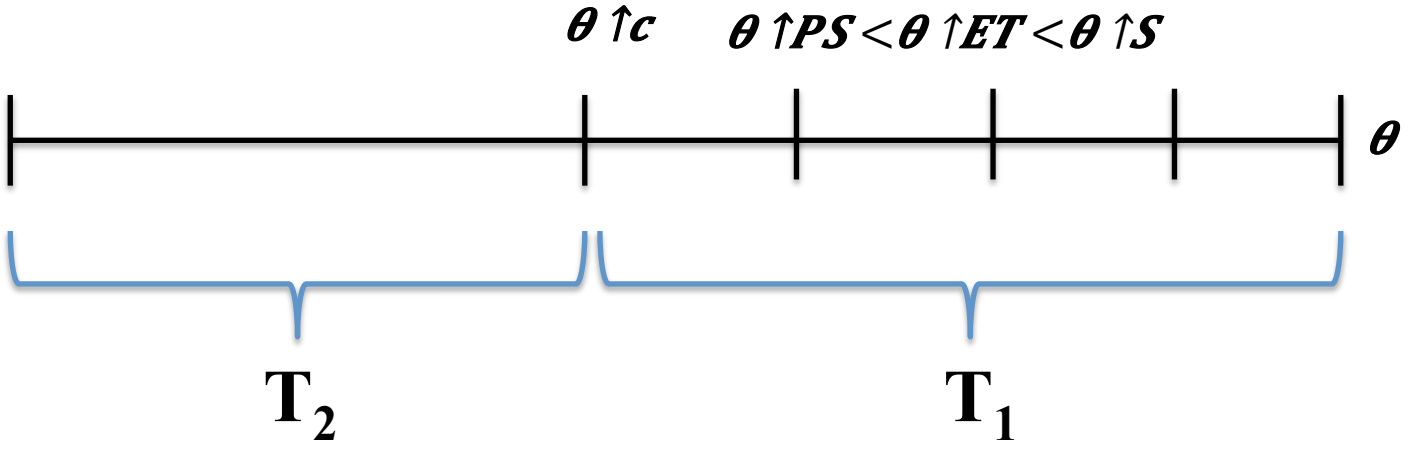

$\Delta\pi_i$
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0
ϕ_i
$\Delta\pi_i^T$
$\Delta\pi_i^S$
$\Delta\pi_i^{PS}$

The Choice of Technologies

- We model the choice between two technologies (same investment cost)
  - Technology 1 (T_1) increases the technology index from θ to θ .
  - Technology 2 (T_2) reduces the generation of emissions per unit of energy from γ to γ .

- We compute a threshold of θ for which T_1 is more profitable than T_2 under each policy instrument.

The Choice of Technologies



Proposition 6: Compared with neutral technological change, the profitability of emission-saving technological change is the highest under emission standards, followed by emission taxes and performance standards.

Conclusions/Implications

- That T_2 is most likely to be adopted under emission standards goes against previous studies suggesting that market-based instruments create more effective technology adoption incentives than conventional regulatory standards.

- The economics of regulatory tiering (small firms subject to emission standards and larger firms subject to taxes) might create additional discontinuities on the size distribution – for instance a bimodal distribution of sizes.