Pollution Abatement and Employment: A Nonparametric Cost Function Analysis

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Introduction

- Society has determined that undesirable by-products of production need to be regulated
- Pollution abatement leads to a reallocation of resources
- Cost / employment effects of pollution abatement remain a source of concern to society

Some Remarks on the Literature

- Structural models used to investigate pollution abatement (PA) and employment
  - Berman and Bui (2001)
  - Morgenstern, Pizer, and Shih (2002)
- Model the joint production of good and bad outputs to investigate PA and employment
  - Färe, Grosskopf, Pasurka, and Shadbegian (2013) – calculate effect of lack of mobility in bad output production among power plants
  - Färe, Grosskopf, Pasurka, and Shadbegian (2017) – use input distance function (i.e., calculate isoquants) to decompose change in employment among power plants

Some Remarks on the Literature (continued)

- Ball, Färe, Grosskopf, and Zaim (2005) introduce a nonparametric (i.e., piece-wise linear) cost function with bad outputs to calculate Malmquist cost productivity measure
- Granderson and Prior (2013) use a nonparametric cost function with bad outputs to investigate sources of productivity changes for a regulated technology
- Decomposition framework used in this paper combines elements of Ball, Färe, Grosskopf, and Zaim (2005), Granderson and Prior (2013), and Färe, Grosskopf, Pasurka, and Shadbegian (2017)

Joint Production Model

- This study uses a nonparametric cost function to model the joint production of good and bad outputs to investigate the factors associated with changes in employment
- “Regulated” isoquant – depicts regulated (i.e., weak disposability) technology (plant is *not* allowed to freely dispose bad outputs it produces)
- “Unregulated” isoquant – depicts unregulated (i.e., free disposability) technology (plant is allowed to freely dispose bad outputs it produces)
- Requires information on inputs and production of good and bad outputs
- Advantage - requires no information on inputs assigned to pollution abatement
- Operationalize joint production model via a nonparametric cost function

Environmental Technology (regulated technology)

- Satisfy standard axioms
  - Inactivity is always possible
  - Finite inputs produce finite outputs
  - Inputs are freely disposable
- Environmental axioms
  - Weak disposability of outputs (allows us to model technology when bads are not freely disposable)
  - Null jointness (i.e., no fire without smoke)

LP problem – nonparametric cost function

- Objective function
  - Minimize cost of producing good and bad outputs
- Constraints
  - (i): Good output production
  - (ii): Bad output production
  - (iii): Inputs – quantities and qualities (Capital, Employees, Coal, Oil, Natural Gas)

Nonparametric Cost Function (regulated technology)

$$C_R(y_{k'}, b_{k'}, r_{k'}, w_{k'}) = min \quad \sum_{n=1}^{N} r_{k'n}\, x_n + w_{k'}L \qquad (6)$$

$$s.t \quad \sum_{k=1}^{K} z_k\, y_k \geqq y_{k'}$$

$$\sum_{k=1}^{K} z_k\, b_k \leqq b_{k'}$$

$$\sum_{k=1}^{K} z_k\, x_{kn} \leqq x_n \qquad n = 1, \dots, N$$

$$\sum_{k=1}^{K} z_k\, L_k \leqq L$$

$$z_k \geqq 0, k = 1, \dots, K$$

Cost Effect and Employment

- Cost Effect
  - Gap between the cost minimizing level of labor associated with producing the output vector of the “regulated” and “unregulated” technologies
- Change in Cost Effect
  - Increased Cost Effect increases Employment - increase in gap between the cost minimizing level of labor associated with producing the output vector of the “regulated” and “unregulated” technologies
  - Decreased Cost Effect decreases Employment - decrease in gap between the cost minimizing level of labor associated with producing the output vector of the “regulated” and “unregulated” technologies

Cost Effect (Period t)

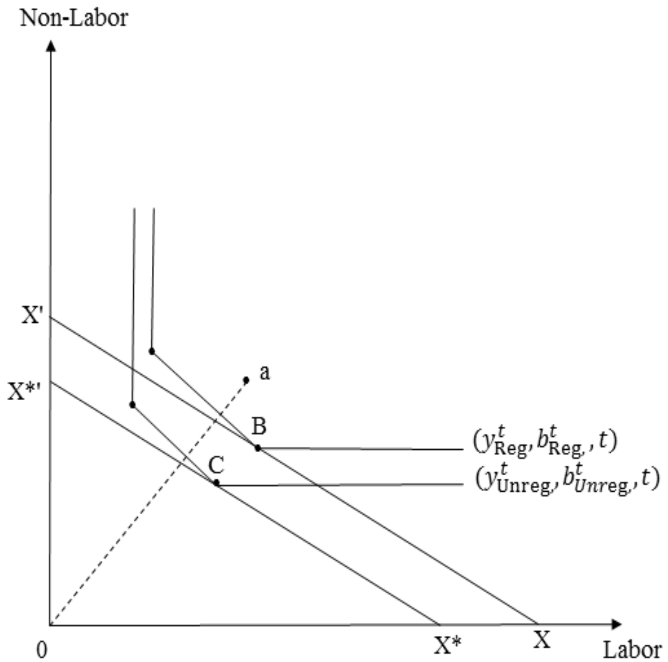

Figure 1. Regulated and Unregulated Isoquants and Isocost Lines (Cost Effect – Period t)

$$CE^t = \left[\frac{B}{C}\right]$$

Change in Cost Effect

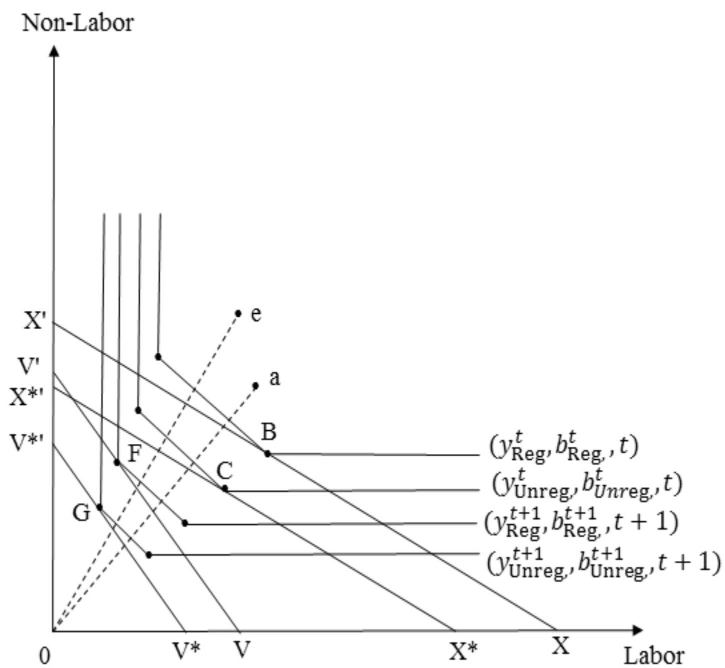

Figure 1. Regulated and Unregulated Isoquants and Isocost Lines (Cost Effect)

$$\Delta CE_t^{t+1} = \left[\frac{(F/G)}{(B/C)} \right]$$

Decomposing Change in Employment (regulated technology)

- Changes in Overall Efficiency (OE)
  - Increased (Decreased) Overall Efficiency decreases (increases) Employment – movement of observation toward or away from cost minimizing level of employment on “regulated” isoquant
- Technical Change (TC)
  - Technical progress (regress) decreases (increases) employment – shift in “regulated” isoquant
- Change in relative cost of labor and non-labor inputs (IC) – substitution (or factor shift) effect
  - Change in mix of labor and non-labor (i.e., capital and fuel) inputs between period t and period t+1 due to change in factor prices
  - Movement along “regulated” production isoquant (i.e., constant level of good and bad output production)
- Change in mix of good and bad output production (OC) – output (or scale) effect for case with no bad outputs
  - Change in employment associated with change in mix of good and bad outputs (i.e., change in emission-intensity)

Decomposing Change in Employment (e/a): (Reference Technology: Period t)

$$OE = \left[\frac{e/F}{a/B}\right]$$

$$TC = \left[\frac{F}{L}\right]$$

$$IC = \left[\frac{L}{M}\right]$$

$$OC = \left[\frac{M}{B}\right]$$

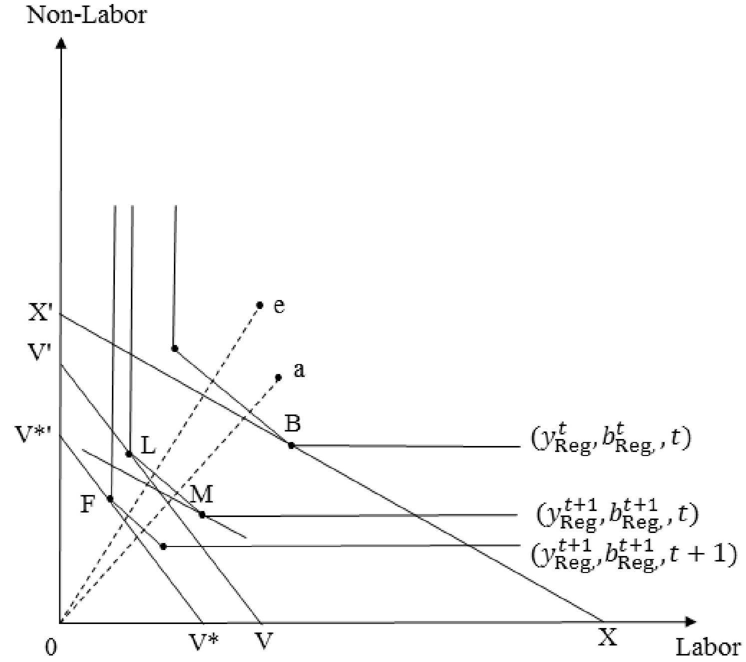

Figure 2. Regulated Isoquants and Isocost Lines (Decomposition)

Decomposing Change in Employment (e/a): (Reference Technology: Period t+1)

$$OE = \left[\frac{e/F}{a/B}\right]$$

$$TC = \left[\frac{J}{B}\right]$$

$$IC = \left[\frac{K}{J}\right]$$

$$OC = \left[\frac{F}{K}\right]$$

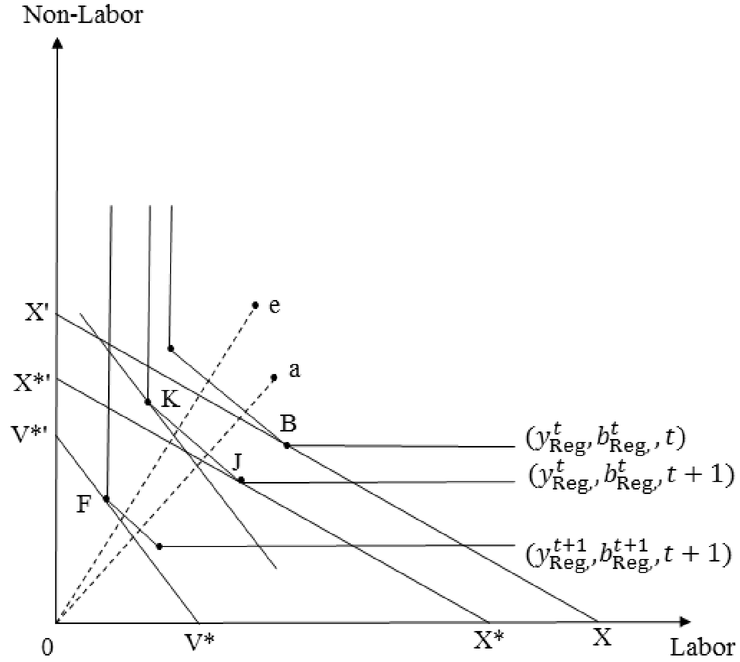

Figure 2. Regulated Isoquants and Isocost Lines (Decomposition)

Data Sources

- Sample: coal-fired power plants in 1998-2005
  - At least 95 percent of BTUs from coal
  - XX power plants in sample
- Outputs
  - Good output: net electricity generation (in kWh) (source: EIA-767 survey)
  - Bad output: SO_2 emissions (source: EPA Continuous Emissions Monitoring System, CEMS)

Data Sources (continued)

- Inputs (quantities and qualities)
  - Capital: value of plant and equipment (source: derived using data from FERC Form 1 and EIA-412 survey)
  - Labor: number of employees (source: FERC Form 1 and EIA-412 survey)
  - Fuel: consumption of coal, oil, and natural gas - physical quantities, BTUs per physical quantity, and sulfur content of coal and oil (source: EIA-767 survey)

Data Sources (continued)

- Inputs (prices)
  - Capital: Need to calculate service price of capital
  - Labor: Divide payroll by number of employees provide estimate of average cost of an employee for a NAICS code – 221112, 22111, or 2211 - in a state (source: *County Business Patterns*)
  - Fuel: cost per physical unit of coal, oil, and natural gas (source: EIA-423, “Monthly Cost and Quality of Fuels for Electric Power Plants Report”)

Results

- Use geometric means of decomposition results for models using (1) period t as the reference technology and (2) period t+1 as the reference technology
- Work-in-progress
- Goal for preliminary results: European Workshop on Efficiency and Productivity Analysis, EWEPA, (London, June 12-15)

Issues

- Input price data
- Address concerns about failure of joint production model to account for material balances

Conclusions

- Joint production model provides strategy for calculating Cost Effect without survey data on cost of inputs assigned to pollution abatement
- Joint production model provides link between the change in observed employment and (1) change in overall efficiency, (2) technical change, (3) input changes, and (4) change in mix of good and bad output production
- Continue effort to use joint production models to provide a unified axiomatic framework to analyze cost and production effects of pollution abatement

That's All Folks!!!

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