

Environmental Efficiency under Globalization: Application to the Industrial Sector in China

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1. Introduction

Industrial growth → Polluted cities

High environmental costs, e.g.,
losses of human life (Dasgupta,
Wang and Wheeler, 1997)

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Consequence of globalization

The problems of liang gao yi zi

(兩高一資)

FDI →



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The pollution havens hypothesis

- Firms in developed countries relocate their major polluters to developing countries.

Globalization ↑ ⇒ Pollution ↑

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Objectives

- Measuring the environmental efficiency of the industrial sector in China from a production approach
- Test the polluting havens hypothesis

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2. Modelling Undesirable Outputs

- Inputs: $x = (x_1, x_2, \dots, x_N)$
- Economic goods: $g = (g_1, g_2, \dots, g_M)$
- Economic bads: $b = (b_1, b_2, \dots, b_L)$

Technology:

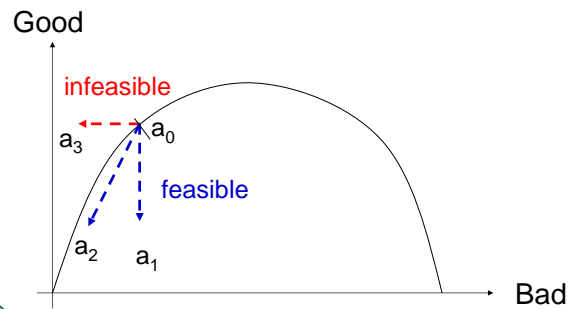
$\mathfrak{T} = \{(x, g, b): x \text{ can produce } (g, b)\}$

Good (g): Strongly disposable

Bad (b): Weakly disposable

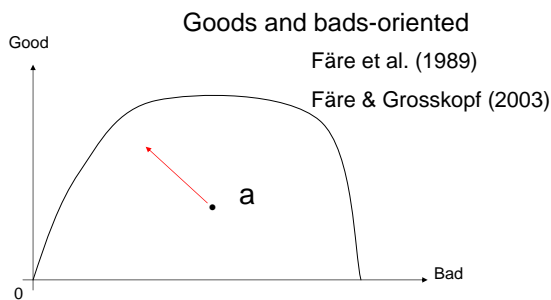
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Output set



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3. Technical vs. Environmental Efficiency



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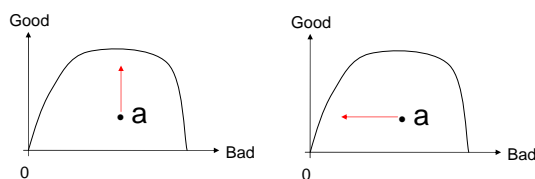
Different behaviours

- **Technical efficiency**
 - Profit maximization
 - There are self-corrections for profit-maximizing firms
- **Environmental efficiency**
 - Externality
 - Market force is not sufficient to eliminate this type of efficiency

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Recommendation of choosing orientation

- Measuring technical efficiency (goods or inputs-oriented) and environmental efficiency (bads-oriented) separately



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4. Efficiency of the Industrial Sector in China

- Source: China Environment Yearbook
- Data: 46 Chinese cities
- Year: 1997
- Good: Gross industrial output value
- Bads: Solid wastes, waste gas and waste water
- Inputs: Capital and labor

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Empirical technologies

$$\mathfrak{T}^1 = \{(x, g, b): tGz \geq g, tBz = b, Xz \leq x, z \in \mathfrak{R}_+^K, t \in (0, 1]\}$$

$$\mathfrak{T}^2 = \{(x, g): Gz \geq g, Xz \leq x, z \in \mathfrak{R}_+^K, \sum_i z_i = 1\}$$

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Existing formulations

Yaisawa and (4)

Tytos (19)

Fa

Kuo

Conceptually Incorrect !!!

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Efficiency measures

- $te_fare = \max_{\beta} \{\beta: (x, g + \beta g, b - \beta b) \in \mathfrak{T}^1\}$
- $te_good = \max_{\theta} \{\theta: (x, \theta g, b) \in \mathfrak{T}^1\}$
- $te_bad = \min_{\lambda} \{\lambda: (x, g, \lambda b) \in \mathfrak{T}^1\}$
- $te_out = \max_{\theta} \{\theta: (x, \theta g) \in \mathfrak{T}^2\}$

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Geometric means

	Orientation	Mean	Implications
$te_fare (> 0)$	Goods & Bads	0.126	Ineff
$te_good (> 1)$	Goods	1.205	Ineff
$te_bad (0 \text{ to } 1)$	Bads	0.333	E. ineff
$te_Out (> 1)$	Outputs	2.046	V. ineff

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Findings in efficiency analysis

- Ignoring bads may bring forth **biased results**
- The manufacturing sector in China is **relatively efficient in the production of goods** but **very inefficient environmentally**

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5. Polluting Havens Hypothesis

- Developed countries relocate their major polluters to developing countries.
 - FDI \uparrow \rightarrow pollution \uparrow
 - i.e. te_bad is closer to zero and the country is more environmental inefficient

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Environmental Kuznets curve

- 1st stage: income $\uparrow \rightarrow$ pollution \uparrow
 - i.e. te_bad closer to zero
- 2nd stage: income $\uparrow \rightarrow$ pollution \downarrow
 - i.e. te_bad closer to one

World Bank (1992) and Grossman and Krueger (1995) found supports for this hypothesis.

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Regression Model

$$\begin{aligned} \text{te_bad} = & \beta_0 + \beta_1 \text{FDI/GDP} \\ & + \beta_2 \text{GDP} + \beta_3 \text{GDP}^2 \\ & + \delta_c \text{Central} + \delta_e \text{East} + \varepsilon \end{aligned}$$

Pollution havens: $\beta_1 > 0$

Environmental Kuznets curve: $\beta_2 < 0$ & $\beta_3 > 0$

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Regression results

Wheeler (2000)

$$\begin{aligned} \text{te_bad} \\ = & 110.45^{**} - 1.60 \text{FDI/GDP} \\ & - 23.29^{**} \text{GDP} + 1.21^{**} \text{GDP}^2 \\ & + 0.36 \text{Central} + 0.72^{***} \text{East} \end{aligned}$$

Central: 1 for central region, 0 otherwise

East: 1 for eastern region, 0 otherwise

*** & **: Significant at 5% & 1%, respectively

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Testing results

- Pollution havens: **Not confirmed**
- Environmental Kuznets curve: **Supported**

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6. Conclusion

- Globalization have not caused more pollution in China.
- People would care more about pollution when they get richer.

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6. Conclusion

- Ignoring undesirable outputs may lead to biased results of measuring performance
- Productive and environmental efficiency should be treated separately
- The manufacturing sector in China is productively efficient but environmentally inefficient

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