Environmental Regulations and International Competitiveness: A Review of Recent Evidence

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Introduction to the Literature

A History of Surmounting Challenges

- Confusing the impact of growth for trade
- Failing to recognize the endogeneity of policy
- Ignoring measurement and data issues
- Failing to use theory to help sort out channels of causation

Goal of This Paper

Review **recent** empirical work on **firm level** responses to further our understanding of the trade, competitiveness, and environmental consequences of environmental regulation.

Method

- Detail the new channels through which firm level responses can affect environmental outcomes.
- Develop a simple model to identify a set of potential mechanisms through which firm level responses can create changes.
- Review the new firm level evidence using the theory and decomposition for guidance.

The Two Hypotheses

- **Pollution Haven Effect.** An increase in environmental stringency has negative cost and competitiveness consequences on exporters or import competing industries.

- **Pollution Haven Hypothesis.** A trade liberalization causes the reallocation of production of pollution intensive output to low income countries because these countries have low environmental standards.

Logical Connections

The two hypotheses are related, but not identical.

- The finding of a pollution haven effect is a necessary, but not sufficient, condition for the pollution haven hypothesis.

- Finding trade flows respond in a manner consistent with the pollution haven hypothesis does not mean differences in environmental regulation caused the trade flow, nor that they have large cost consequences (i.e. a strong pollution haven effect).

Empirical Connections

- Estimating the strength of the pollution haven effect need not use data on trade nor data on more than one country. It does need variation in the stringency of environmental regulations.

- Evaluating the pollution haven hypothesis requires data on trade, and needs variation arising from a trade liberalization together with some information on the relative stringency of regulations across trading partners.

Firm Level Responses
&
Environmental Outcomes

Scale, Composition & Technique

- An economy with N industries. N is fixed.
- Each industry i has a continuum of firms indexed on the interval $[0, n_i]$.
- n_i is endogenously determined by the industry's profitability.
- Each firm generates emissions of some pollutant Z, where emissions in industry i are

$$Z_i = \int_0^{n_i} z_i(n)dn \tag{1}$$

Firm Level Emissions Decomposition

- The emissions of firm n is

$$z_i(n) = \tilde{e}_i(n) y_i(n) \tag{2}$$

- The scale of output in industry i is

$$S_i = \int_0^{n_i} p_i(n) y_i(n) dn \tag{3}$$

Emissions Decomposition

Using (2) and (3), emissions in industry i can be written as

$$Z_i = S_i \int_0^{n_i} e_i(n)\varphi_i(n)dn \tag{4}$$

where

$$e_i(n) = \tilde{e}_i(n)/p_i(n) \tag{5}$$

$$\varphi_i(n) = p_i(n)y_i(n)/S_i \tag{6}$$

And, the aggregate emissions of Z is

$$Z = \sum_{i=1}^{N} Z_i$$

Emissions Decomposition

- The average emission intensity in industry i is defined as

$$E_i \equiv \int_0^{n_i} e_i(n)\varphi_i(n)dn \tag{7}$$

- Then, the aggregate emissions of Z is

$$Z = \sum_{i=1}^{N} Z_i = \sum_{i=1}^{N} E_i S_i \tag{8}$$

The Standard Decomposition

Take logs and differentiate yields to get the industry-level decomposition

$$\hat{Z} = \hat{S} + \sum_{i=1}^{N} \Theta_i \hat{E}_i + \sum_{i=1}^{N} \Theta_i \hat{\Phi}_i \tag{9}$$

Industry Level Decomposition

To investigate the change in average emission intensities, take logs and differentiate yields in (7)

$$\begin{aligned}\hat{E}_i = &\int_0^{n_i} \hat{e}_i(n)\theta_i(n)dn \\ &+ \int_0^{n_i} \hat{\varphi}_i(n)\theta_i(n)dn \\ &+ n_i[\theta_i(n_i) - \varphi_i(n_i)]\hat{n}_i \end{aligned} \tag{10}$$

The New Decomposition

Combining (9) and (10) yields the full decomposition

$$
\begin{aligned}
\hat{Z} = \hat{S} & \\
& + \sum_{i=1}^{N} \Theta_i \hat{\Phi}_i \\
& + \sum_{i=1}^{N} \Theta_i \int_0^{n_i} \hat{e}_i(n)\theta_i(n)dn \\
& + \sum_{i=1}^{N} \Theta_i \int_0^{n_i} \hat{\varphi}_i(n)\theta_i(n)dn \\
& + \sum_{i=1}^{N} \Theta_i n_i [\theta_i(n_i) - \varphi_i(n_i)]\hat{n}_i
\end{aligned}
\tag{11}
$$

Firm Level Adjustments

- Direct firm level responses to tighter environmental policy
  $\Rightarrow$ The Technique Effect

- Indirect changes in the allocation of share across firms in as they respond differentially to the new regulation
  $\Rightarrow$ The Market Share Effect

- Indirect changes created by entry and exit of either cleaner or dirtier firms
  $\Rightarrow$ The Selection Effect

Melitz Model Example

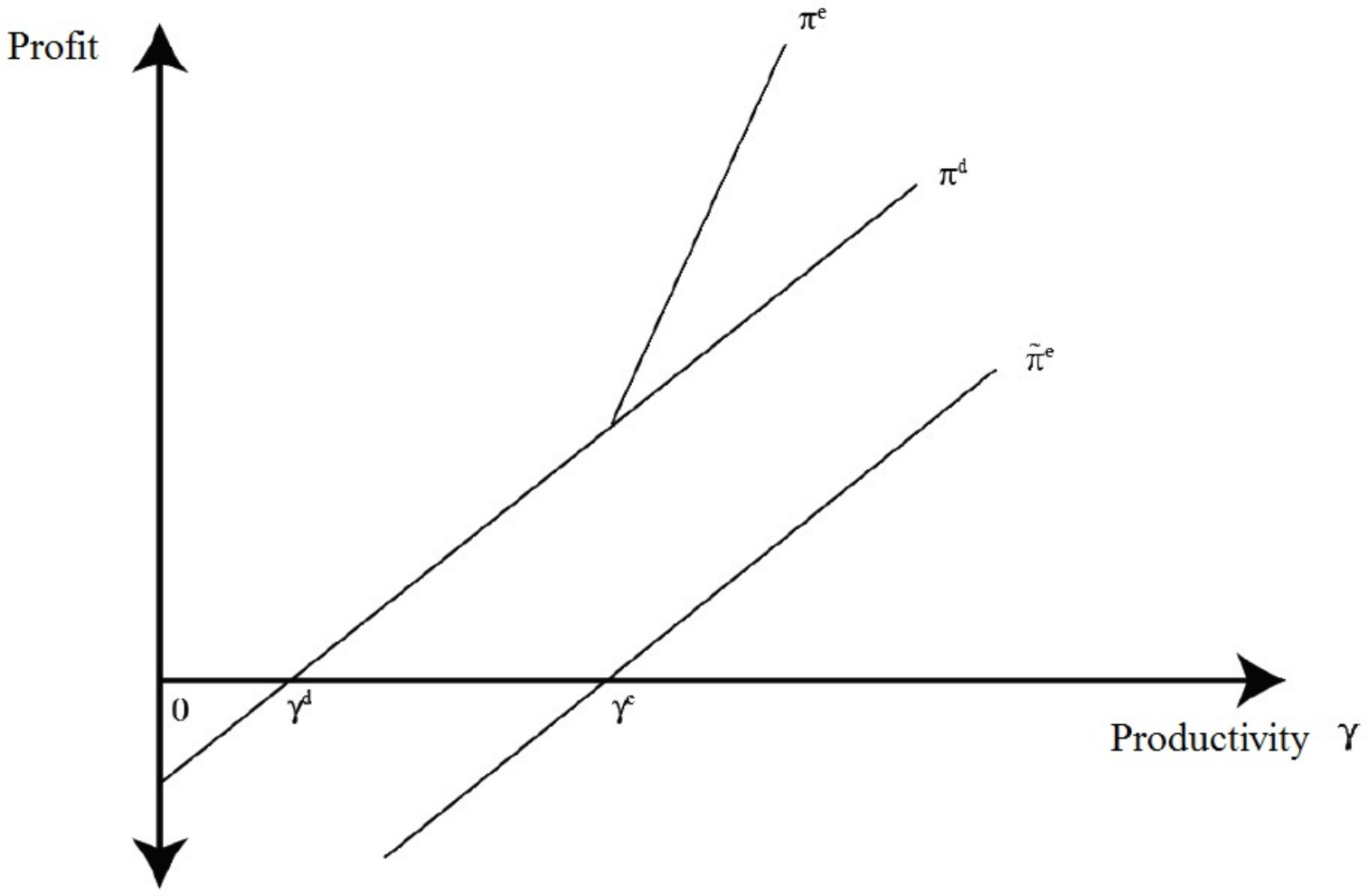
- Firm uses clean and dirty inputs to produce output.
- Pollution from dirty input can be abated at cost.
- Firms differ in their total factor productivity.
- Productivity differences are neutral.
- Each firm has some market power.
- Entry into domestic and foreign markets is costly.
- Shipping goods abroad is costly.

Basic Model Features

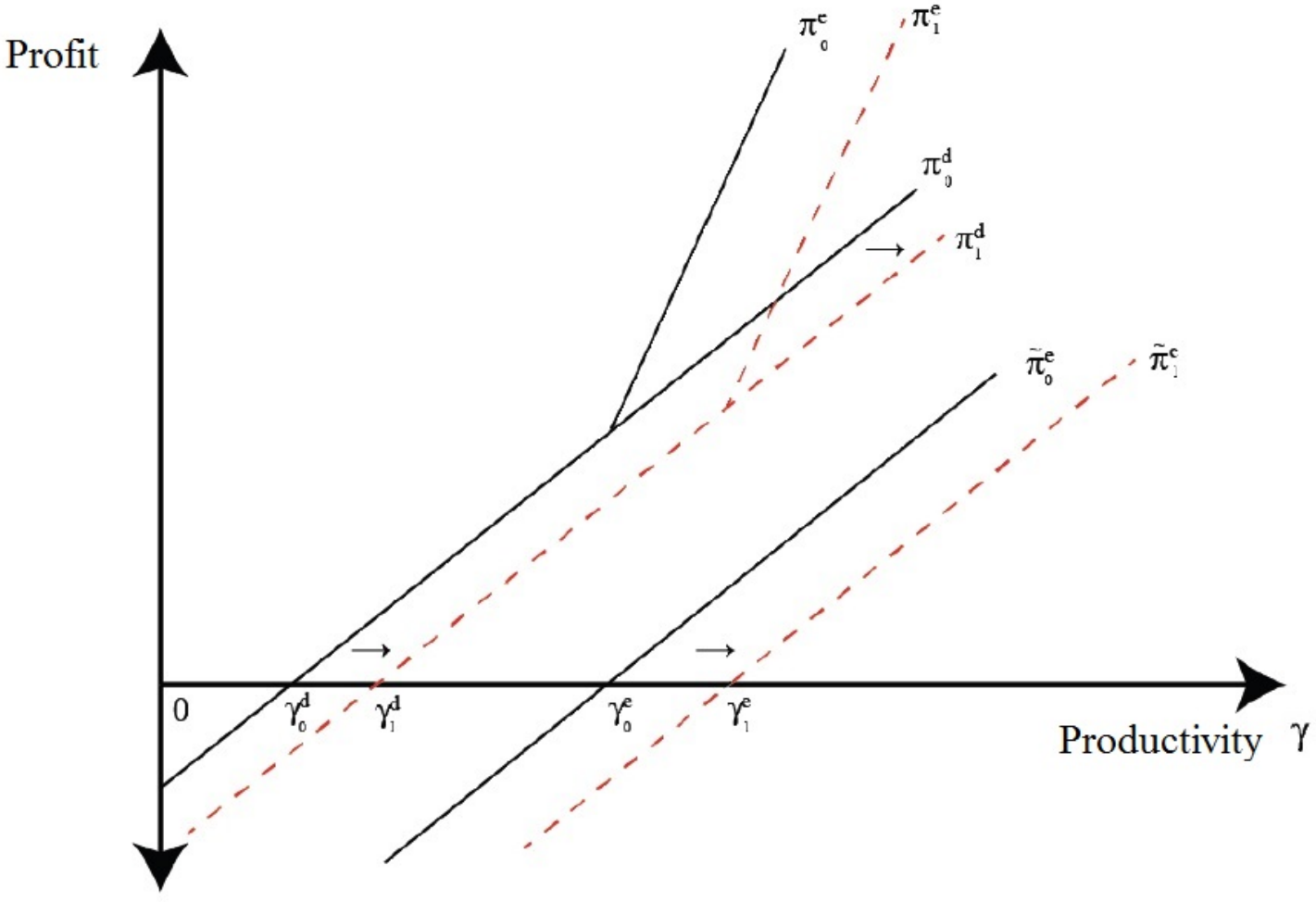
- More productive firms produce more and have lower emissions per unit output.
- More productive firms abate more and have lower emissions per unit output.
- Industry distribution of firm size is Pareto.

An Initial Industry Steady State

Determination of Productivity Cutoffs



The Pollution Haven Effect



Firm Level Impacts

- Direct impact is higher costs, lower profits, and less emission intensive output because of abatement.
- Market share effect is negative assuming foreigners are unaffected. Emissions may rise or fall.
- Selection effect is negative as well, range of purely domestic and exporting firms falls.
- Strength relies on: pollution intensity; elasticity of substitution; availability of abatement opportunities.

Empirical Methods

- **Henderson Type Studies:** Use CAAA amendments to obtain over county and across time variation useful for a DD research design.

  Finding: Plant births lower in non-attainment counties for a variety of pollutants over long periods of time.

  Problem: Consistent with pollution haven effect selecting out dirty firms and market shares shifting to cleaner plants lowering births; but also just county-by-time specific events driving things.

Empirical Methods

- **Greenstone Type Studies:** Use CAAA amendments to obtain over county, across time, and across industry variation for a DDD research design.

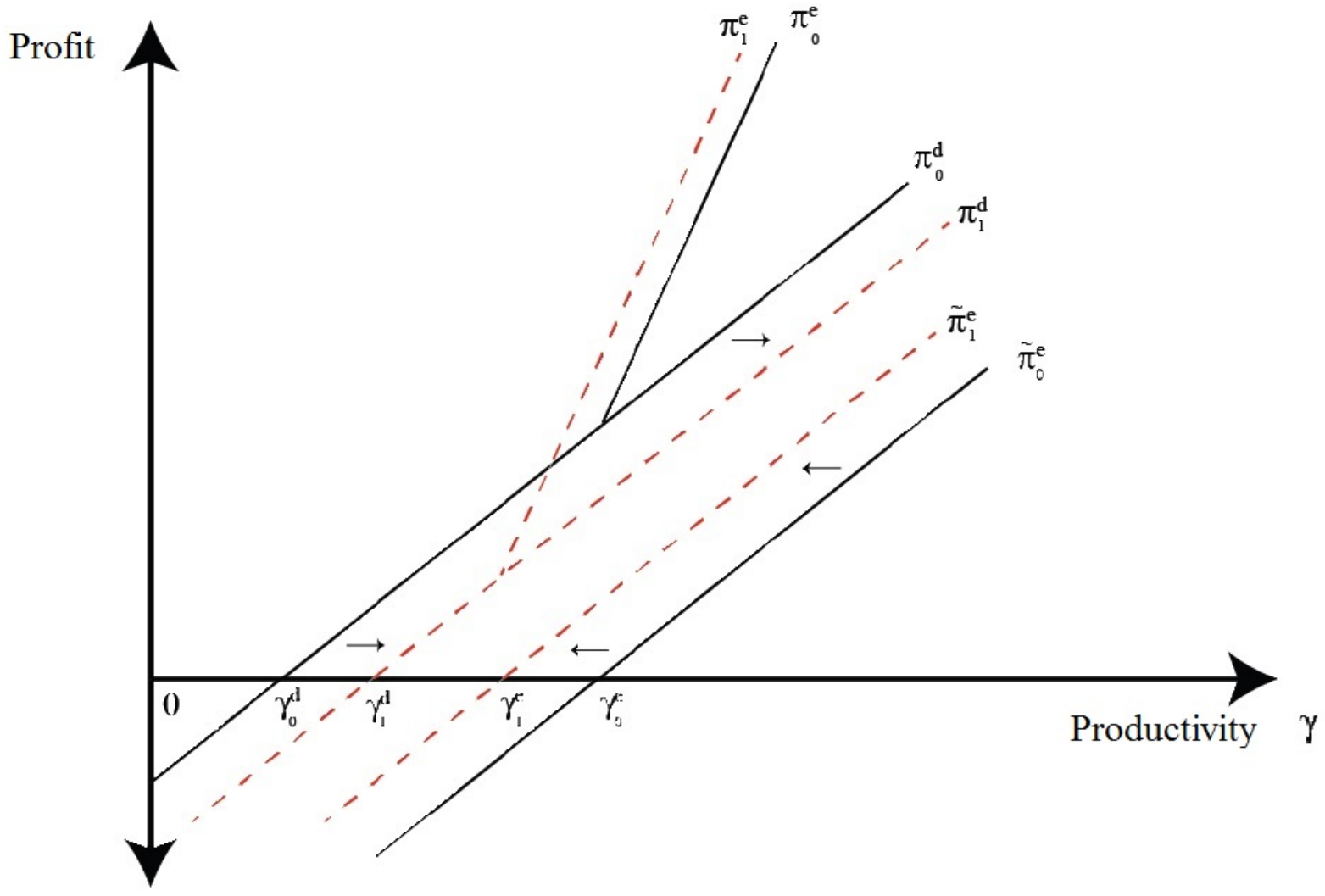
  Finding: Employment, capital stocks, productivity, and output lower in non-attainment counties.

  Effects are relatively large, significant, and replicable.

Problems and Questions

- Significant costs may alter market structure and conduct which then confounds estimation (Ryan).
- Interference is exactly the indirect effects highlighted before in the theory (Price indices).
- Estimates come from the CAAA that mandates technology choices under certain conditions; i.e. they are command and control. This is a problem for external validity. Market based instruments may be less costly.

The Pollution Haven Hypothesis



Firm Level Impacts

- Direct impact is larger markets for exporting but more competition. Lower productivity domestic firms exit; new exporters are created; existing exporters expand.
- Selection effect tends to lower average emission intensity since exiting firms tend to be dirtier.
- Market share expands with relatively clean exporters expanding.
- Technique effect is positive since abatement is fixed cost spread over more units.
- Scale and Composition effects can undo these changes.

Firm Level Evidence

- **Holladay Type Studies:** Use over time variation in openness to trade together with fixed export status of plants. Control is non-exporting plants.

  Finding: Exporters are on average cleaner.

  Problem: Both exporting and abatement are endogenous, so it's difficult to suggest trade caused exporters to clean up.

Firm Level Evidence

- **DD Type Studies:** Use over time and across industry variation in trade barriers to examine trade's impact on environmental outcomes.

  Finding: Tariff reductions across industries are related to within firm changes in their energy use. Changes may come from competitive pressures or access to cheaper inputs. Evidence of a firm level technique effect.

  Problem: Tariff reductions are not assigned across industries randomly.

Firm Level Evidence

- **DDD Type Studies:** Cherniwchan (2013). Uses across industry, over time, and geographic variation in the level of trade costs to relate trade liberalization to environmental outcomes .

  Finding: NAFTA inspired tariff cuts in the US, lowered emissions in US plants of particulates, lead and toxic chemicals. Evidence of a within plant technique effect, no evidence of offshoring.

  Problem: We need more work like this!

Conclusion

- Adopting firm level perspective is useful in gaining a more complete and credible understanding of how regulation affects trade flows, and how environmental outcomes may be shaped by trade.

- Much remains to be done. There is really only a handful of credible studies. Access to firm level data is key to future work.

- Apart from more work, more evidence is needed in small number industries, on how different instruments affect costs, and on the potentially important role general equilibrium considerations may have on estimation.