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The efficiency of schools in an international comparison – results from PISA 2012

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Agenda

- Research questions

- Data, descriptive statistics

- Results
    - Efficiency scores
    - Factors associated with efficiency scores
   - Efficiency and equity

Research questions

- How does the efficiency of schools in the high-spending countries look like, in a comparative perspective?
    - Are the differences between countries higher or lower than those within countries?

- Which are the main factors associated with the efficiency of schools, when estimated using an international benchmark?
    - Heterogeneity of these factors?

- How is the (eventual) link between schools' efficiency and equity?
    - Equality and/or inclusion

Selection of countries
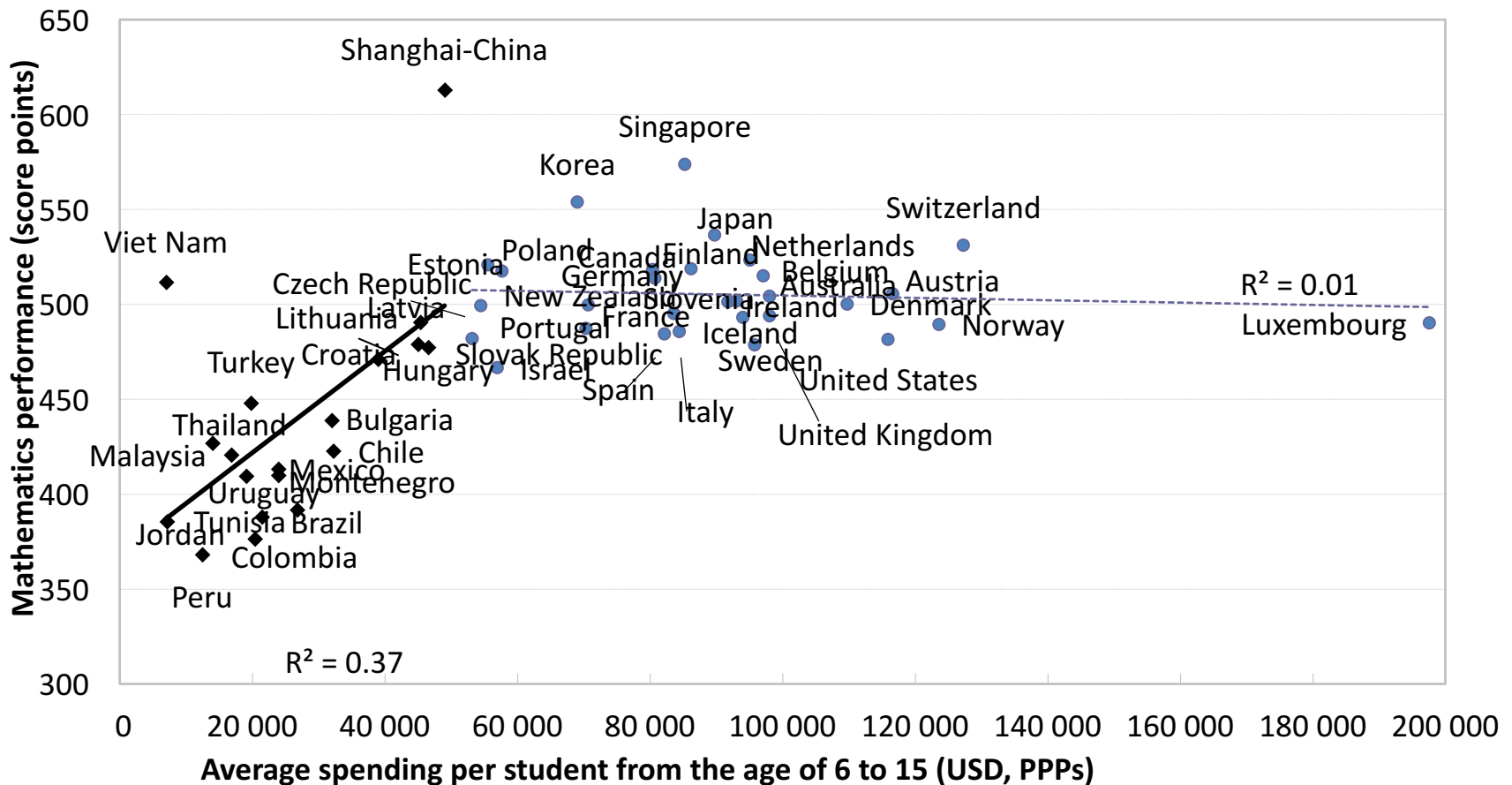
Empirical model (1)

- Data Envelopment Analysis
  - Output orientation
  - Variable returns to scale (VRS)
  - Simar & Wilson (2000) bootstrap procedure (2,000 replicates) [estimated with Benchmarking © in R]
  - Robustness check:
    - SFA
    - DEA with different combinations of inputs and outputs

- Second-stage regression
  - Tobit regression
    - Robustness check: Simar & Wilson (2007) procedure
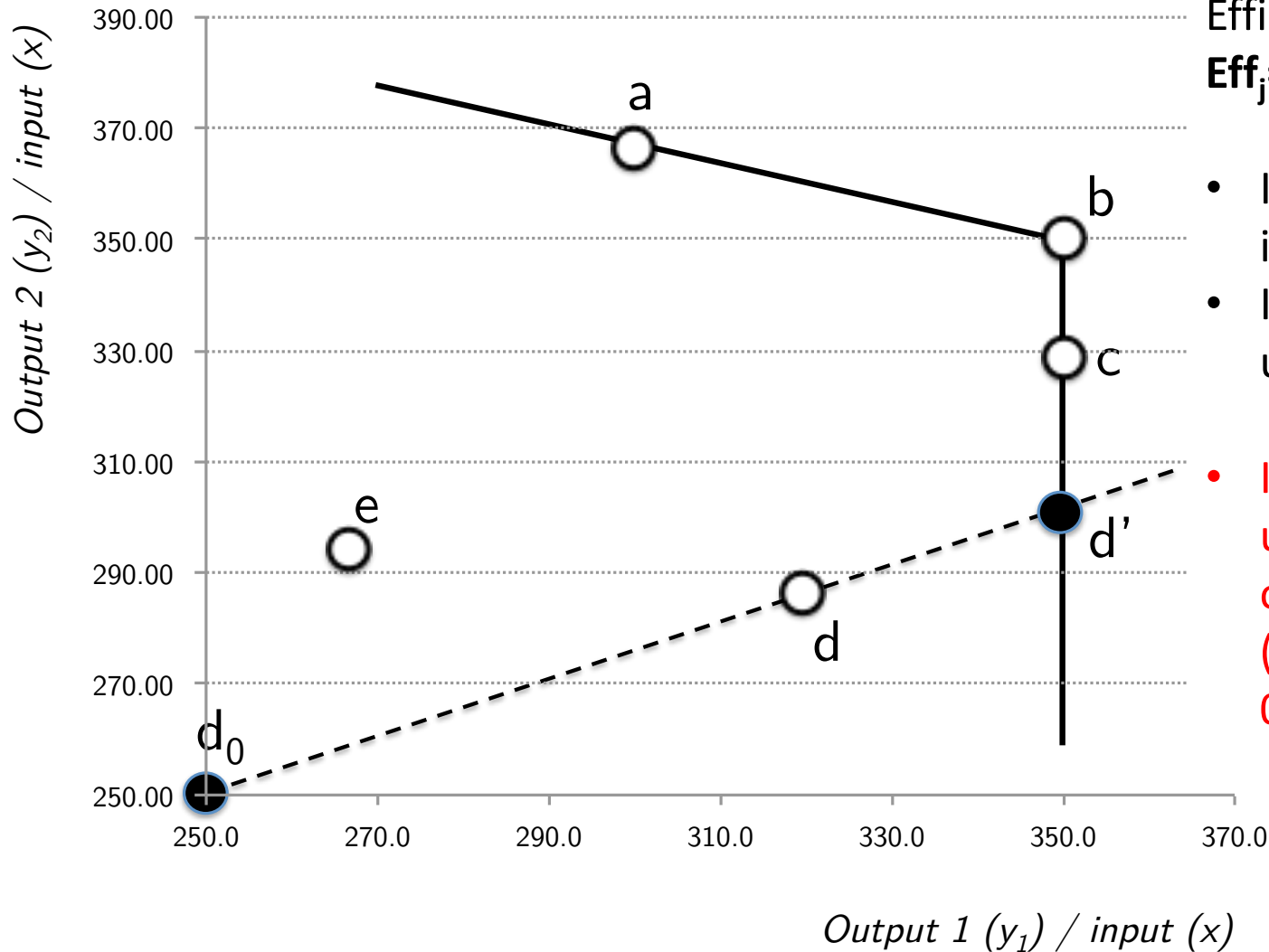
Efficiency score
$Eff_j = d_0 d' / d_0 d$

- If $eff_j > 1$ is inefficient
- If $eff_j = 1$ efficient unit
- In the paper I used the inverse of these scores (range between 0;1)

Empirical model (3)

- Mathematically, DEA efficiency score is a ratio between (weighted) outputs and (weighted) inputs

$$\max\left(h_0 = \frac{\displaystyle\sum_{r=1}^{s} u_r y_{r0}}{\displaystyle\sum_{i=1}^{m} v_i x_{i0}} \right)$$

- r(r=1,…s) outputs and i(i=1,…,m) inputs; u and v are optimal weights

- Then, it is solved with linear programming

Selection of inputs and outputs

- Literature, conceptual production function:
    - Quality/quantity of human and financial resources
    - *Expenditures – missing*
    - Students' socioeconomic background
    - Cognitive skills (i.e. test scores)
    - *Success in education (pass rates, graduation, etc.) – missing*
    - *Non-cognitive skills – missing [see extension]*

- Final selection
    - (Inverse of) students/teachers ratio (*St_Ratio*)
    - Number of computers per student (*Computer_n*)
    - Students' average *ESCS* (index of Economic, Social and Cultural Status)
    - Average test score in mathematics (*pv1math*) and reading (*pv1read*)
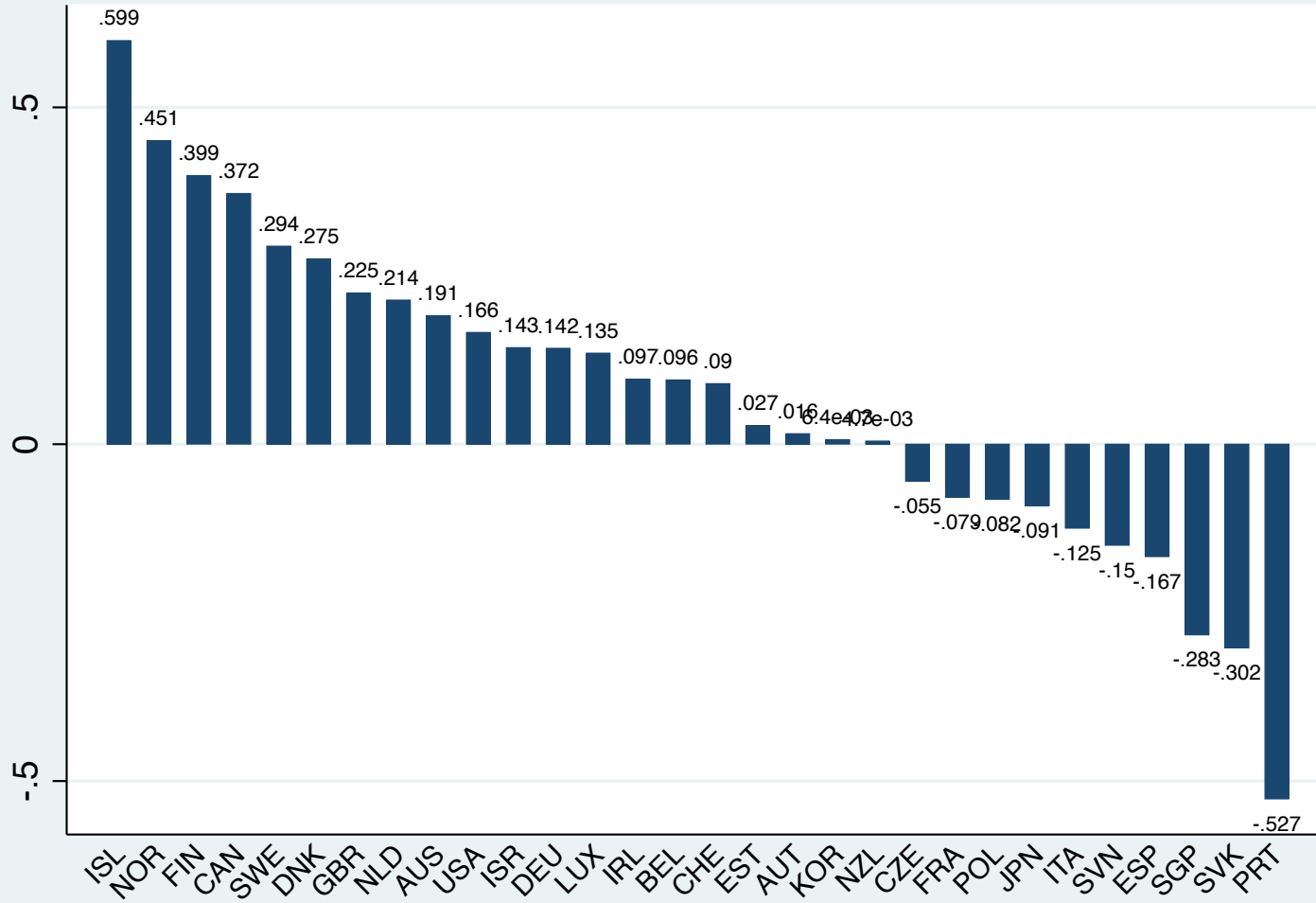
Inputs and outputs, descriptive statistics

- In the overall sample: 8,640 schools
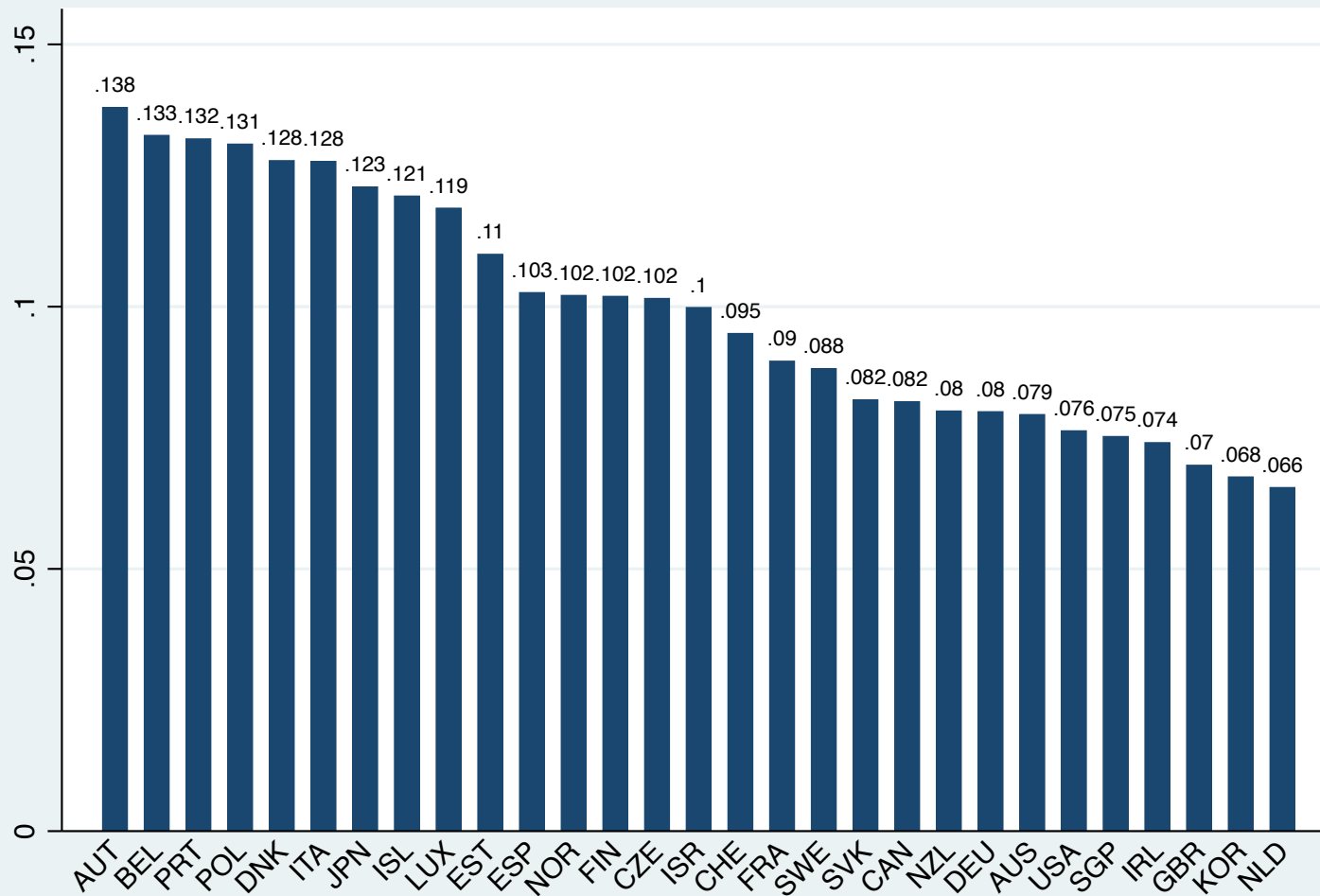
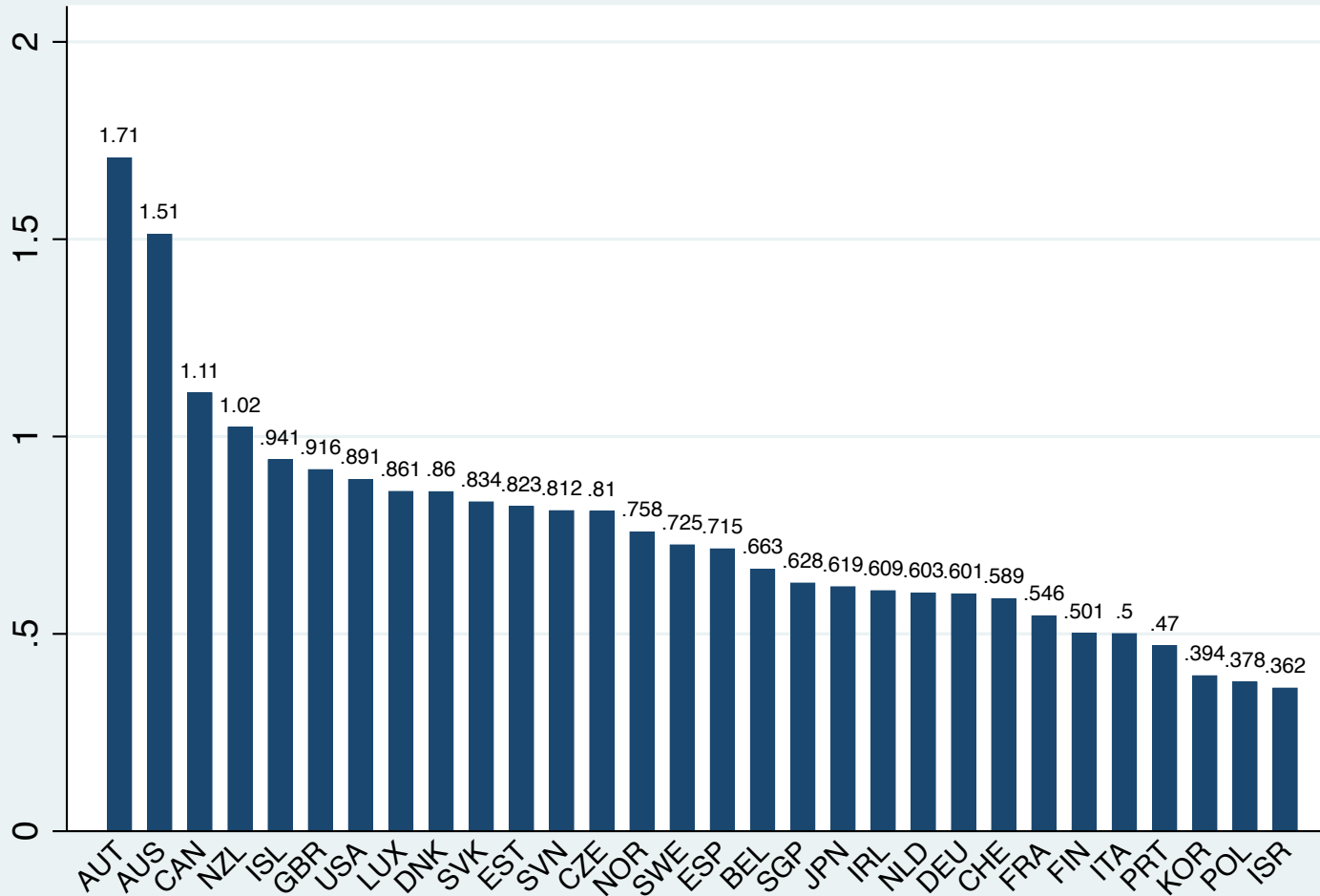| Variable	Mean	Std. Dev.
ESCS	0.063	0.528
StRatio	0.105	0.141
Computer_n	0.836	1.250
pv1math	496.583	63.736
pv1read	495.393	66.350

Descriptive statistics, by country: ESCS

Descriptive statistics, by country: (inverse of) students/teachers ratio

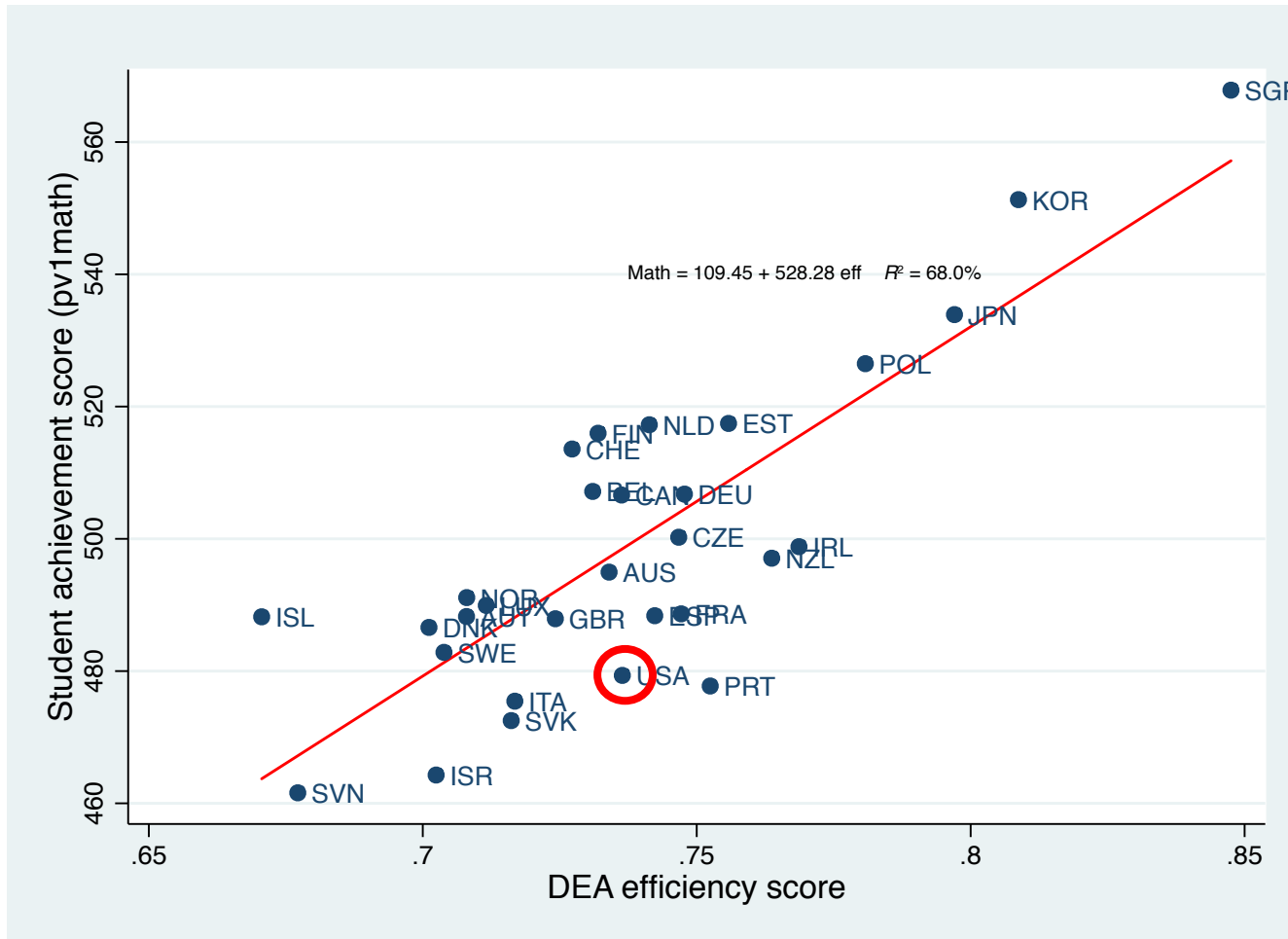Descriptive statistics, by country: # computers per student

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Descriptive statistics, by country: avg test score in mathematics
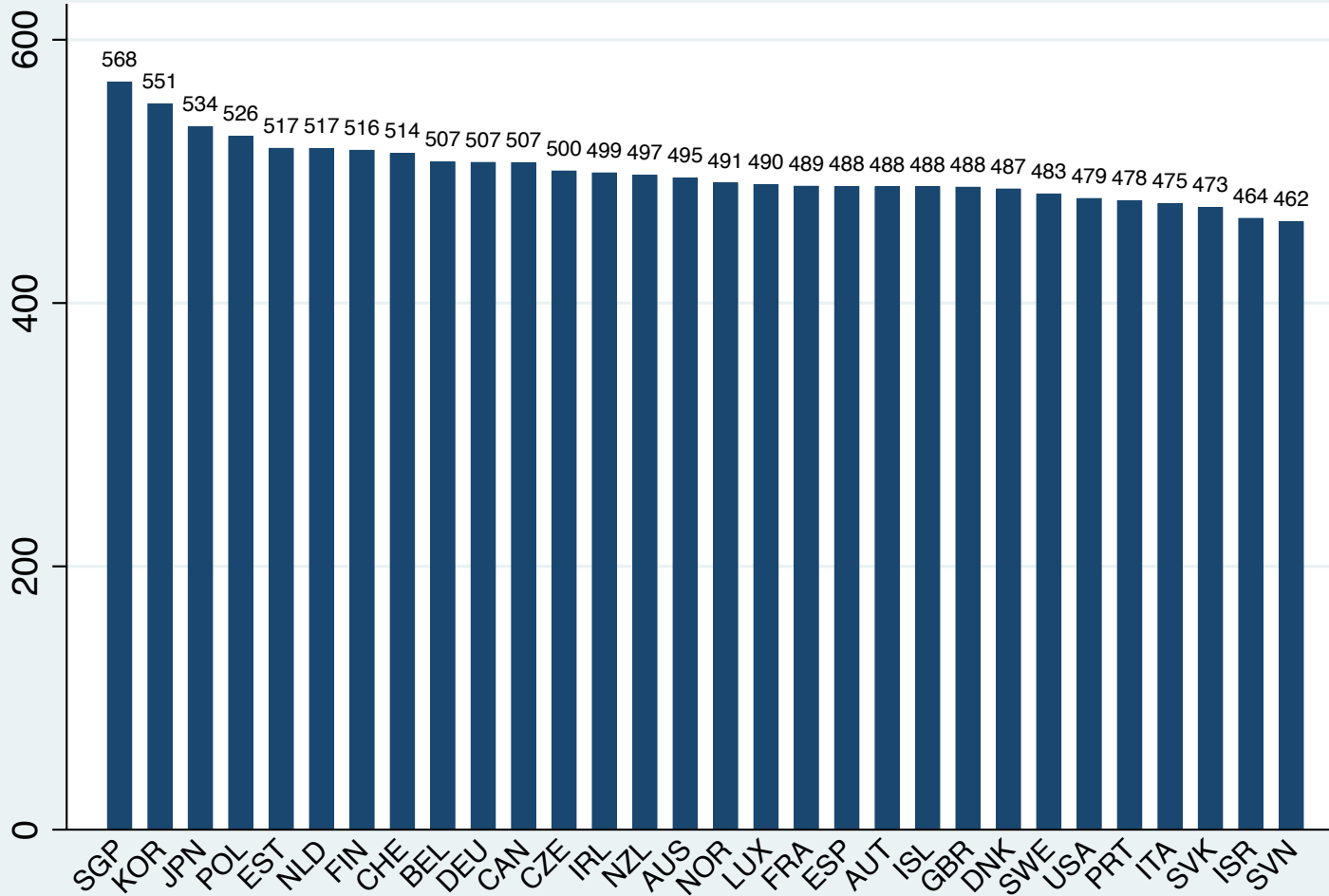
Results: efficiency scores

- It is interesting to show not only mean schools' efficiency scores, but their distribution by country
  - How much differentiated are the educational systems, *within*?
  - How many schools are more efficient than the average – as computed through the international benchmark?

- There is NOT the "average" Italian, Spanish, American... etc. school
  - the main message: efficiency is a property of schools, not countries – the focus is not on structural differences
  - for the single school: the international benchmark allows a wider set of efficient solutions to look at for improving its own activities

Efficiency and performance, by country

Math = 109.45 + 528.28 eff R^2 = 68.0%

Y-axis: Student achievement score (pv1math)

X-axis: DEA efficiency score

Efficiency and performance: USA
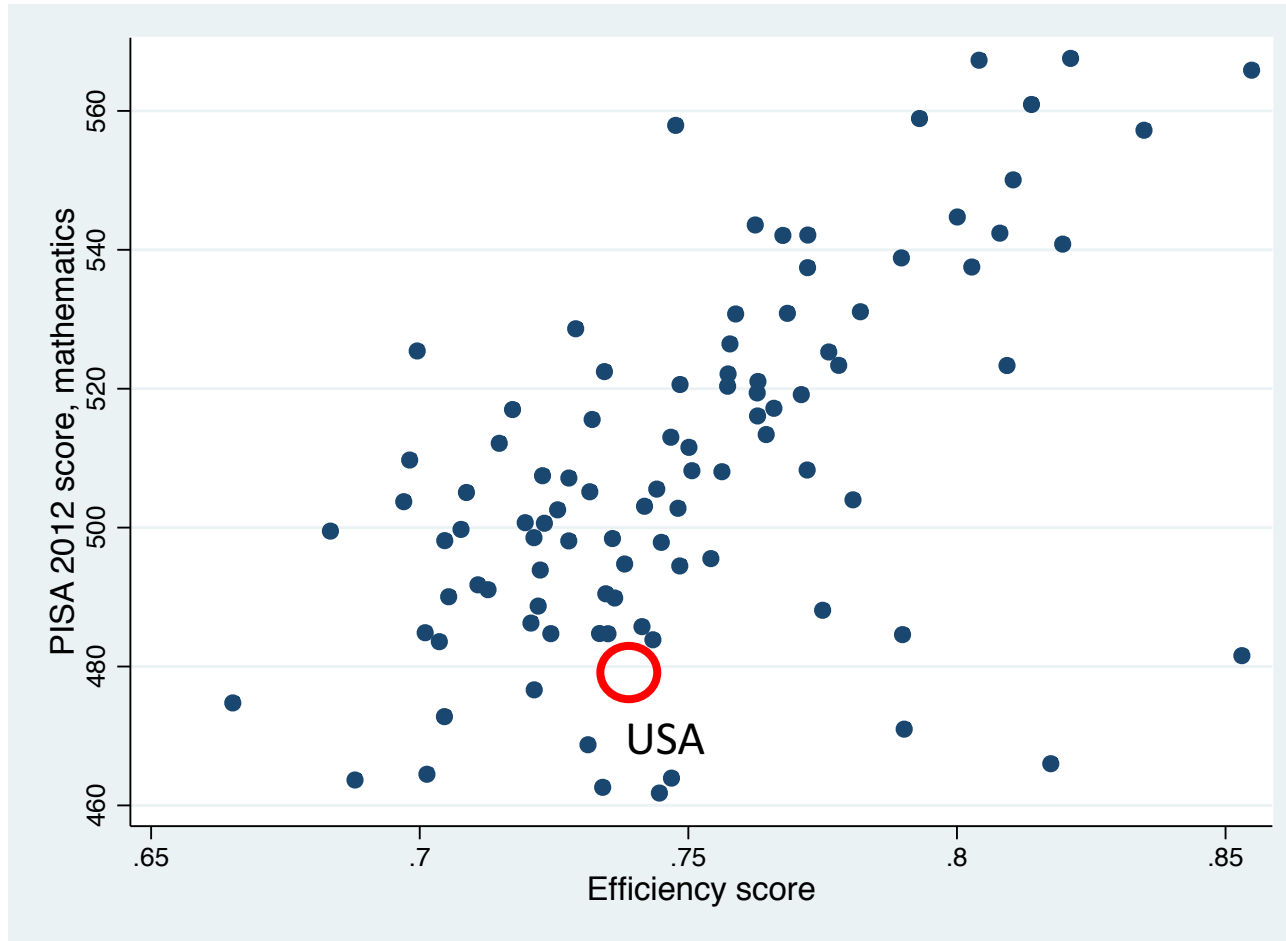
Efficiency scores' distribution, by country
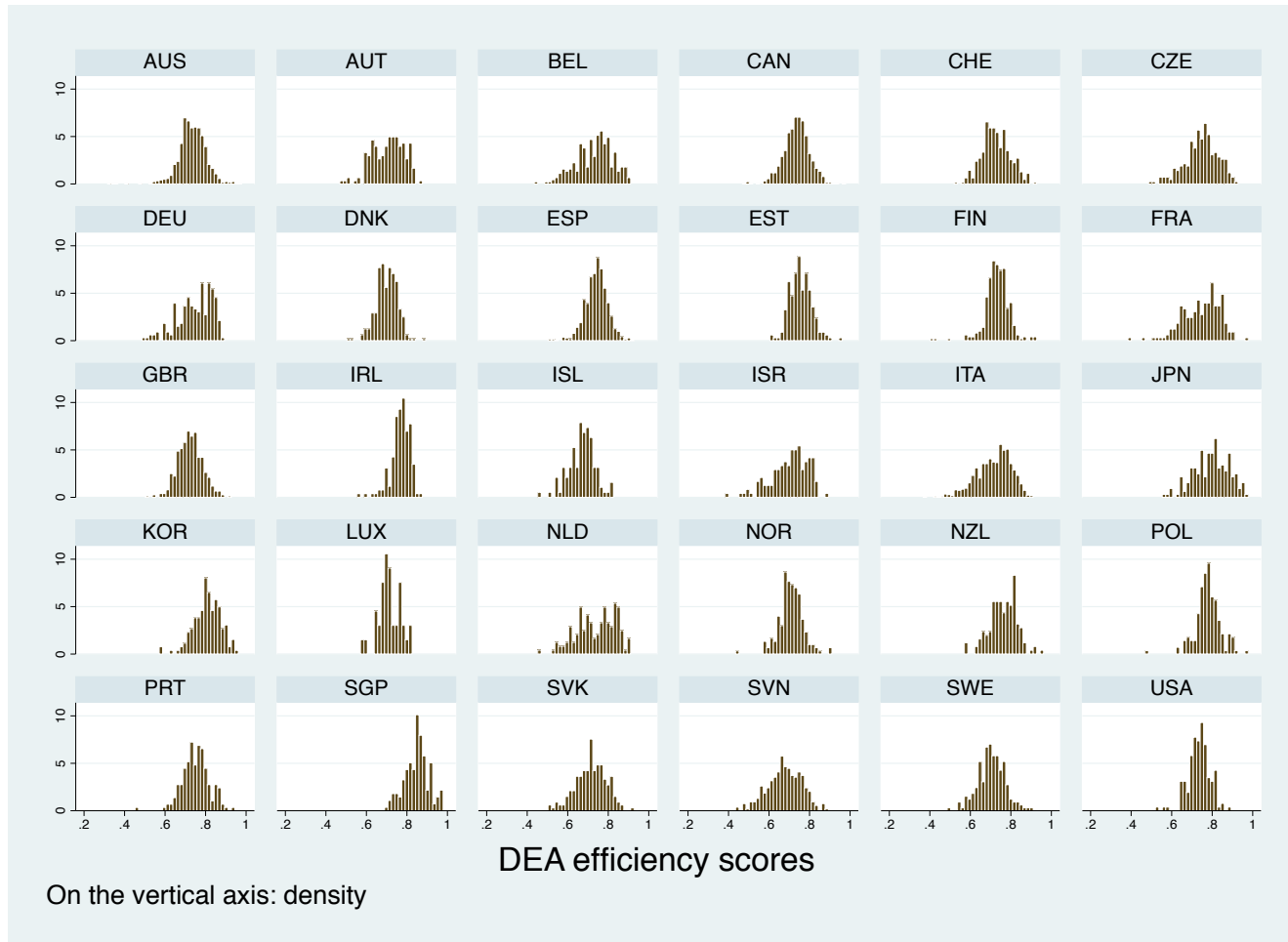
DEA efficiency scores

On the vertical axis: density

Efficiency and performance, comparing countries (1)

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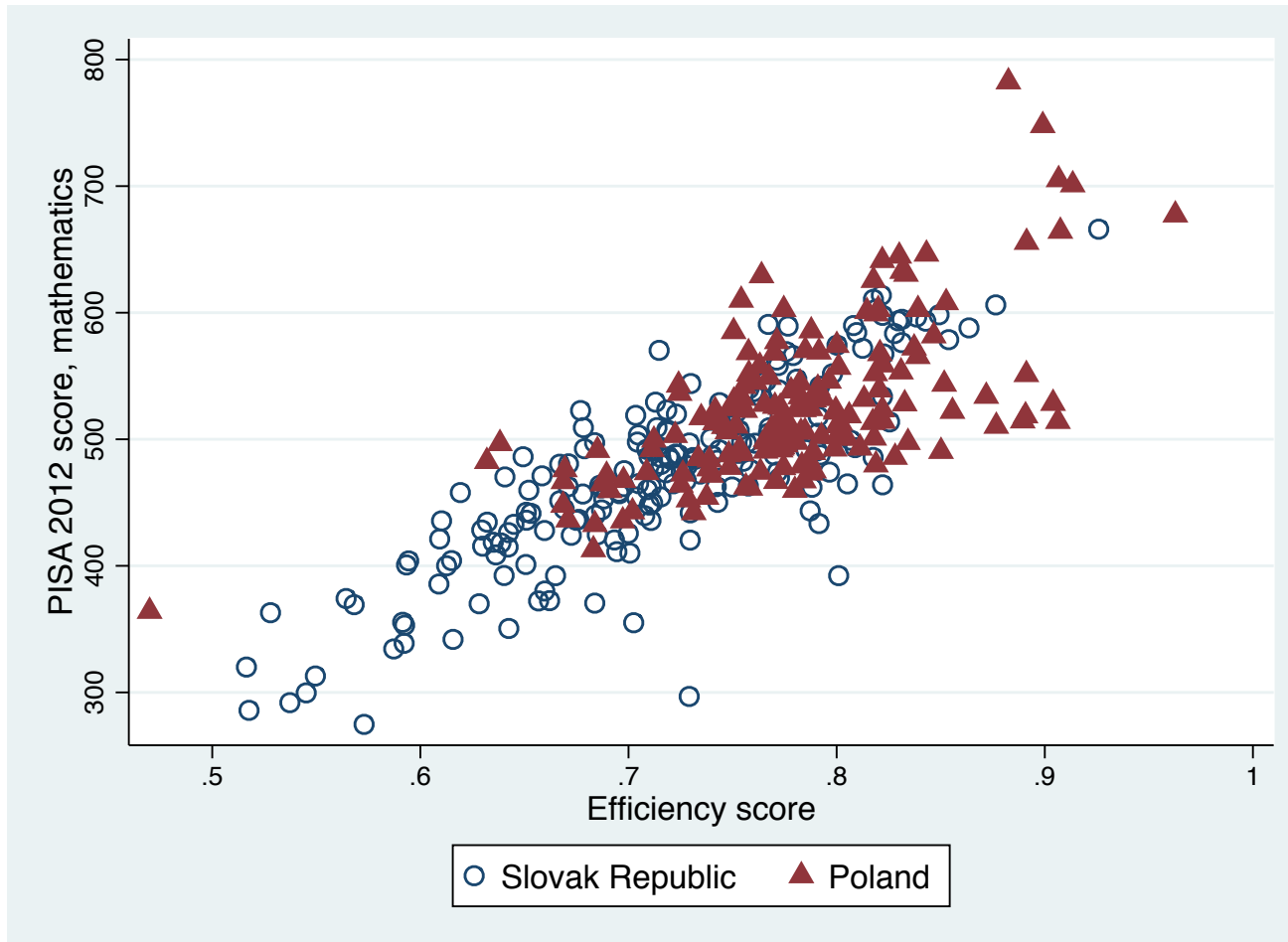
Efficiency and performance, comparing countries (2)
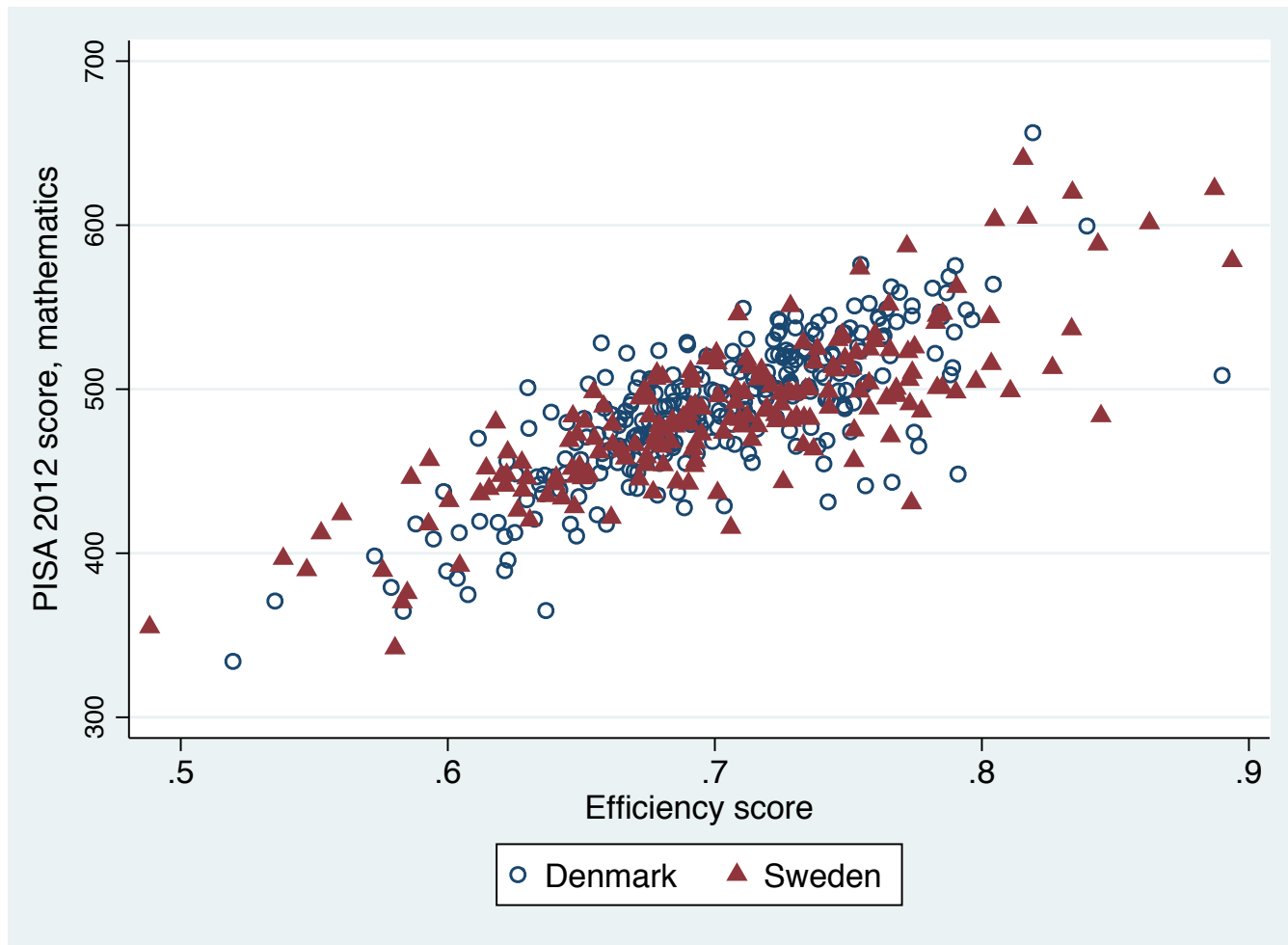
Efficient and inefficient schools

- How many schools are more/less efficient than the average, by country?
  [The CI does not cross the average value]

Selected countries	n	More efficient than avg		Less efficient than avg	
		n	%	n	%
AUS	718	369	51%	290	40%
DEU	194	110	57%	64	33%
EST	199	128	64%	51	26%
IRL	**152**	**125**	**82%**	**18**	**12%**
ISR	**141**	**60**	**43%**	**69**	**49%**
ITA	1,044	488	47%	459	44%
JPN	190	143	75%	33	17%
PRT	171	99	58%	40	23%
SGP	**163**	**155**	**95%**	**3**	**2%**
USA	152	73	48%	41	27%
Total	8,640	4,377	51%	3,325	38%

Distribution of efficiency scores: ITA

Distribution of efficiency scores: SGP

Mean efficiency: 0.734

DEA efficiency score

.4
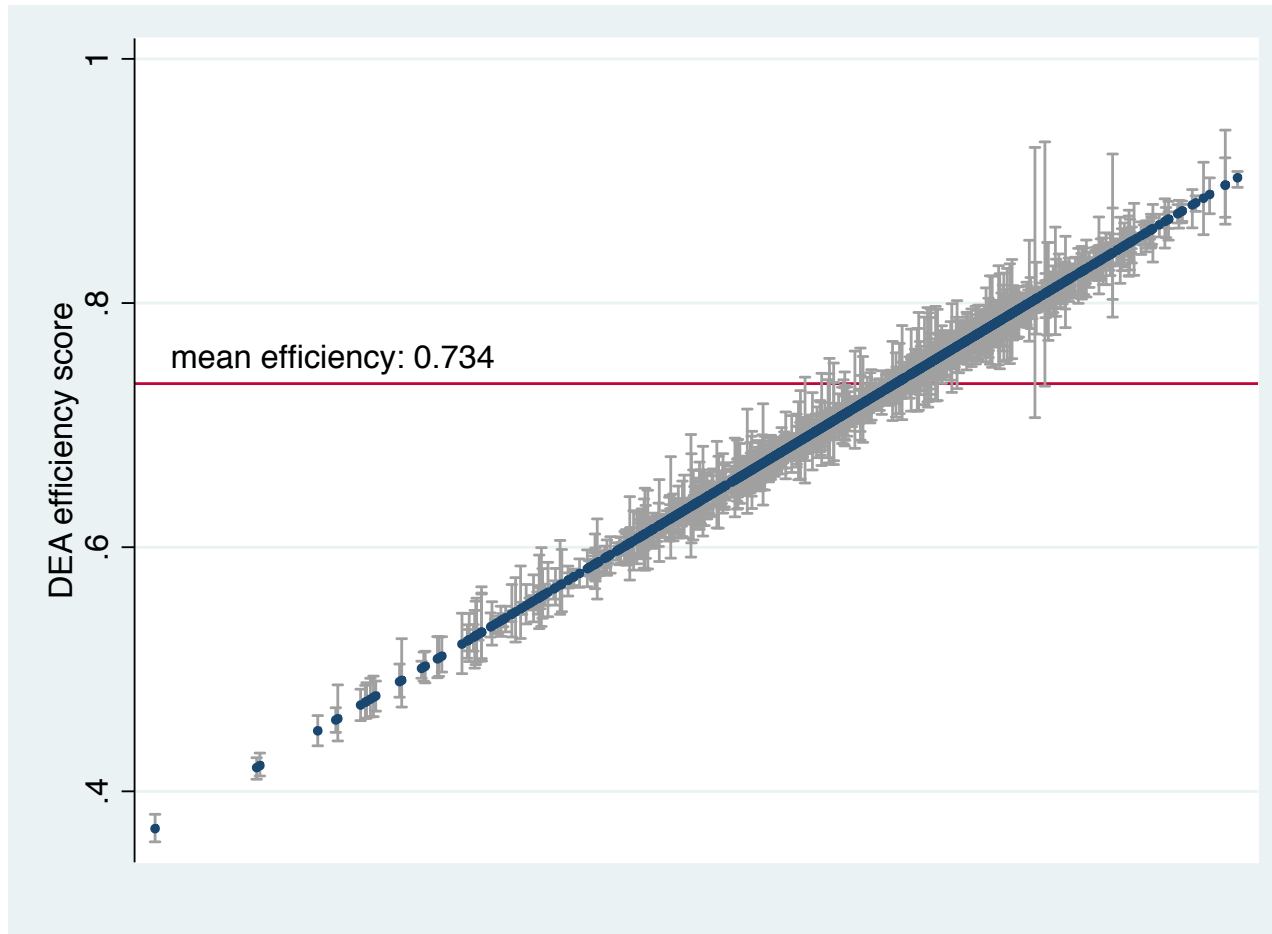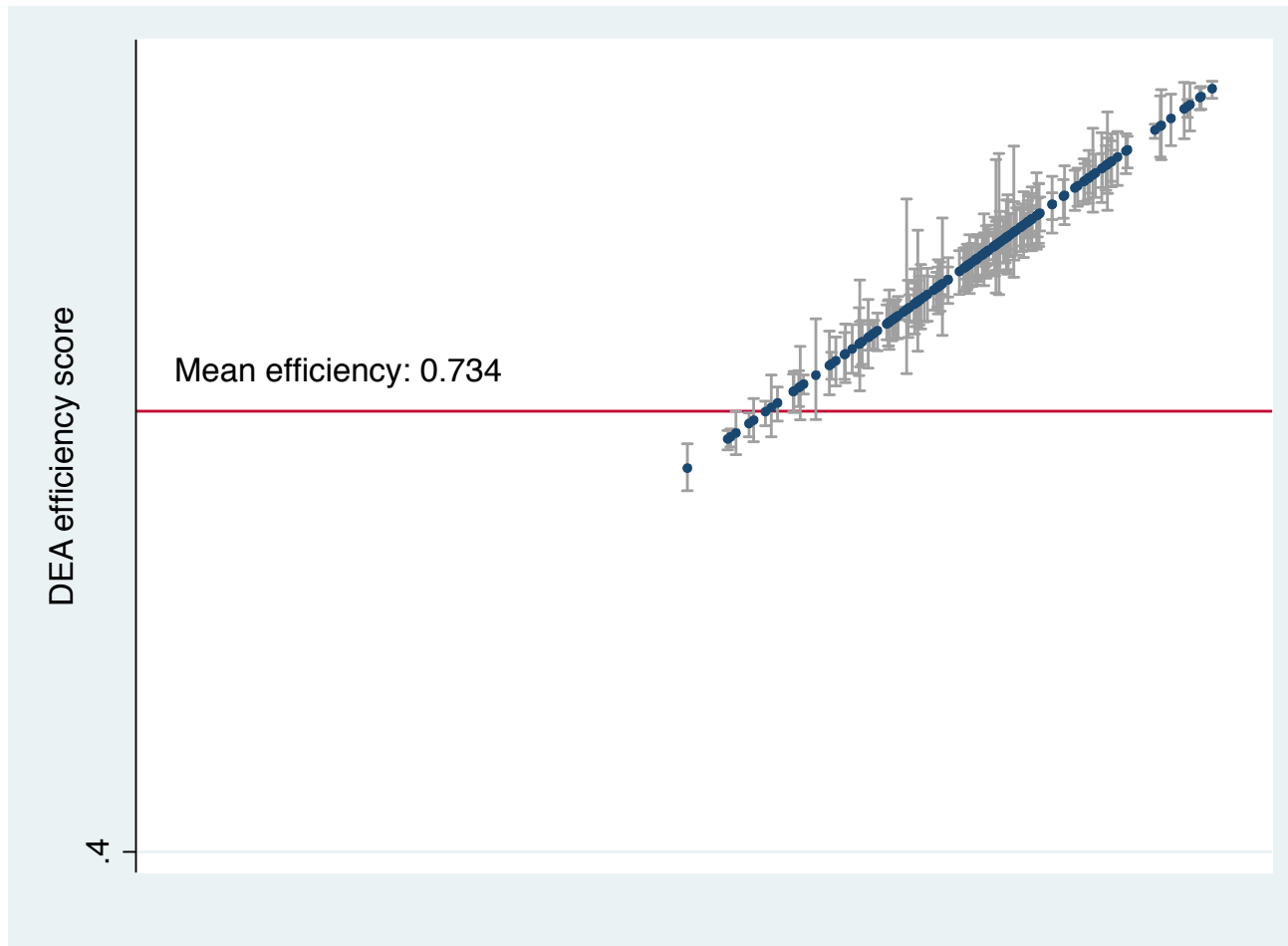
Characteristics of very efficient schools

- Different ways of being efficient
  - Inputs and outputs of schools in the 5th percentile

Country	ESCS	StRatio	Computer_n	pv1math	pv1read	n
AUS	0.676	0.073	1.340	**640.264**	**636.830**	18
ESP	**-0.436**	0.073	1.105	524.552	539.409	8
FRA	0.392	0.084	0.505	590.715	**631.255**	9
GBR	0.838	**0.064**	1.018	602.717	621.805	5
ITA	0.245	0.082	**0.378**	597.066	610.742	12
JPN	0.130	0.086	0.352	613.103	617.450	44
POL	**-0.058**	0.112	0.407	602.568	611.190	10
PRT	**-0.667**	0.079	0.362	527.473	540.924	5
SWE	0.759	0.069	0.831	600.166	**634.517**	2
Total	0.248	0.086	0.696	614.485	611.199	266

Factors associated w/efficiency scores (1)

- Second-stage Tobit regression
    - Dependent variable: bias-corrected DEA score
    - Backward and forward automatic procedure over a wide set of variables
    - Robustness check: Simar & Wilson (2007) – double-bootstrap procedure [done, results qualitatively and quantitatively similar]
- Set of variables
    - **School's general characteristics** (orientation; isced2, dispersion of scores and ESCS, private, size and class size)
    - **Students' characteristics** (% females, immigrants, repeaters, students who skipped school days; hours spent for homework)
    - **Schools' practices, resources and processes**
    - Program type and country dummies

Factors associated w/efficiency scores (2)

Positively associated w/efficiency	Negatively associated w/efficiency
• Program's orientation: general/academic • % immigrant students • % female students • Hours spent for studying homework (set by teachers) • % certified teachers • Principal responsible for budget allocation • Principal organises meeting with teachers (instructional activity) • School organises volunteering	• % students below proficiency level 2 • Private school • Class size avg<15 students • Standard deviation of ESCS • % students who skipped 1 or more days • Students report bad relationships with teachers • Selectivity • Achievement data are made public

Factors associated w/efficiency scores (3)

Heterogeneity across countries	Statistically significant	Positively associated w/eff	Negatively associated w/eff
School's general characteristics			
Program's orientation: general	8	6	2
Private	14	3	11
Class size (avg) < 15 students	12	4	8
Students' characteristics			
Standard deviation of ESCS	**14**	**6**	**8**
% female students	17	17	0
Hours spent for homework	**11**	**9**	**2**
% students who skipped 1 or + days	17	5	12
School's practices and processes			
Principal responsible - budget allocation	9	8	1
Index of teachers participation/governance	7	4	3
Achievement scores publicly available	9	3	6
School organises volunteering	8	5	3
Schools practices	8	2	6
School competes for students w/2 schools or +	10	4	6

Examples of different countries (1)

- Austria

	AUT
Students' characteristics	
% female students	0.05193**
	0.018
Hours spent for homework	0.01151***
	0.003
% Repeater students	-0.17698***
	0.034
School's general characteristics	
isced2	0.11701***
	0.019
pv1mathsd	0.00106***
	0.000
pv1_belowprof2	-0.06867**
	0.021
Class size, small	-0.02848
	0.015

Examples of different countries (2)

- Czech Republic

	CZE
Students' characteristics	
% immigrant students	-0.41297***
	0.085
% female students	0.05056**
	0.016
ESCS (standard deviation)	-0.06886**
	0.022
School's general characteristics	
Orientation: general	0.01941*
	0.008
pv1_belowprof2	-0.13706***
	0.016
Schools' practices and processes	
Principal's autonomy in budget formulation	-0.05355**
	0.019

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Examples of different countries (3)

- Estonia

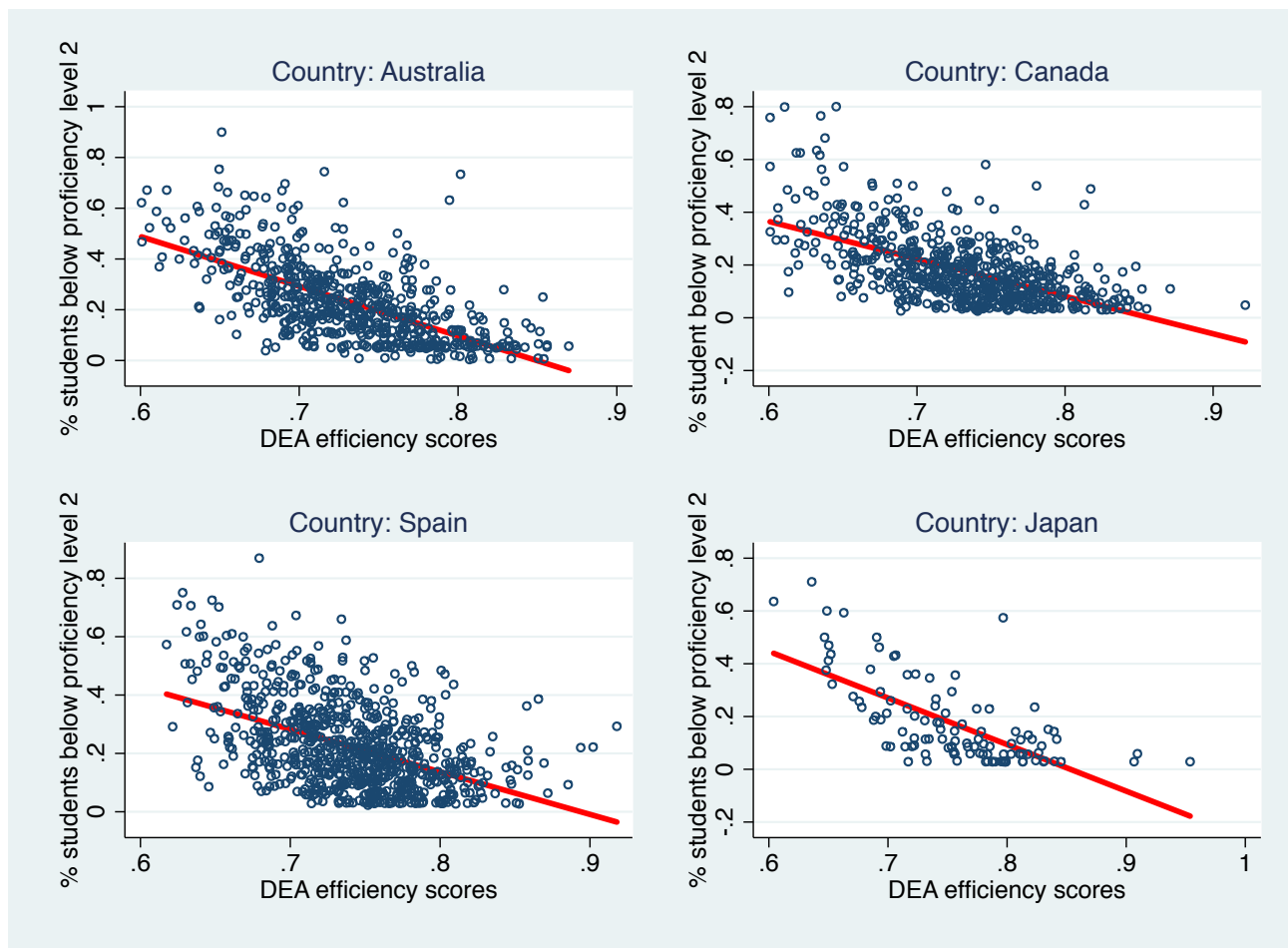|	EST
Students' characteristics	
% immigrant students	0.47389***
	0.122
% students who skipped > one day	-0.07320**
	0.024
School's general characteristics	
Pv1math (standard deviation)	0.00031
	0.000
pv1_belowprof2	-0.37525***
	0.031
Class size, small	-0.02350**
	0.008
Schools' practices and processes	
Principal's autonomy in budget formulation	0.04102**
	0.014
Extracurricular activities: volunteering	0.02623***
	0.007
Competition, >2 schools competing for same students	0.01534*
	0.006

Efficiency and equity: correlations

- Equity definition(s)
  - **Inclusion**: the proportion of students below proficiency level 2 (Schleicher, 2014)
  - **Equality**: dispersion of scores around the mean (standard deviation), similar to the concept proposed by Freeman *et al.* (2010)

- Inclusion:
  - The "automatic" relationship with performance/efficiency (the lower the proportion of low performing students, the higher the performance/efficiency, all else equal) but (i) exceptions and (ii) different possibilities (i.e. higher equality for lower means)

Efficiency and inclusion

Scatter plot with x-axis "DEA efficiency scores" ranging from .65 to .85 and y-axis "% students below proficiency level 2 (pv1_belowprof2)" ranging from 0 to .4. Countries plotted: SVN, ISR, SVK, ITA, PRT, SWE, AUT, USA, FRA, NZL, ISL, DNK, LUX, NOR, GBR, BEL, ESP, CZE, DEU, IRL, CAN, CHE, NLD, FIN, POL, EST, JPN, KOR, SGP.

$$m\_pv1below = 1.1866 - 1.318 \ m\_deabaga1 \quad R^2 = 53.6\%$$
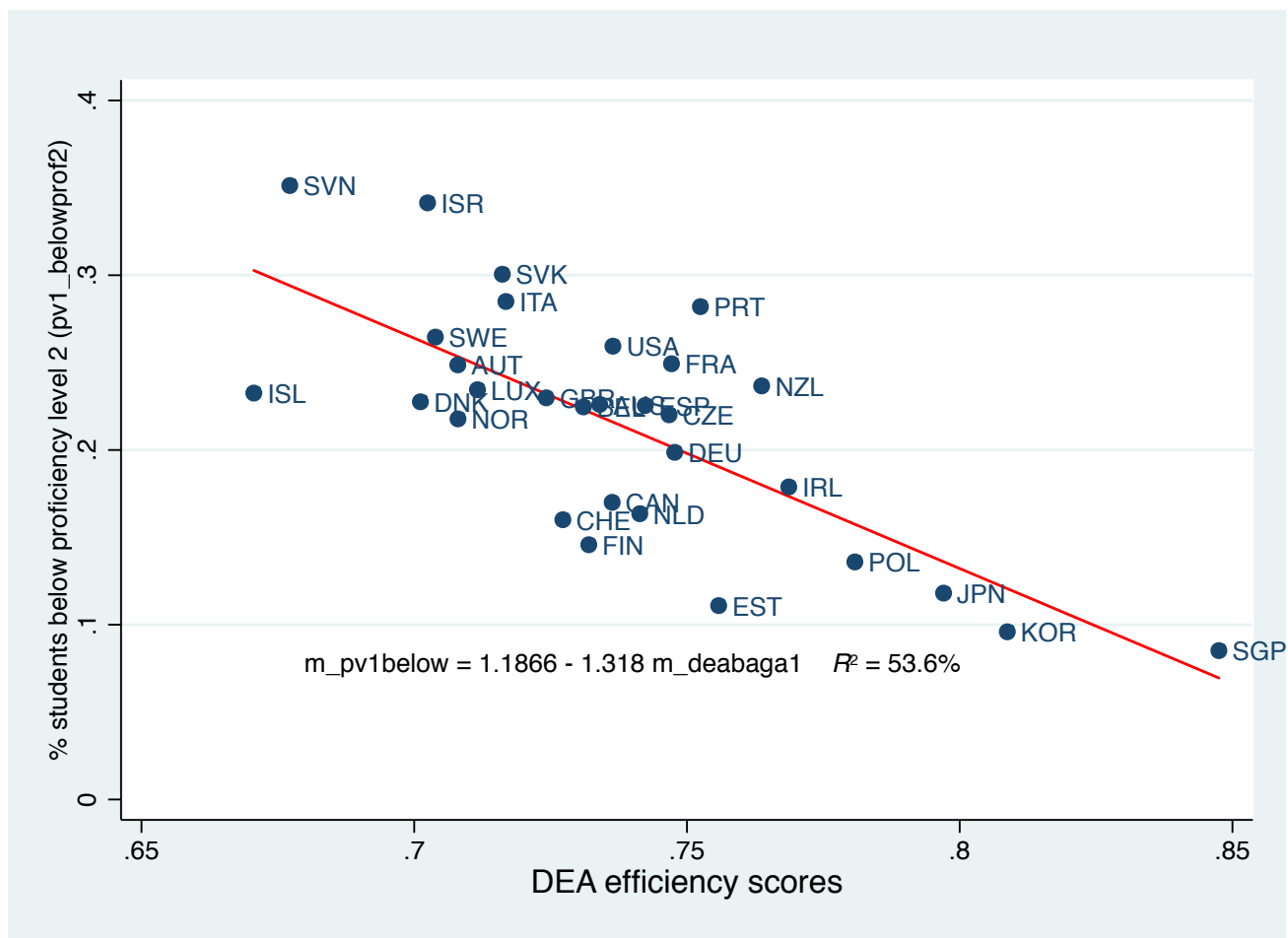
Efficiency and inclusion, selected countries

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What can we learn? Policy implications

- Caution in interpreting efficiency measures ➔ they depend on assumptions, and measure only partial phenomena
  - We are NOT looking at mechanisms for transforming inputs into outputs

- Some factors are more likely than others to be positively correlated with efficiency scores
  - (i) students' commitment (hours spent at homework, not skipping school days), (ii) schools/principals' autonomy in managing resources, (iii) extracurricular activities, …

- Negatively associated with efficiency:
  - (i) bad school climate, (ii) high proportion of students below proficiency level 2

Concluding remarks (1)

- Setting an international frontier for estimating schools' efficiency can be interesting if accepting the existence of comparable outputs and inputs ➔ a higher number (and types) of schools to be compared with [managerial implication]
  - How taking the structural differences between countries into account? The related literature about "institutional settings" (Hanushek & Woessmann, 2010)

- Within-country differences are wider than between-countries (structural) ones
  - Does it make sense comparing the efficiency of countries' educational systems *as a whole*?

Concluding remarks (2)

- Potential extensions
  - New concepts and measures of equity ➔ for example, proportion of resilient students
  - How the distribution of efficiency scores (within and between countries) evolved over time? ➔ Comparing PISA 2003 and PISA 2012
  - Including some variable at country level for "explaining" structural differences in schools' efficiency across countries

- Adding further robustness checks:
  - SFA – Stochastic Frontier Analysis (Annex)
  - Different DEA specifications (Annex)
 - Eliminating outliers (*to be done*)

Additional materials

- Measures of non-cognitive skills
- Developing countries

Measures of non-cognitive skills

- Schools do not only "produce" achievement or cognitive skills
  - OECD (2013) vol. III Students' engagement, drive and self-beliefs

- Focus on two measures:
  - Perseverance (**persev**): constructed index based on students' responses about their willingness to work on problems that are difficult, even when they encounter problems
  - Openness to problem solving (**openps**): constructed index based on students' responses about their willingness to engage with problems

 Both indexes: mean=0 sd=1 across OECD countries

Perseverance and efficiency, by country

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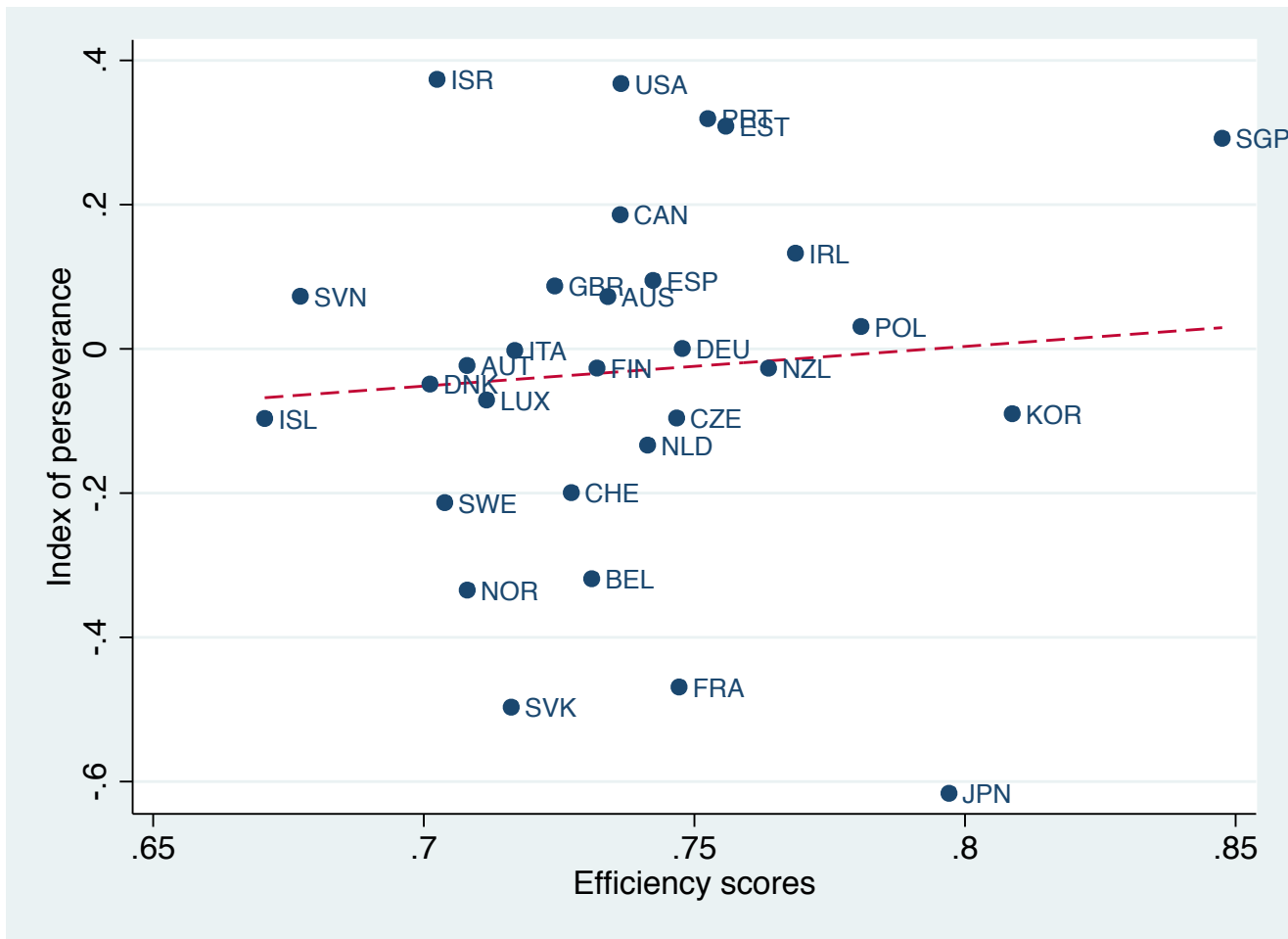
Efficiency model w/ alternative outputs

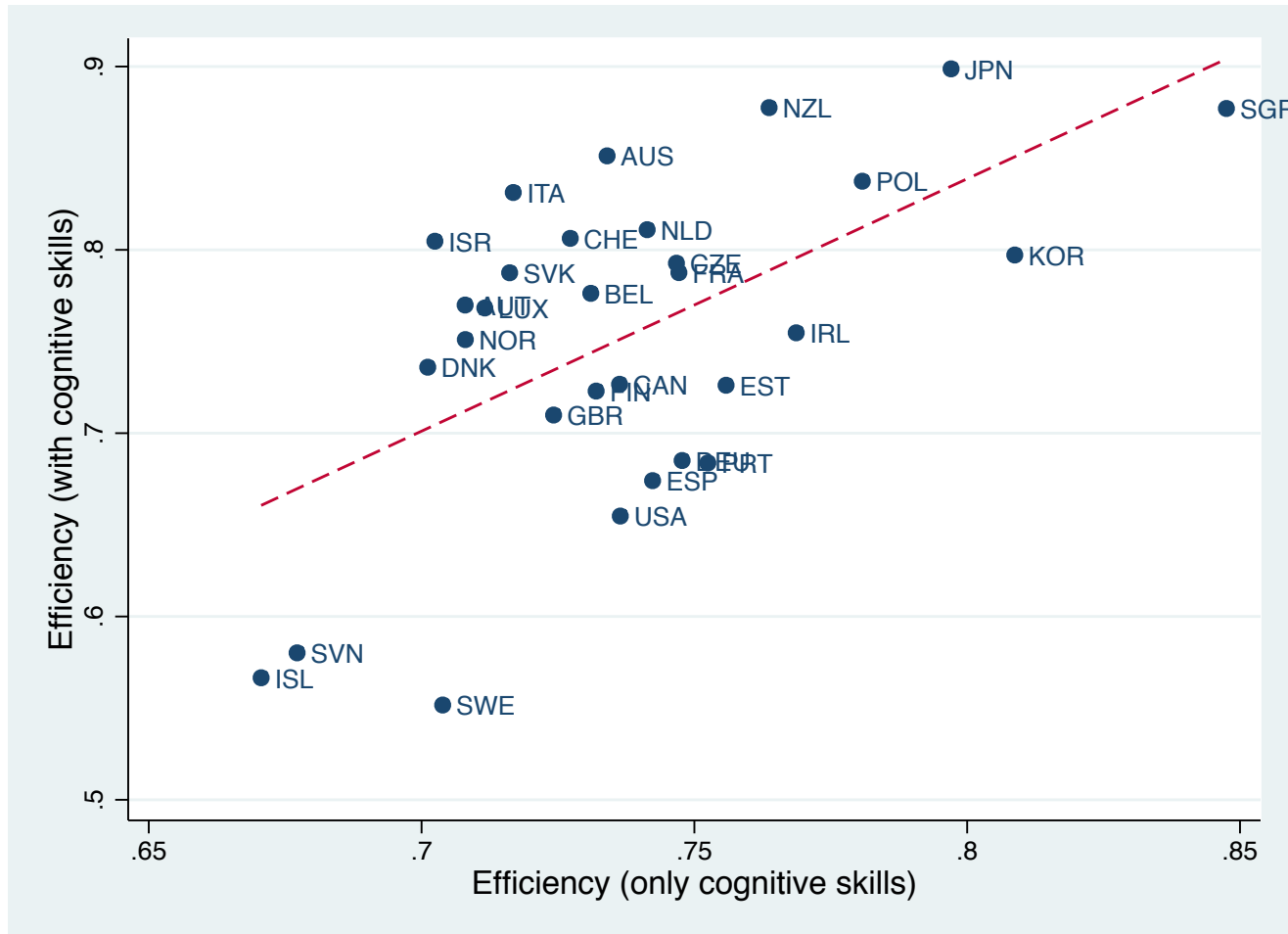- What happens when we model schools' efficiency including *persev* as an output?
  - Inputs: as in previous model (StRatio, ESCS, Computer_n)
  - Outputs: pv1math, *persev*

- If the results do not change substantially:
  - Achievement scores could be considered as the main drivers of the school outputs' vector
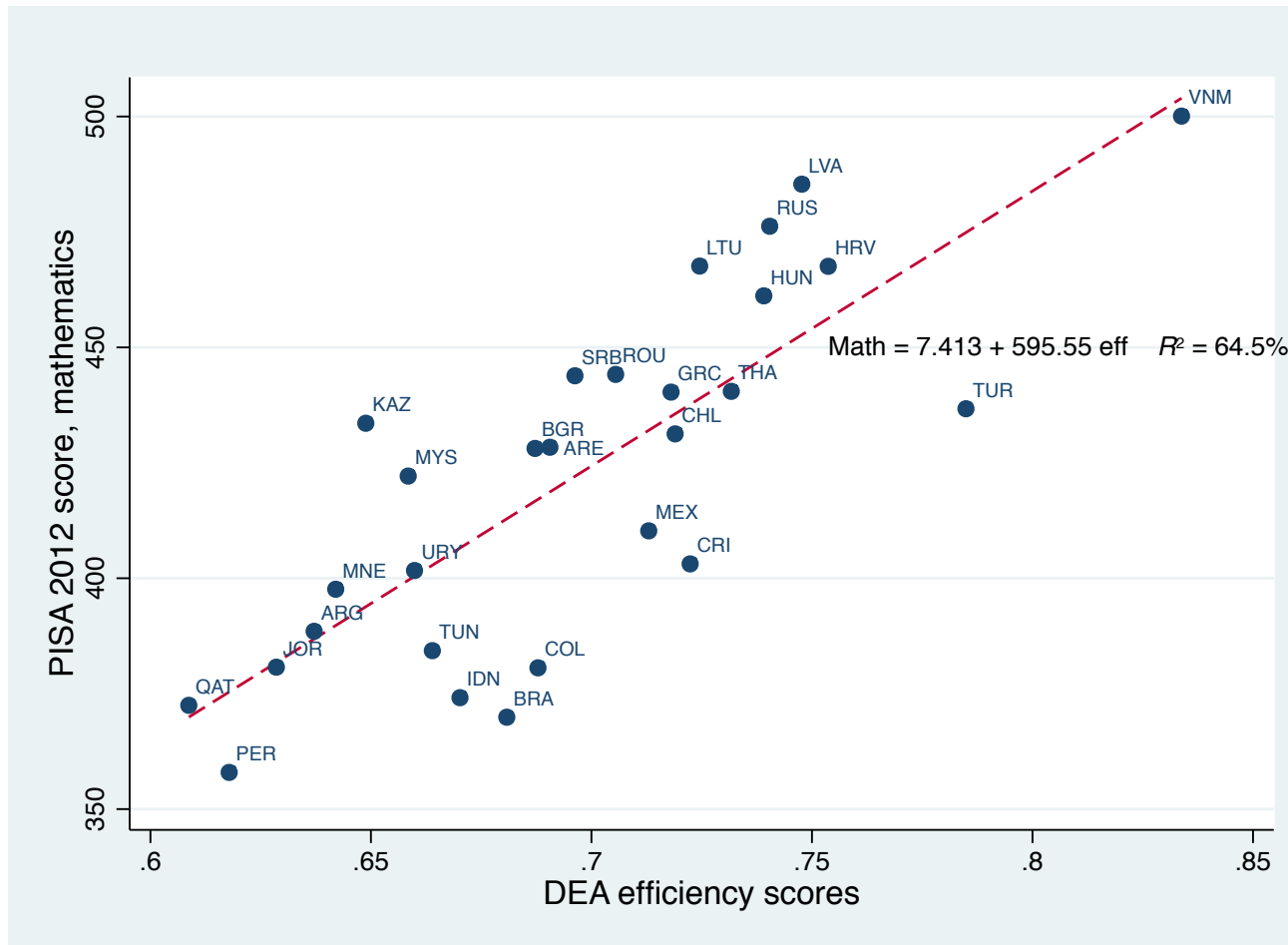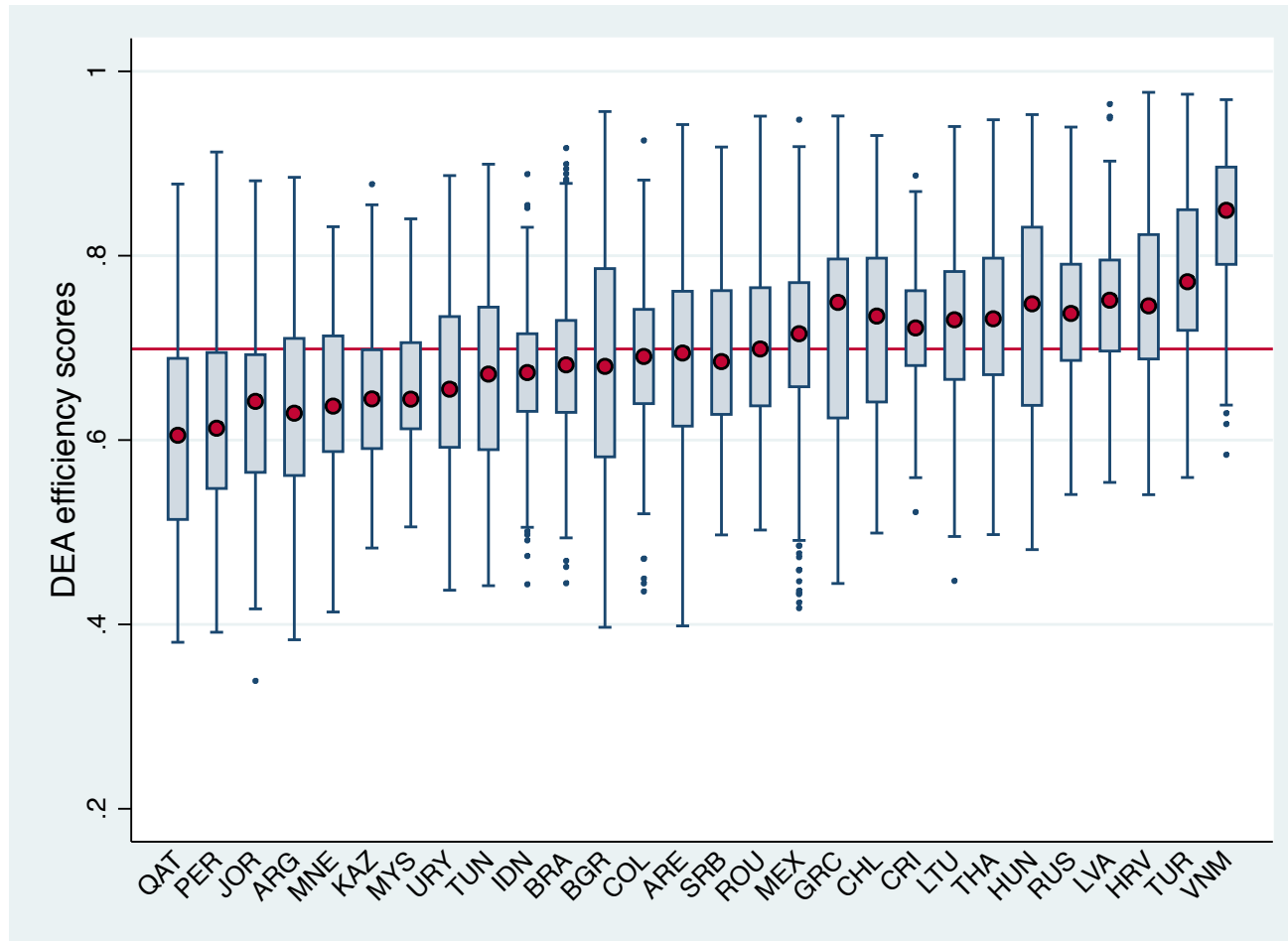
Distribution of efficiency scores

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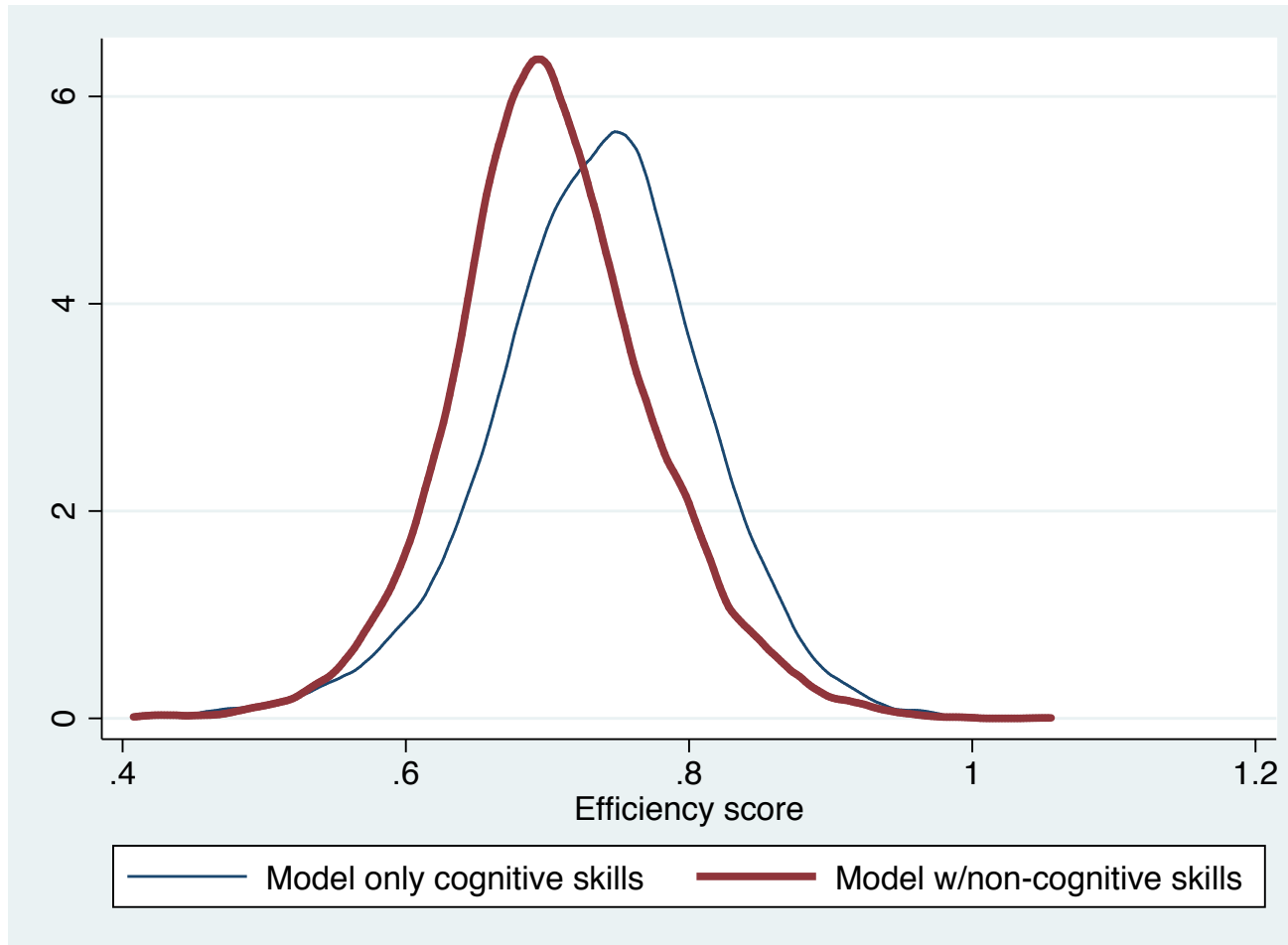
Efficiency with and without non-cognitive

Developing countries (1)

Developing countries (2)

Developing countries (3)

On the horizontal axis: efficiency scores

— Eff. scores: international benchmark   ••••••••• Eff. scores: country-specific benchmark

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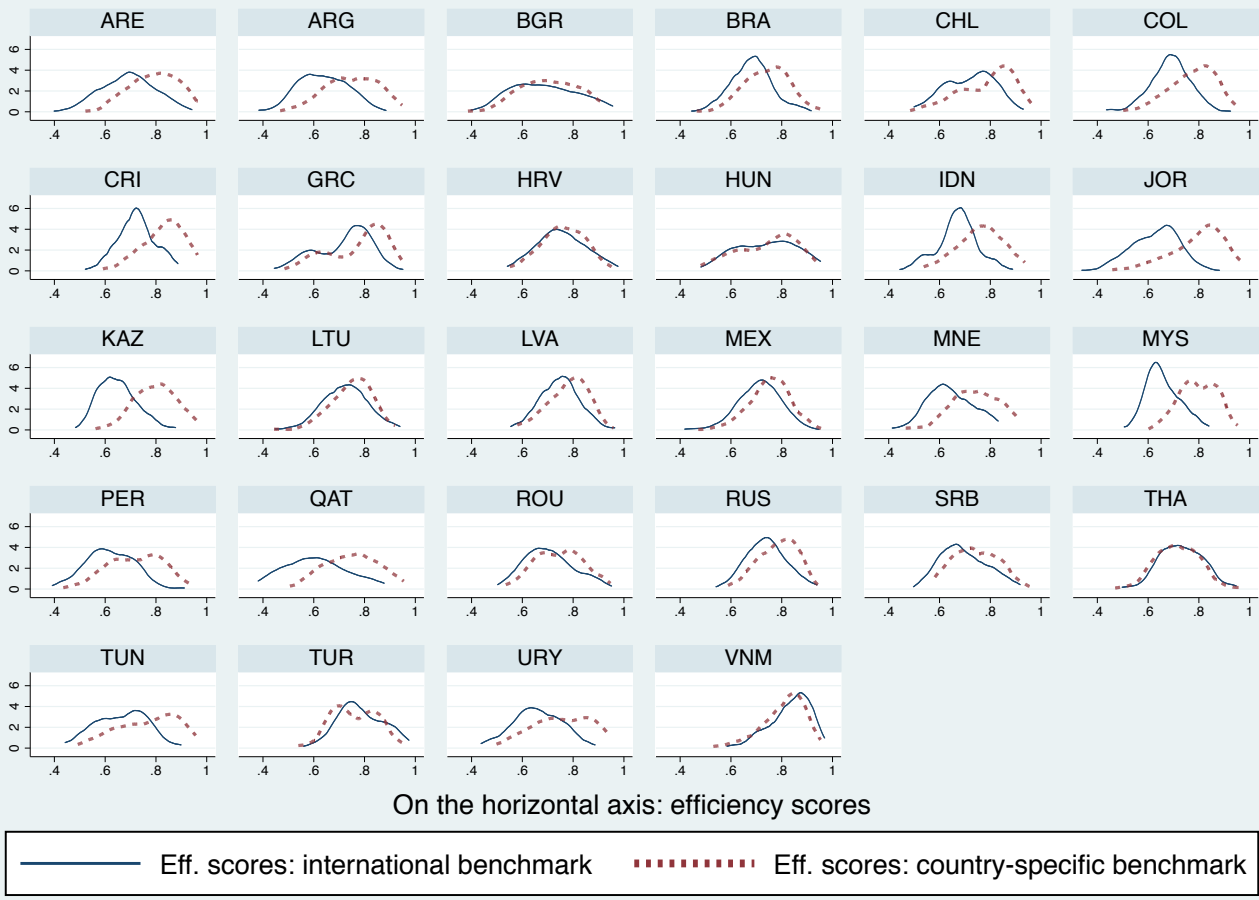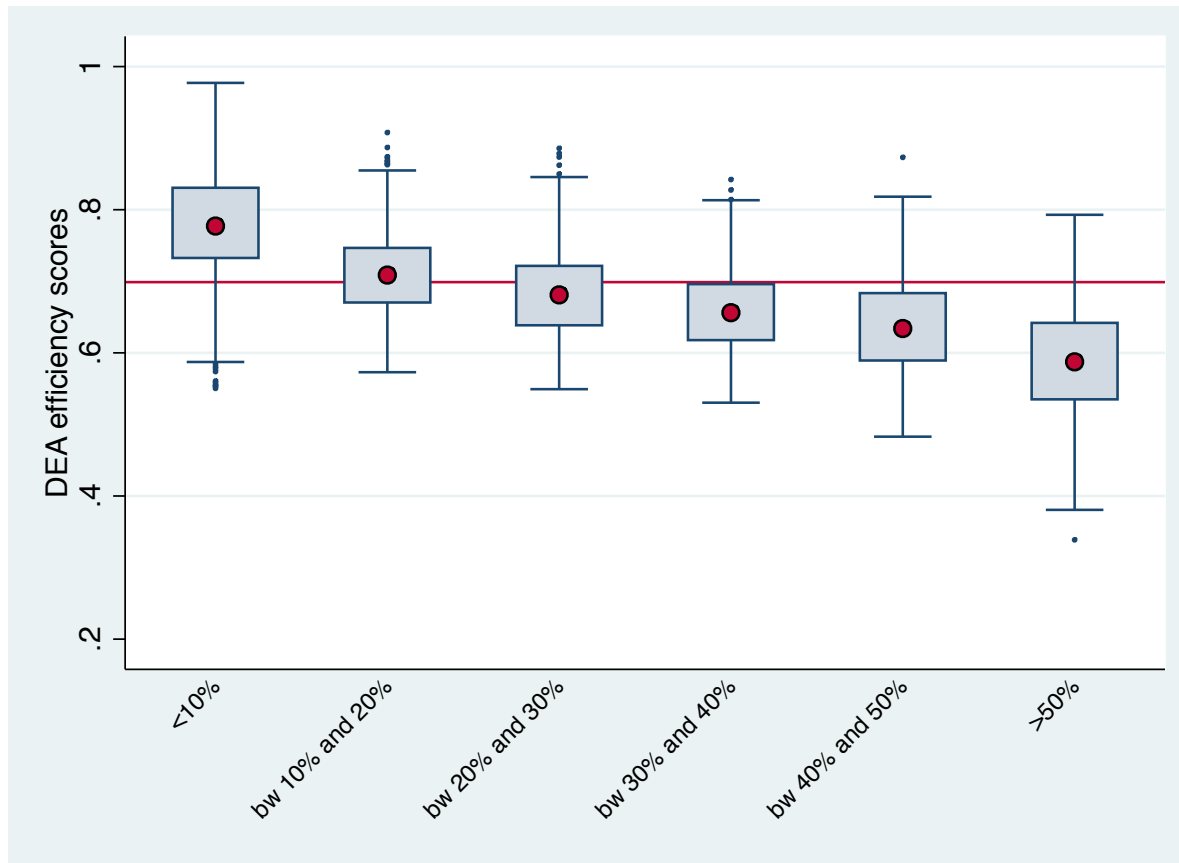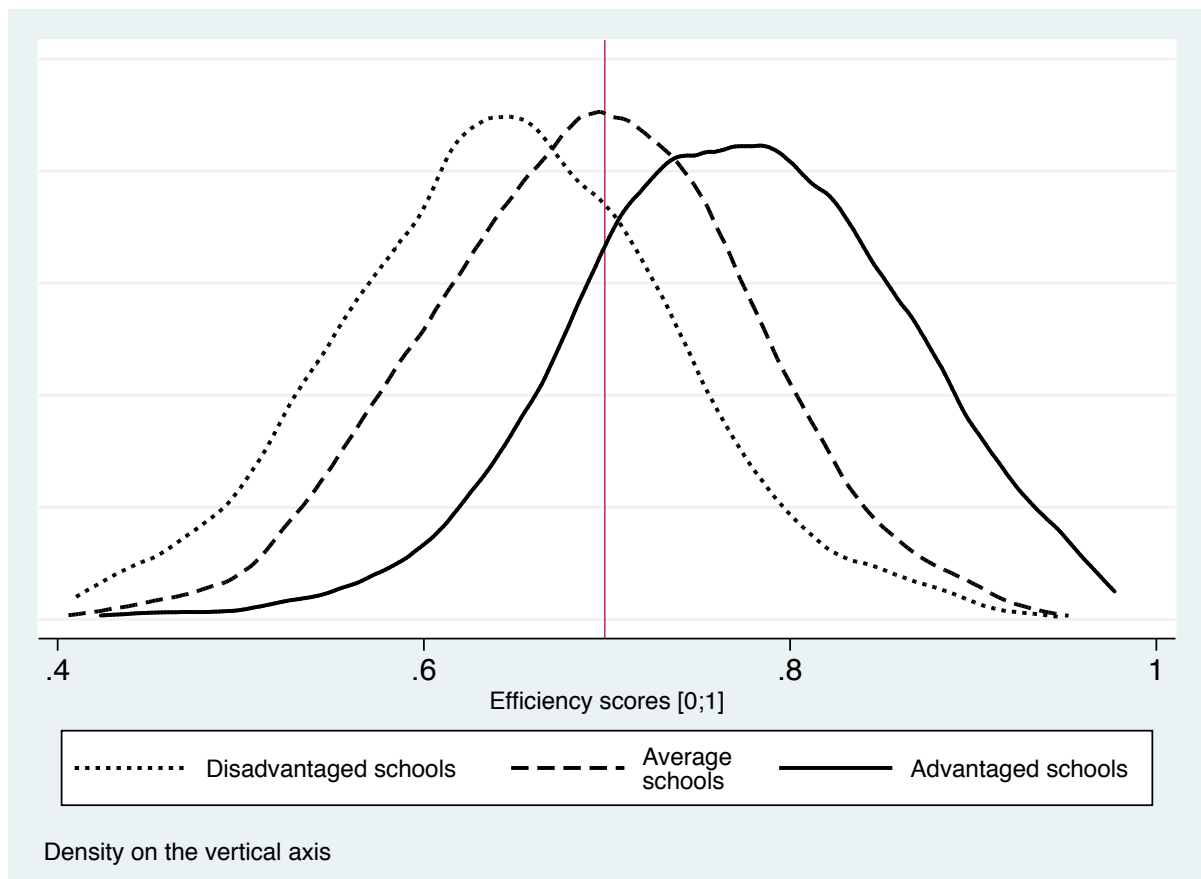
Developing countries (4)

- % students with proficiency level <1

Developing countries (5)

- % students with ESCS advantaged/disadvantaged

Efficiency scores [0;1]

Disadvantaged schools — Average schools — Advantaged schools

Density on the vertical axis

Developing countries (6)

- Advantaged/Disadvantaged schools, by country

On the horizontal axis: efficiency scores

···················· Disadvantaged schools   – – – – · Average schools   ——— Advantaged schools

Vertical line: average efficiency (international frontier). Density on the vertical axis