Productivity and Efficiency Analysis

1) Introduction

b) *Taxonomy of frontier estimation methods*

Timo Kuosmanen

Aalto University School of Business

https://people.aalto.fi/timo.kuosmanen

Productivity and efficiency: basic concepts

Productivity growth depends on

- **Technical progress**

- **Efficiency improvement**
  - Technical efficiency
  - Scale efficiency
  - Allocative efficiency

- **Structural change**
  - Entry and exit
  - Reallocation of resources

Productivity and efficiency: basic concepts

Productivity growth depends on

- **Technical progress** = frontier shift over time

- **Efficiency improvement** relative to frontier
  - Technical efficiency
  - Scale efficiency
  - Allocative efficiency

- **Structural change**
  - Entry and exit
  - Reallocation of resources

Unified frontier model

$$y_i = f(\mathbf{x}_i) - u_i + v_i, \quad i = 1,...,n$$

where

y_i is output of firm i

f is frontier production function

$\mathbf{x}_i$ is input vector of firm i

u_i is asymmetric inefficiency term of firm i

v_i is random noise term of firm i

Kuosmanen, Johnson & Saastamoinen (2014) Stochastic nonparametric approach to efficiency analysis: A Unified Framework, in J. Zhu (Ed) *Handbook on DEA Vol. 2*, Springer.

Taxonomy of methods

based on Kuosmanen & Johnson (2010), Operations Research

		Parametric	Nonparametric	
			Local averaging	**Axiomatic**
Average curve		*OLS* Gauss (1795), Legendre (1805)	*Kernel regression* Nadaraya (1964), Watson (1964)	*Convex regression* Hildreth (1954), Hanson and Pledger (1976)
Frontier	**Deterministic (Sign constr.)**	*Parametric programming* Aigner and Chu (1968)	*Nonparametric programming* Post et al. (2002)	*DEA* Farrell (1957), Charnes et al. (1978)
	Deterministic (2-stage)	*Corrected OLS* Winsten (1957) Greene (1980)	*Corrected kernel* Kneip and Simar (1996)	*Corrected CNLS* Kuosmanen and Johnson (2010)
	Stochastic	*SFA* Aigner et al. (1977) Meeusen and van den Broeck (1977)	*Semi-nonparametric SFA* Fan, Li and Weersink (1996)	*StoNED* Kuosmanen and Kortelainen (2012)

Taxonomy of methods

based on Kuosmanen & Johnson (2010), Operations Research

		Parametric	Nonparametric	
			Local averaging	**Axiomatic**
Average curve		*OLS* Gauss (1795), Legendre (1805)	*Kernel regression* Nadaraya (1964), Watson (1964)	*Convex regression* Hildreth (1954), Hanson and Pledger (1976)
Frontier	**Deterministic (Sign constr.)**	*Parametric programming* Aigner and Chu (1968)	*Nonparametric programming* Post et al. (2002)	***DEA*** **Farrell (1957),** **Charnes et al. (1978)**
	Deterministic (2-stage)	*Corrected OLS* Winsten (1957) Greene (1980)	*Corrected kernel* Kneip and Simar (1996)	*Corrected CNLS* Kuosmanen and Johnson (2010)
	Stochastic	***SFA*** **Aigner et al. (1977)** **Meeusen and van den Broeck (1977)**	*Semi-nonparametric SFA* Fan, Li and Weersink (1996)	*StoNED* Kuosmanen and Kortelainen (2012)

Taxonomy of methods

based on Kuosmanen & Johnson (2010), Operations Research

		Parametric	Nonparametric: Local averaging	Nonparametric: Axiomatic
Average curve		*OLS* Gauss (1795), Legendre (1805)	*Kernel regression* Nadaraya (1964), Watson (1964)	*Convex regression* Hildreth (1954), Hanson and Pledger (1976)
Frontier	**Deterministic (Sign constr.)**	*Parametric programming* Aigner and Chu (1968)	*Nonparametric programming* Post et al. (2002)	***DEA*** **Farrell (1957),** **Charnes et al. (1978)**
	Deterministic (2-stage)	*Corrected OLS* Winsten (1957) Greene (1980)	*Corrected kernel* Kneip and Simar (1996)	*Corrected CNLS* Kuosmanen and Johnson (2010)
	Stochastic	***SFA*** **Aigner et al. (1977)** **Meeusen and van den Broeck (1977)**	*Semi-nonparametric SFA* Fan, Li and Weersink (1996)	***StoNED*** **Kuosmanen and Kortelainen (2012)**

DEA model

$$y_i = f(\mathbf{x}_i) - u_i, \quad i = 1,...,n$$

where

y_i is output of firm i

f is production function

$\mathbf{x}_i$ is input vector of firm i

u_i is asymmetric inefficiency term of firm i

~~v_i is random noise term of firm i~~

Banker (1993): Maximum likelihood, consistency and data envelopment analysis: a statistical foundation, *Management Science*.

SFA model

$$y_i = \boldsymbol{\beta}'\mathbf{x}_i - u_i + v_i, \quad i = 1,\ldots,n$$

where

y_i is output of firm i

$\boldsymbol{\beta}$ is parameter vector

$\mathbf{x}_i$ is input vector of firm i

u_i is asymmetric inefficiency term of firm i

v_i is random noise term of firm i

Aigner, Lovell & Schmidt (1977): Formulation and estimation of stochastic frontier production function models, *Journal of Econometrics*.

Next lesson

1c) Productivity analysis in action: Incentive regulation of electrictity distribution networks