

Efficiency in the Education sector

Intangible assets and locus of decision-making

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Motivation

Spending on education in the EU is an average of 6% of GDP, of which 90% from public funds.

How efficiently are these funds being spent?

Research questions

- What is the role of intangible capital in the provision of education?
- Are centralised countries more efficient in the provision of education compared to decentralised countries?

Outline

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Methodology

2 stage procedure

- *Stage 1*: Non-parametric estimation of the production function of education relates education outputs to education inputs and yields **efficiency scores**
- *Stage 2*: Regression of the efficiency scores on environmental variables

Data requirements

- Education output
- Education inputs
- Environmental variables

Education output

Education output

Quality-adjusted measure of the number of students going through the education system

O'Mahony & Stevens (2009), Schreyer (2010), INDICSER (2012)

- Compulsory Education (ISCED 0 to 2):

$$Y_{CE} = PISA * (N_0 + N_1 + N_2) \quad (1)$$

- Post-compulsory Education (ISCED 3 to 6):

$$Y_{PCE} = \sum_{ISCED3}^{ISCED6} N_i * \bar{W}_i \quad (2)$$

where

$$\bar{W}_i = p_i^G p_i^E W_i + (1 - p_i^G) p_{i-1}^E W_{i-1} \quad (3)$$

Education output

- N_i : Number of students enrolled in ISCED level i (Eurostat)
- $PISA$: average PISA reading scores, measured at age 15 (OECD)
- W_i : Average wage of population with education level ISCED i (Eurostat)
- p_i^E : employment rate by education level ISCED i (Eurostat)
- p_i^G : graduation rate by education level ISCED i

Flexibility of non-parametric methodology does not require aggregating compulsory and post-compulsory levels. Output measured in **levels** rather than growth rates.

Education inputs

- 1 Number of employees in the Education sector
- 2 Capital stock in the Education sector
- 3 *Intangible capital stock* in the Education sector

Sources: World Input-Output Database (WIOD) Soci-Economic Accounts, OECD STAN database, *SPINTAN database (forthcoming)*

Environmental variables

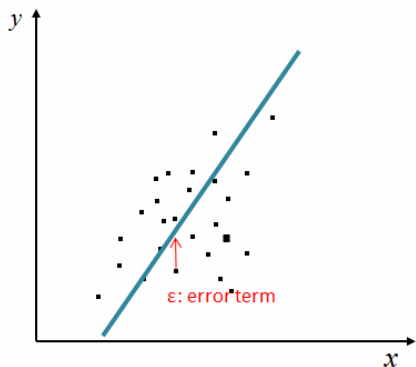
3 main variables are important for student achievement
(Woessmann, 2003):

- Teacher quality
- Competition from private schools
- **Locus of decision making**

Sources: Education at a Glance (OECD, 2011, 2012) and Eurostat

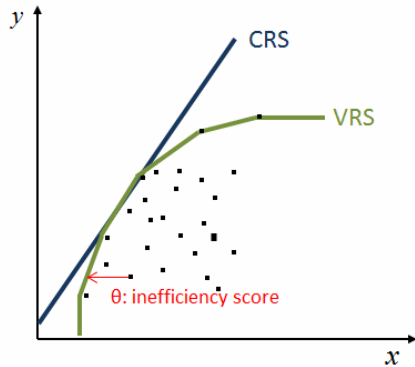
Parametric vs. Non-Parametric production functions

Linear Regression



$$y = \alpha + \beta X + \epsilon$$

Data Envelopment Analysis



Production function of education

Input efficiency score

Amount by which observed inputs can be reduced and still produce the observed level of output

$$\theta_{DEA}(x, y) = \inf \{ \theta \mid (\theta x, y) \in \Psi_{DEA} \} \quad (4)$$

$$\theta_{DEA}(x, y) = \inf \left\{ \theta \mid y \leq \sum_{i=1}^n \gamma_i Y_i; \theta x \geq \sum_{i=1}^n \gamma_i X_i; \theta > 0; RTS \right\} \quad (5)$$

$$0 < \theta \leq 1 \quad (6)$$

4-dimensional framework:

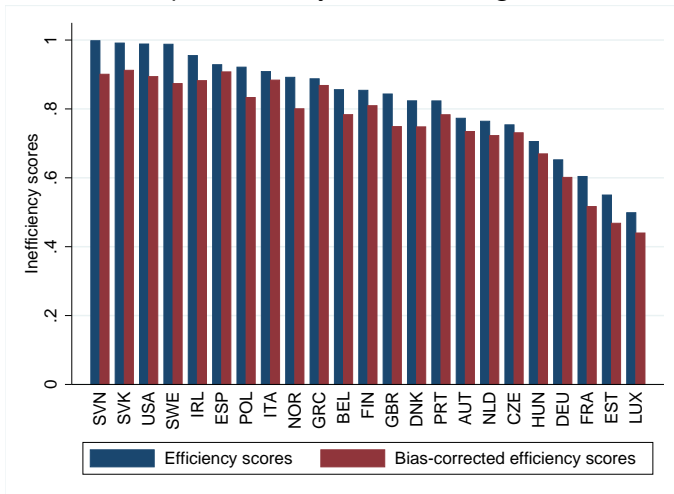
Outputs $Y_{it} = \begin{pmatrix} Y_{CE} \\ Y_{PCE} \end{pmatrix}_{it}$ and inputs $X_{it} = \begin{pmatrix} E \\ K \end{pmatrix}_{it}$

Caveats of DEA

- 1 Deterministic framework with no room for statistical error
- 2 Upward bias of efficiency scores
We apply simple bootstrap to get the *bias-corrected efficiency scores*.
- 3 Sensitivity to outliers
- 4 Curse of dimensionality
Adding **intangible investment** will affect the issue of dimensionality. We can test how much this extra dimension adds explanatory power.

Efficiency scores

Bias-corrected input efficiency scores, average over 2002-2010



Source: Authors calculations based on data from Eurostat, OECD and WIOD

Estimation equation

Truncated Regression

$$\theta_{it} = \alpha + \beta_1 \text{TeachSalaries}_{it} + \beta_2 \text{RatioPrivate}_{it} + \beta_3 \text{Decisions}_{it} + u_{it} \quad (7)$$

$$0 \leq \theta_{it} \leq 1$$

Variables

Dependent variable: Efficiency scores from Stage 1

Explanatory variables:

- Relative teacher pay compared to GDP per capita
- Percentage of students enrolled in private institutions
- Locus of decision-making: % of decisions taken at a each level

	Central	Intermediate	School	Sum
Personnel	x_p	100%
Resource	x_r			100%
Org. of instruction	x_i			100%
Planning & structures	x_s			100%
TOTAL	$\frac{(x_p + \dots + x_s)}{4}$			100%

Results

Summary decision-making index

	Eff1	Eff2	Eff1 _{BC}	Eff2 _{BC}
	(1)	(2)	(3)	(4)
teachsal	.476 (.125) ^{***}	.299 (.146) ^{**}	.387 (.130) ^{***}	.210 (.126) [*]
ratioprivall	-.445 (.214) ^{**}		-.535 (.196) ^{***}	
ratiopriv0to2		.396 (.288)		.471 (.237) ^{**}
ratiopriv3to6		-.692 (.219) ^{***}		-.828 (.192) ^{***}
decisionscentral	-.005 (.001) ^{***}	-.003 (.002) ^{**}	-.004 (.001) ^{***}	-.002 (.001)
decisionschool	-.0004 (.002)	.003 (.002)	.0008 (.002)	.005 (.002) ^{**}
cons	.501 (.156) ^{***}	.491 (.143) ^{***}	.477 (.150) ^{***}	.448 (.128) ^{***}

Results

Looking at decision areas

	Decisions	Pers	Res	Inst	Plan
	(1)	(2)	(3)	(4)	(5)
teachsal	.304 (.102)***	.374 (.091)***	.277 (.100)***	.209 (.085)**	.219 (.090)**
ratiopriv3to6	-.423 (.138)***	-.343 (.113)***	-.286 (.127)**	-.334 (.131)**	-.299 (.165)*
decisionscentral	-.004 (.001)***				
persmanagcentral		-.004 (.0005)***			
resourcescentral			-.003 (.001)***		
instructioncentral				-.008 (.001)***	
planningcentral					-.0001 (.0008)
cons	.605 (.100)***	.512 (.094)***	.542 (.113)***	.658 (.093)***	.595 (.078)***

Results

Looking at decision areas

	All	PersPlan	ResPlan	InstPlan
	(1)	(2)	(3)	(4)
teachsal	.276 (.101)***	.345 (.084)***	.260 (.099)***	.166 (.088)*
ratiopriv3to6	-.166 (.136)	-.140 (.131)	-.140 (.149)	-.153 (.149)
persmanagcentral	-.005 (.001)***	-.005 (.0004)***		
resourcescentral	.002 (.001)		-.004 (.001)***	
instructioncentral	-.005 (.003)*			-.009 (.001)***
planningcentral	.002 (.0006)***	.002 (.0006)***	.001 (.0007)**	.002 (.0006)***
cons	.522 (.105)***	.429 (.074)***	.475 (.112)***	.600 (.089)***

Summary of the results

- Teacher quality is consistently associated with higher school efficiency
- The presence of private institutions seems to matter only for post-compulsory education, and is associated with worse school efficiency
- The centralisation of decisions at the national level seems to be detrimental to efficiency, apart from decisions relating to planning and structures, such as programme design and accreditation.

Next steps

- **Include Intangible capital stock as a third input**
By definition, will increase the efficiency of units. Agnostic about how this will change the ranking of countries, and hence results of the 2nd stage regression
- **2-stage Bootstrap procedure** (Simar and Wilson, 2007)
Necessary to take into account that the dependent variable is estimated and is sensitive to outliers.
Will affect the standard errors.
- **Semi-Parametric approaches** (eg. SFA)
Imposes structure either on the error term or on the production function

Thank you for your attention



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