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Markup Dispersion and Partial Coverage of Environmental Regulation

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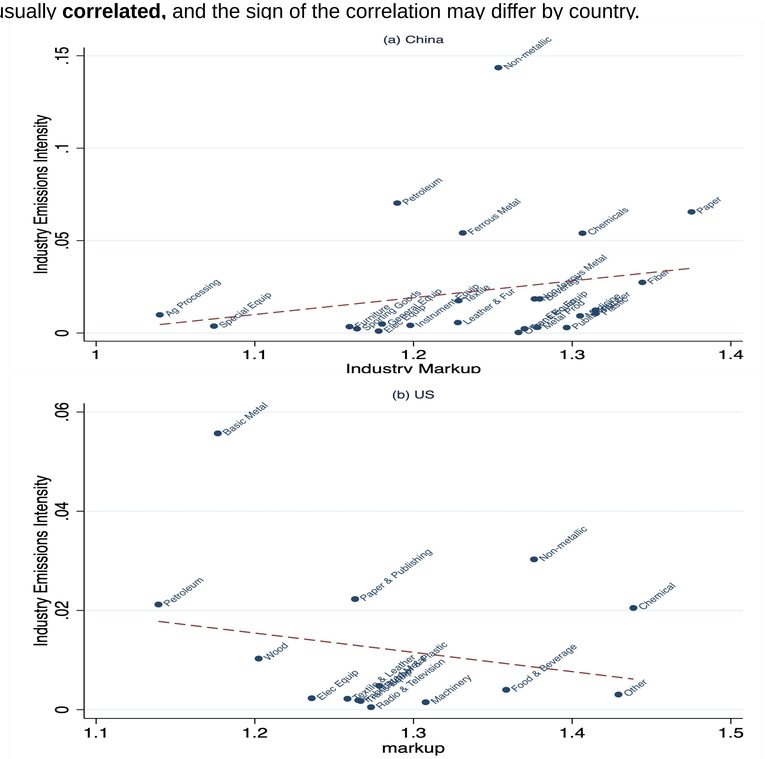
1. Introduction

Key words:
Markup dispersion, Partial Coverage, Environmental Regulation, Cost-effectiveness

- Classical environmental economics: cost-effective regulation requires "equalized" marginal abatement costs.
- "**Full coverage principle**": regulate all sectors at the same emissions price – provide a "fair playground" for every sector reduces total abatement cost (Fowlie, 2009; Holladay et al., 2018; Li and Wu, 2022), e.g., the expansion of sectors included in EU-ETS.
- In reality, sectors are usually unevenly distorted: some of them underproduce compared to the social optimality even in the absence of environmental regulation, whereas others overproduce.
- One example is that different industries enjoy **different degrees of market power** and charge **different markups** (Liu, 2019). Sectors with high markups underproduce (valued more by the society), while those with low markups overproduce.

2. Motivating Facts

Industry **markup (market power)** and **emissions intensity (energy cost share)** are usually **correlated,** and the sign of the correlation may differ by country.



- Environmental regulation affects industry output differently by industry emissions intensity, alleviating/exacerbating the distorting effect of **markup dispersion**.

3. Objectives

Conceptually

- Explore how the correlation between industrial markup dispersion and emissions intensity affects the cost of environmental regulations.
  - ✓ Markup dispersion distorts the economy (Edmond et al., 2018).
  - ✓ Contributes to the large literature on the interaction of environmental policies and pre-existing distortions (Montgomery, 1972; Goulder, 1995)
- Explore the potential of partial sector coverage to dominate full sectoral coverage under markup dispersion.

Empirically: apply the model to carbon regulation in China.

- Identify which sectors should be covered under different aggregate emissions abatement targets.

4. The Conceptual Framework

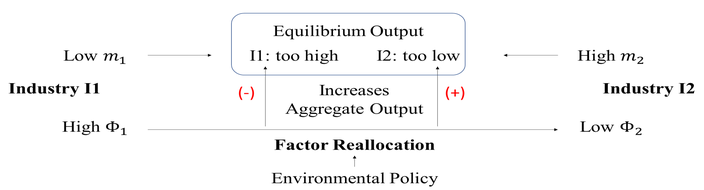
Model Description: A tractable GE model adjusted from Melitz (2003)

- *I* manufacturing industries with industry-specific markups (m_i) and energy use intensities (Φ_i). The consumption share of industry is fixed at β_i (can be relaxed).
  - ✓ Φ_i the overall energy intensity in firms' production and entry.
- Each industry consists of monopolistically competitive firms using labor and energy to produce differentiated goods. Energy is produced with.
- Emissions: proportional to energy use; regulated by a cap-and-trade system.

Aggregate Marginal Abatement Cost (MAC) Decomposition: full industry coverage

$$\frac{dQ^{FR}}{dZ} = \frac{Q^{FR}\bar{m}}{Z(1-\frac{Z}{Z^{NR}}\sum\beta_i\Phi_i)}\underbrace{[(1-\frac{Z}{Z^{NR}})\sum_i\beta_i\Phi_i}_{Abatement\ Effect} + \underbrace{\sum_i(\frac{m_i}{\bar{m}}-1)\beta_i\Phi_i]}_{Dispersion\ Effect},$$

- *Q* -- aggregate output, *Z* -- aggregate emissions cap. Z^{NR} -- aggregate emissions without environmental regulation.
- "Abatement Effect": lower Z reduces *Q*, i.e., increases policy cost, straightforward.
- **"Dispersion Effect":** originates from **the correlation** between m_i and Φ_i
  - If industries with lower m_i are also more "dirty", i.e., have higher Φ_i, the dispersion effect is more negative, i.e., reduces the MAC.



- **Corollary 1**: Dispersion effect reduces MAC $\Leftrightarrow$ $Cov(m_i, \Phi_i) < 0$.

MAC: full industry coverage (FR) vs. partial industry coverage (PR)

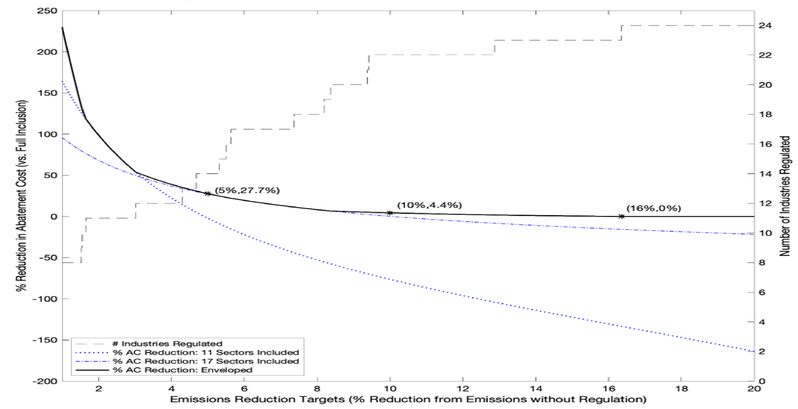
- **Corollary 2**: partial industry coverage is less costly than full coverage if and only if

$$\frac{\sum_C(\frac{m_i}{\bar{m}}-1)\beta_i\Phi_i}{\sum_C\beta_j\Phi_j} < \frac{\sum(\frac{m_i}{\bar{m}}-1)\beta_i\Phi_i}{\sum\beta_i\Phi_i}$$

  - ✓ *C* : set of regulated. Other industries are unregulated under the PR scheme.
  - ✓ Comparing: dispersion effects under FR and PR, "adjusted" by the regulated emissions scale.

5. Application: Carbon Regulation in China

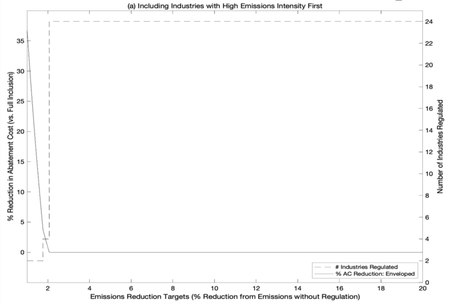
- $Cov(m_i, \Phi_i) > 0$ in China – Markup dispersion increases carbon regulation cost.
- Solve out an "optimal" partial regulation scheme that minimizes policy cost?
  - ✓ Infeasible– discrete optimization with 24 industries.
  - ✓ A "heuristic" optimization routine motivated by the conceptual framework: sort industries ascendingly by m_i -- **regulate industries with lowest m_i first**.
    - ➢ At least guarantees a negative dispersion effect with small *C* set.



Key Messages:

- ✓ Optimal # of covered industries increases in aggregate abatement target.
  - ➢ Leakage becomes more costly under PR when target ↑⇨ needs high coverage
  - ➢ PR under "ascending markup scheme" is less costly than FR when target < 16%
  - ➢ 5%-10% target is often reasonable: EU ETS phase II, Five-year plans in China.

What if we follow the traditional rule: regulate industries with highest Φ_i first?



Key Messages:

- Becomes worse than FR quickly when target > 2.5%.
  - ✓ Reasonable: $Cov(m_i, \Phi_i) > 0$
    - ➢ similar to regulating high m_i sectors
    - ➢ more positive dispersion effect, increases PR MAC.
- The "**Ascending markup scheme**" is better than the "**descending emissions intensity scheme**"

6. Conclusions

- The first paper to show that the **dispersion**, on top of the level, of markups across economic entities affects the cost-effectiveness of environmental regulations.
- We provide a sufficient statistic for the influence of markup dispersion on MAC, i.e., the correlation between individual markup and emissions intensity.
- We provide a clear rule to decide whether a particular partial coverage scheme is more cost-effective than full coverage. We apply the model to China carbon regulation and solve "optimal" sector coverages under different abatement targets.