HIS: Hochschul Informations System GmbH

German Higher Education Institutions and Efficiency – Empirical Evidence from a Data Envelopment Analysis. Accounting for Heterogeneity.

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motivation

Are Higher Education Institutions (HEIs) productive, or not?

- financing of German Higher Education Institutions (HEI) almost completely secured by public funding
- lack of competition among German HEIs

→ scarcity of public budgets intensify the interest of accountability

→ there is a need for more information about the performances of HEIs

- considering HEI as a production unit using inputs to produce outputs → allows statements about (in)efficient production

→ but, comparability of HEIs‘ performances fails due to the heterogeneity of production technologies

  - sectoral characteristics
    non-profit nature, lack of price information, multiple inputs/outputs
  - structural characteristics
    subjects, size, teaching/research orientation, staff composition

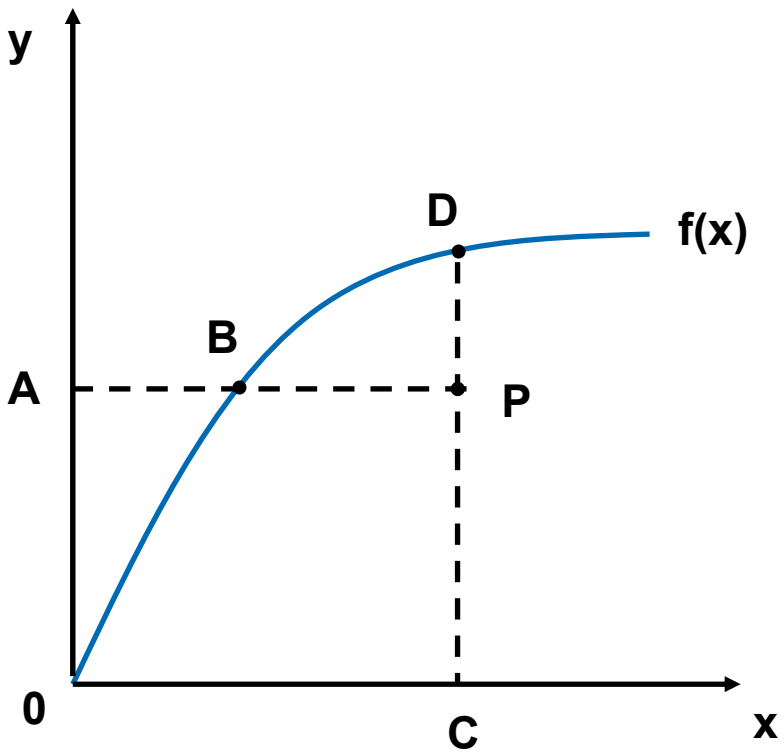
→ focus on efficiency at a disaggregated level (subjectgroup/department level) while accounting for heterogeneous production conditions

theoretical concept

- distance function approach by Shephard (1953, 1970)
  - allows to describe a multi-input, multi-output production technology
  - requires no specific behavioral objective
- input vs. output orientation
  - depends on the DMUs possibility to influence inputs or outputs
  - HEI almost no influence on inputs, but outputs
  - → output-orientated distance function: $\mathbf{D(x,y) = min\ \{\varphi:(y/\theta) \in P(x)\}}$
- constant vs. variable returns to scale
  - constant returns to scale (CRS) → optimal production size of HEIs (–)
  - variable returns to scale (VRS) → varying sizes of HEI (+)
    - → comparing HEIs of similar size
    - → (in)efficiency variation is based on scale differences

theoretical concept (graphical)

- production function (one-input/one-output):
  - output-orientation
  - variable returns to scale



- points on the production frontier are technically efficient
- distance from each point to the production frontier measures technical inefficiency
- technical efficiency in point P: $\mathbf{TE} = \frac{\mathbf{CP}}{\mathbf{CD}}$

data

- HEI data
  - using AKL data for German universities from HIS GmbH, augmented with HEI specifics and environmental characteristics
- HIS GmbH (Hochschul-Informations-System)
  - publicly funded as non-profit-organisation in 1969
  - research on higher education, IT-system and facility management for HEI
- project AKL (Ausstattungs-, Kosten- und Leistungsvergleich)
  - endowment, cost, and performance indicators
  - report and monitoring system (for each HEI, comparison studies)
- advantage of AKL data
  - data set with detailed information at the level of teaching units („Lehreinheiten“)
  - homogeneous data collection based on similar methodology
  - data provided directly by HEIs

data set

- number of observations
  - 119 subject groups across 23 universities
  - within 6 states (“Bundeslaender”) for the year 2004
  - 591 teaching units can be aggregated on:

    → the level of subject groups (for each university, if available)

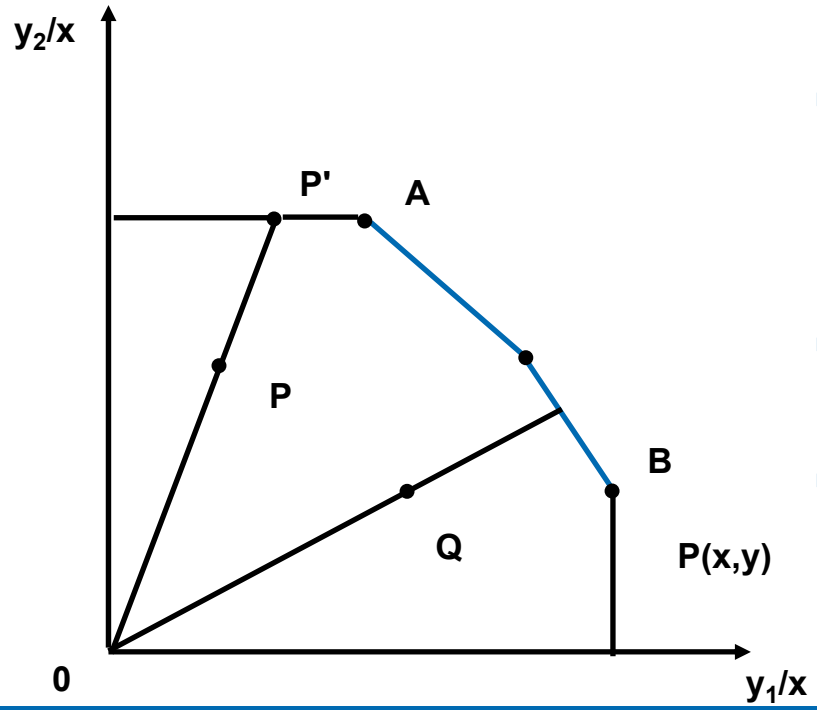
    - agronomy and nutritional sciences
    - humanities and cultural sciences
    - engineering
    - fine arts, music, performing arts
    - law, economic and social sciences
    - mathematics and natural sciences
    - sport

    → the level of university

    (→ the level of virtual built departments)

methodology – DEA model (graphical)

- data-envelopment-analysis (DEA) vs. stochastic-frontier-analysis (SFA)
  - SFA → need of functional form of the cost or production function (-)
  - DEA → required no assumption of functional and distributional form (+)
    → bootstrapping technique can limit the problem of measurement errors and other stochastic noise in the data (+)
- output-orientated DEA (one-input/two-outputs):



- efficency is measured by comparing each firm in an industry to a best practice efficient frontier formed by the most efficient firms in the industry
- points on the efficiency frontier between A and B indicacte technical efficiency
- points under the efficiency frontier indicate technical inefficiency

methodology – DEA model

- DEA model: output-orientation assuming variable returns to scale

first stage

calculation of the efficiency scores (by using bootstrapping technique)

$$\max_{\varphi,\lambda} \varphi \quad \text{s.t.} \quad \sum_{j=1}^{n} \lambda_j y_{rj} \geq \varphi_k y_{rk} \quad (r = 1, 2, \ldots, s)$$

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{ik} \quad (i = 1, 2, \ldots, m)$$

$$\sum_{j=1}^{n} \lambda_j = 1 \quad (j = 1, 2, \ldots, n)$$

$$y_{rj}, x_{ij} \geq 0, \quad \lambda_j \geq 0,$$

second stage

controlling for environmental effects using truncated regression

$$y_i = \beta_0 + \beta_i x_i + \varepsilon_i \quad \text{mit } y_i > 0 \quad (i = 1, 2, \ldots, N)$$

data construction

inputs	**proxy**	base model
quantity measures		
sum of expenditures	financial endowment	x
scientific personnel	personnel endowment of academics	x
non-scientific personnel	personnel endowment of non-academics	x
quality measures		
ratio of academics	teaching/research knowledge at HEI	x

outputs	**proxy**	base model
quantity measures		
sum of funds	research outcome due to research grants	x
Phd graduates	research outcome of post-graduates	x
graduates	teaching outcome of graduates	x
quality measures		
graduates	teaching outcome of graduates	x
ratio of professors	research outcome due to research activity	x

environmental variables	**proxy**	**base model**
HEI specifics	size, reputation, prestige	x
structural specifics	economic spillovers	x
regional dummies	location	x

data descriptives

subject group level: N=119

	expenditures (in 1,000 €)	employees		funds (in 1,000 €)	gradu-ates	Phd graduates
		academics	non-academics			
mean	17,000	82	69	4,302	223	36
median	11,000	55	25	1,208	107	15
skewness	1.58	1.42	2.31	2.50	2.05	1.92
cv	1.16	1.13	1.44	1.72	1.26	1.38

university level: N=23

	expenditures (in 1,000 €)	employees		funds (in 1,000 €)	gradu-ates	Phd graduates
		academics	non-academics			
mean	88,000	426	358	22,300	1,153	185
median	77,400	440	276	18,500	946	112
skewness	0.12	-0.02	0.44	0.72	0.90	0.71
cv	0.65	0.64	0.75	0.81	0.78	0.88

some first results

(1)

efficiency scores	mean	median	min	max
university level	0.90	1	0.60	1
subject group level	0.81	0.84	0.23	1

(2)

dispersion of (in)efficient universities	efficient (φ=1)	highly efficient (0.88 < φ< 0.94)	less efficient (0.60 < φ< 0.73)
number	12	5	6

(3)

examples of (in)efficiency	**HU Berlin**	**U Magdeburg**
university level	1	0.60
subject group level		
agronomy and nutritional sciences	1	-
cultural sciences	0.93	0.61
engineering	-	0.61
fine arts, music, performing arts	0.89	0.38
law, economic and social sciences	1	0.63
mathematics, natural sciences	0.83	0.45
sport	0.51	0.64

outlook

(1) analysis of HEIs' objectives of optimization

(2) efficiency estimation of „virtual" departments built by clustering teaching units → taking into account the structural differences within subject groups

(3) increasing competition among HEI within Germany and Europe → teaching, research, teaching/research intense HEIs' orientation

focus on teaching outcome:

- increasing significance of the success/employability of graduates

→ use of unemployment rate of graduates as proxy for quality of teaching activities

focus on research outcome:

- use of publications and citations information as proxy for quality of research activity

(4) productivity growth of universities

Thank you for your attention!

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