Does One Size Fit All?
The impact of cognitive skills on economic growth

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Introduction

- The question of which factors determine economic growth has been a major topic in economic research.
- The importance of human capital for economic growth has been called into question by a large number studies that failed to find a **positive relationship** between the quantity of education and economic growth in cross-country analysis.
- Despite the large number of recent empirical studies carried out on data involving international comparisons, the assumption of a clear and positive relationship between the investment in human capital and economic growth has been largely called into question.

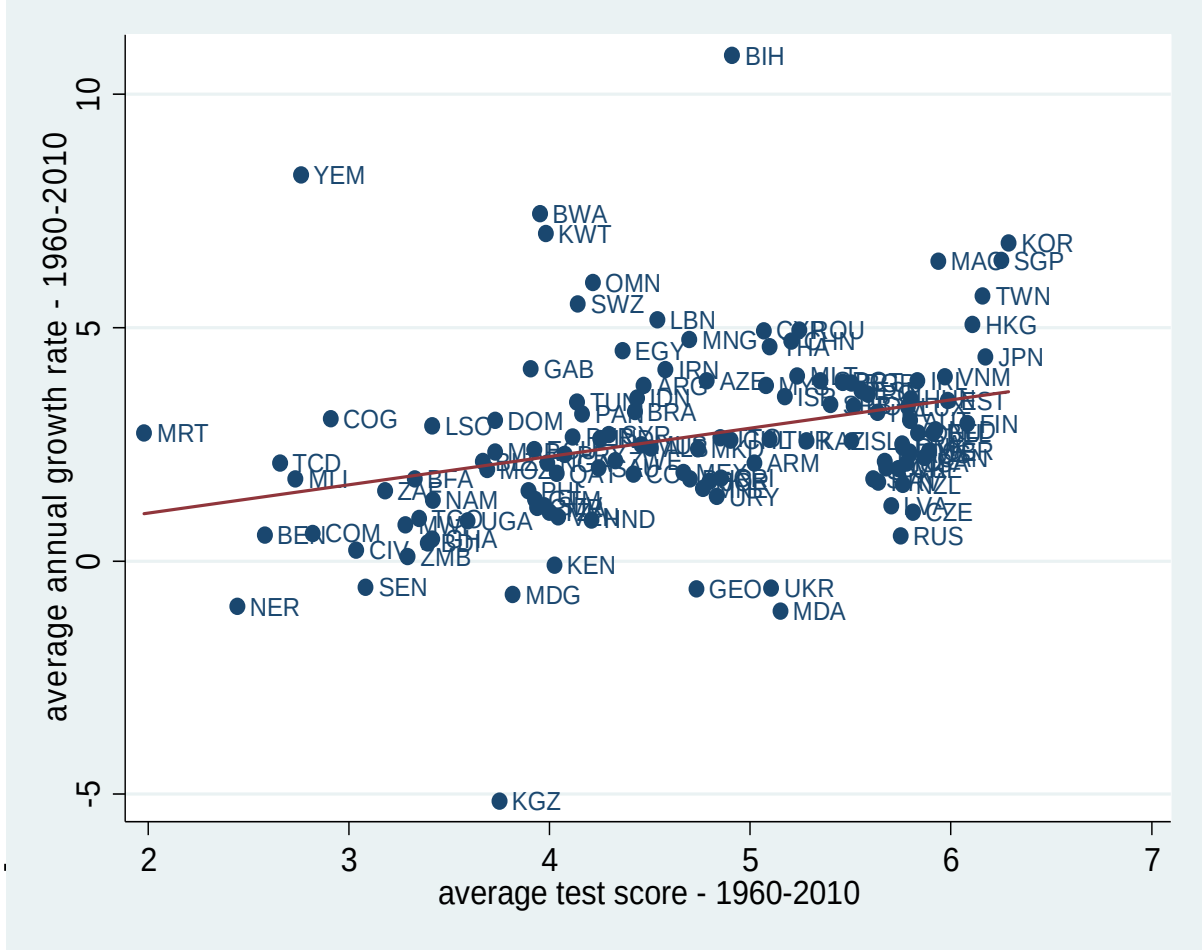
Introduction

- In 2001, Lant Pritchett underlined the controversies surrounding the relationship between education and growth (Pritchett, 2001).
- Pritchett highlighted the importance of the quality of education and argued that if **the quality of education is so low,** it may not produce the necessary skills to lead to economic growth.
- Should we consider that one year of schooling in country *i* is similar than one year of schooling in country *j* ?
- For instance, a one year increase of education in Germany may not give the same output that one year increase yields in Turkey or Indonesia.
- This difference may explain why we fail to find a strong positive relationship between education and economic growth.

Introduction

- Thus, the studies which take into account only quantitative indicators of education will be biased, owing to the fact that they regard human capital as a homogeneous factor of production
- For instance, recent results from PISA 2012 assessment show that the performance of students from Germany in maths are 15% higher than results in Turkey, and 37% compared to Indonesia.
- Using a recent data set which aggregates results from student achievement tests (Altinok *et al.*, 2014), we investigate the relationship between cognitive skills and the average annual growth rate of the economy between 1960 and 2010
- We find a positive correlation between the two variables (Figure 1).

Figure 1: Relationship between learning outcomes and economic growth (1960-2010)



Review of literature

- **Barro (1991)** was the first study to emphasize school quality along with other measures of education. Barro presented evidence that school quality matters; higher primary and secondary pupil teacher ratios in 1960 have marginally significant negative impact.
- The work of **Hanushek and Kimko (2000)** was the first to include measures of educational quality using data from international student achievement tests
- Using data from ISATs that administered similar mathematics and science tests to students in 31 countries, they construct normalized test scores and include these as measures of the human capital stock (called "Labor Force Quality") in their analysis of economic growth (from 1960 to 1990).
- Their estimated impact is large, suggesting that a **one standard deviation increase in schooling quality (measured by test performance, and approximately equal to 100 points) increases the rate of economic growth by 1.4 percentage points.**

Review of literature

- A recent paper by **Hanushek and Woessmann (2012)** (hereafter HW) aimed at improving the work of Hanushek and Kimko (2000).
- Using the Cohen and Soto (2007) years of education instead of Barro and Lee dataset, they update test score data that include more developing countries (50 countries, of which 27 are developing countries) and the period analyzed is extended to cover the 1960-2000 period.
- HW find that years of schooling has no impact on economic growth when test score measure is included.
- **A one-standard deviation increase in school quality (approximately 100 score points) is associated with a 1.3-2.0 percentage point higher rate of economic growth**.
- Thus, the higher performance of Germany compared to Mexico (difference of about 100 score points) may explain why Germany grew faster than Mexico during the last 70 years.

Value-added of our paper

- Our paper aims at improving and extending the analysis done by Hanushek and Woessmann (2012) in a number of ways.
- Firstly**,** we use a **larger dataset** for our test score variable, by including more developing countries: our dataset provides **an increase in the number of countries of about 60%.**
  - A recent database (Altinok *et al.*, 2014) compiled the results of countries in the international assessments of the pupils for each skill (mathematics, sciences and reading) between 1965 and 2007.
  - While this original dataset provides data until 2007, we replicate the same methodology in order to update it until 2012.
  - Resulting updated database includes comparable cognitive skills for **125 countries compared to HW that take into account 77 countries.**

Value-added of our paper

- **Secondly,** the methodology used for our test scores data set tends to reduce measurement error and is exclusively based on data sets available at the student level.
  - In most previous studies, only mean scores published in international reports were used.
  - On the contrary, we used raw data in order to compute the adjusted means for each assessment.
- **Lastly,** since our data includes countries around many continents, in addition to estimating an average effect of education on economic growth, we can also test for heterogeneity in the effects across sub regions.
  - In addition to the regional level analysis, we also analyze potential differences in the amplitude of the effects of cognitive skills on economic growth by the economic level of countries.

Main findings

- We find five main results.
  i. While the quantity of schooling (measured as initial years of education) is not robust in our estimates, **coefficient associated with our updated cognitive skills variable is quite strong over most estimations**.
  ii. Our results show that **including more developing countries increases the overall impact of cognitive skills** on economic growth from 1.3 standard deviation to **1.5 standard deviation**.
  iii. Moreover, it appears that the effect has **a higher amplitude for low income countries**, whereas the effect is lower for the middle income countries.
  iv. In the panel data analysis, we find that the amplitude of cognitive skills on economic growth remains positive and significant for a larger sample of countries

Main findings

- We find five main results.
  v. Lastly, the focus on the share of basic and top performers within each country highlights different effects between subsamples.
    - While in **high income countries, the share of top performers** in student achievement tests has a strong and positive effect on economic growth,
    - this is the **share of student reaching the minimum level which has the most important impact on economic growth for countries from Middle-East, Arab States and Sub-Saharan Africa**.
    - Indeed, investing in the quality of education may enhance economic growth of countries, even if we take into account potential reversal causality issues, measurement error and omitted variable bias.

Theoretical framework: A Simple Growth Model

- We use a simple growth model: a country's growth rate (*g*) is a function of the skills of workers (*H*) and other factors (*X*).
  - These factors include initial levels of income and technology, specific institutional dimensions, and other factors that are used in the growth empirics.
- Our specification assumes that *H* is a one-dimensional index and that growth rates are linear in these inputs:

$$g = \gamma H + \beta X + \varepsilon \quad (1)$$

- In our model, this is the **level of human** capital which explains the **economic growth** of the economy.
- The most important specification issue in this framework is the nature of the skills (H) and where they might come from.

Theoretical framework: A Simple Growth Model

- In the educational production function literature (Hanushek, 2002), skills are explained by many factors such as family inputs (*F*), the quantity and quality of inputs provided by schools (*qS*), individual ability (*A*), and other relevant factors (*Z*) which include labor market experience, health, and other specific characteristics:

$$H = \alpha F + \beta(qS) + \gamma A + \delta Z + v \quad (2)$$

  - In our specification, the schooling term (*qS*) combines school attainment (*S*) and its quality (*q*). However, human capital is a latent variable that cannot be directly observed.
  - Following the pioneering analysis of Hanushek and Kimko (2000), we focus directly on the cognitive skills component of human capital and **evaluate *H* with test-score measures of mathematics, science, and reading achievement**.

Data and methodology

- The main innovation in terms of data source in this analysis is the use of **a larger dataset on cognitive skills** than previous papers.
- The dataset related to cognitive skills used in this paper is based on Altinok *et al.* (2014).
- In order to construct achievement indicators, various international learning achievement tests are used.
- There are seven groups of international surveys in which 105 countries have participated. These can be divided into two main subgroups.
- The first one consists of international student assessments tests (ISATs), while the second one consists of regional student assessments tests (RSATs).
  - ISATs included in the construction of achievement indicators include the well-known "Trends in International Mathematics and Science Study" (TIMSS), "Progress in International Reading Literacy Study" (PIRLS) and "Programme for International Student Assessment" (PISA) tests.

Data and methodology

- There are seven groups of international surveys in which 105 countries have participated. These can be divided into two main subgroups.
- The first one consists of international student assessments tests (ISATs), while the second one consists of regional student assessments tests (RSATs).
- Along with these international assessments tests, three major regional assessments that have been conducted in Africa and Latin America helps us extend the achievement data to a larger set of countries.
  - SACMEQ: *Southern and Eastern Africa Consortium for Monitoring Educational Quality* (1995, 2002, 2007)
  - PASEC: Programme of Analysis of Education Systems (1990-2012)
  - LLECE: *Latin American Laboratory for Assessment of the Quality of Education,* 1998, 2006

Data and methodology

- **Step 1:** Our methodology consists of anchoring ISATs with the results of United States in the US NAEP (National Assessment of Educational Progress) for only the very first ISATs.
- **Step 2:** In parallel to this anchoring, recent achievement tests - for instance, the Trends in International Mathematics and Science Study (TIMSS) - permit us to make over time comparisons of country performance.
- **Step 3:** Adjusting RSATs needs a new methodology which uses countries participating in at least one ISAT and one RSAT. By using these countries' performance in both tests, we make an anchoring of RSATs with ISATs.
  - We therefore combine these new series – i.e. the Regional Student Achievement Tests – by using scores for countries which took part in at least one ISAT for the same period.

Data and methodology

– An example of anchoring:

	FRA	USA	UK	Doubloons' Mean	Adjusted data Cntry C
Ref TIMSS	46	53.8	...	49.9	
PISA 2003	48.8	49.9	60	49.3	60 x (49.9)/(49.3)
					= 60.7

Empirical strategy

- **Step I.** Since we use an extended data set based on a different methodology than HW, we first replicate results from HW using their own data as well as this paper's data set confined to the HW sample.
- **Step II.** We then reports results from our new extended data which shows to what extent earlier results reported in the literature hold for a larger set of countries and with more recent data.
- **Step III.** We investigate **heterogeneity in the relationship between cognitive skills and economic growth** for various subsamples and test robustness of results to alternative identification strategies.
- **Step IV.** We focus on advanced and minimum levels and not only on mean scores. By defining proficiency level for performance in math/science, we are able to regress the share of students above the thresholds on economic growth of countries.

Results I. Baseline results (part 1)

	(1)	(2)	(3)	(4)[a]	(5)[b]	(6)[c]	(7)[d]	(8)[e]
(A) Data from Hanushek and Woessmann (2012a), sample from Hanushek and Woessmann (2012a)								
Cognitive skills		1.238	1.199	1.224	1.102	1.006	0.853	0.594
		(8.62)	(7.38)	(6.88)	(8.13)	(3.33)	(5.02)	(5.18)
Years of schooling 1960	0.408		0.050	0.014	0.064	0.070	-0.003	-0.014
	(4.41)		(0.79)	(0.18)	(0.76)	(0.79)	(0.04)	(0.23)
GDP pc 1960	-0.399	-0.294	-0.321	-0.300	-0.317	-0.270	-0.334	-0.315
	(4.85)	(9.21)	(8.49)	(7.48)	(5.74)	(5.10)	(7.18)	(6.80)
(A) Observations	50	50	50	50	52	50	47	45
(A) R-squared (adj.)	0.313	0.753	0.756	0.754		0.778	0.800	0.803

Results I. Baseline results (part 2)

	(1)	(2)	(3)	(4)[a]	(5)[b]	(6)[c]	(7)[d]	(8)[e]
(B) Data from updated Altinok et al. (2014), Sample from Hanushek and Woessmann (2012a)								
Cognitive skills		1.312	1.316	1.383	1.382	1.185	1.023	0.669
		(8.86)	(7.24)	(6.84)	(11.13)	(4.44)	(4.57)	(3.56)
Years of schooling 1960	0.408		-0.004	-0.062	-0.045	0.006	-0.038	-0.018
	(4.41)		(0.06)	(0.76)	(0.69)	(0.07)	(0.52)	(0.27)
GDP pc 1960	-0.399	-0.319	-0.317	-0.294	-0.301	-0.243	-0.327	-0.314
	(4.85)	(9.41)	(8.18)	(7.30)	(6.29)	(4.19)	(6.73)	(6.49)
(B) Observations	50	50	50	50	52	50	47	45
(B) R-squared (adj.)	0.313	0.792	0.792	0.794		0.823	0.820	0.791

Results I. Baseline results (part 3)

	(1)	(2)	(3)	(4)[a]	(5)[b]	(6)[c]	(7)[d]	(8)[e]
(C) Data from updated Altinok et al. (2014), Sample from updated Altinok et al. (2014)								
Cognitive skills		1.629	1.510	1.382	1.587	1.101	1.531	0.720
		(13.14)	(10.50)	(8.36)	(10.40)	(3.96)	(5.66)	(2.72)
Years of schooling 1960	0.465		0.115	0.168	0.099	0.149	0.055	0.003
	(4.90)		(1.83)	(2.51)	(1.29)	(2.28)	(0.83)	(0.06)
GDP pc 1960	-0.220	-0.270	-0.310	-0.315	-0.294	-0.314	-0.281	-0.308
	(3.82)	(9.43)	(8.21)	(8.63)	(7.29)	(7.18)	(6.37)	(6.84)
(C) Observations	84	84	80	80	85	80	68	68
(C) R-squared (adj.)	0.232	0.719	0.729	0.739		0.756	0.714	0.750

Results I. Robustness – sensitivity tests

	(1)	(2)	(3)	(4)	(5)
	Full	OECD	Non-OECD	High-Income	Low-Income
Test-score specification					
(A) Data from Hanushek and Woessmann (2012a)					
All math and science	1.120	1.144	1.273	0.978	1.368
	(7.38)	(7.08)	(5.66)	(4.33)	(5.94)
Only lower secondary	1.177	1.128	1.231	0.831	1.399
	(6.84)	(6.39)	(5.68)	(3.83)	(7.27)
No. of countries (A)	50	26	24	31	19

Results I. Robustness – sensitivity tests

	(1)	(2)	(3)	(4)	(5)
	Full	OECD	Non-OECD	High-Income[a]	Low-Income[a]
Test-score specification					
(B) Data from updated Altinok, Diebolt, de Meulemeester (2014)					
(B1) All math and science	1.510	1.471	1.524	1.181	1.746
	(10.50)	(3.41)	(7.70)	(7.68)	(8.18)
(B2) Only lower secondary	1.107	1.057	1.109	0.799	1.437
	(9.06)	(3.50)	(6.30)	(6.91)	(9.42)
No. of countries (B1)	80	27	53	40	40
No. of countries (B2)	56	27	29	37	19

Empirical strategy II. IV estimation technique

- We take into account endogeneity and measurement error issues by performing an Instrumental Variable estimation.
- **Part 1.** We firstly use the same instruments used in Hanushek and Woessmann (2012):
  - External exit exam systems
  - Catholic share in 1900
  - Relative teacher salary
- **Part 2.** Since our database includes more country than previous papers, we used additional instruments in order to include a higher sample of countries
  - Instruments used in Islam et al. (2014): disability-adjusted life years lost per 100,000 population (DALY), estimated death rates due communicable, maternal, perinatal, and nutritional diseases per 100,000 population (EDR)
  - Instruments from Adams & Lim (2014): measure of government effectiveness (Worldwide Governance Indicators)

Results II. IV-GMM results (part 1)

	(1) [a]	(2) [a]	(3) [a]	(4) [b]	(5) [b]	(6) [b]
Second stage						
2SLS						
Cognitive skills	1.155	1.467	1.137	1.860	1.473	1.917
	(7.47)	(3.77)	(5.68)	(4.95)	(7.71)	(8.74)
Catholic share in 1970					0.061	-0.289
					(0.21)	(1.28)
Fuller(1) modification of LIML	1.155	1.452	1.221	1.841	1.485	1.907
Cognitive skills	(7.66)	(4.04)	(3.66)	(5.20)	(7.45)	(8.91)
No. of countries	29	30	37	47	50	80
First-stage F-statistic	17.00	5.70	6.60	4.58	9.61	21.86
Sargan statistic	0.030	0.179	1.111	0.941	1.540	0.017
p-value	(0.864)	(0.673)	(0.292)	(0.332)	(0.215)	(0.900)
Durbin-Wu-Haussman X^2 test	0.022	0.272	0.253	1.448	2.499	5.329
p-value	(0.883)	(0.602)	(0.615)	(0.229)	(0.114)	(0.021)
Cognitive skills measure						
Hanushek and Woessmann data	Yes	No	Yes	No	Yes	No
Altinok et al. data	No	Yes	No	Yes	No	Yes

Results II. IV-GMM results (part 2)

	(1)	(2)	(3)	(4)	(5)	(6) [a]
Second stage						
GMM						
Cognitive skills	1.913	1.898	2.012	1.986	1.938	1.866
	(9.74)	(9.09)	(5.47)	(5.06)	(11.03)	(5.82)
Fuller(1) modification of LIML	1.905	1.889	2.090	2.061	1.927	1.886
Cognitive skills	(9.87)	(9.24)	(5.60)	(5.19)	(11.08)	(5.99)
No. of countries	78	78	78	78	78	27
First-stage F-statistic	47.00	30.91	39.43	37.47	35.55	5.31
Sargan statistic			1.764	1.932	0.078	0.428
p-value			(0.184)	(0.165)	(0.780)	(0.513)
Durbin-Wu-Haussman X^2 test	3.900	2.960	0.666	0.497	7.089	0.580
p-value	(0.048)	(0.085)	(0.414)	(0.481)	(0.008)	(0.447)

Results II. Panel data estimation

	(1) [a]	(2)	(4) [b]	(6)	(7) [b]	(10) [e]
Trend in cognitive skills	0.042	0.035	0.037	0.032	0.036	0.029
	(3.21)	(3.68)	(3.83)	(1.71)	(1.79)	(1.46)
Average annual growth rate in GDP per capita 1975-2010		-0.067	-0.071		-0.019	-0.006
		(3.88)	(3.83)		(1.58)	(0.43)
No. of countries	14	14	14	32	32	32
R^2 (adj.)	0.412	0.625	0.645	0.140	0.201	0.310

Empirical strategy III. Sensitivity to sub-samples of countries

- We estimate our regressions for different subsamples in order to test for heterogeneity.
- Or low-income countries group includes both middle and low income countries.
- **Part 1.** We use baseline OLS estimation for each subsample:
  - The effect remains positive and significant in nearly all subsamples
  - The effect is higher for low-income countries group, suggesting a possible 'international learning skills convergence' hypothesis
- **Part 2.** In order to control for possible endogeneity and measurement errors, we also use an IV-GMM estimation
  - Panel B1. We use instruments previously presented like DALY, government effectiveness or EDR (early deaths rates)
  - Panels B2.B3. We employ additional instruments specific to low-income countries like Gini coefficients, drop-out rates.

Results III. Sensitivity to sub-samples of countries

	(1) All countries	(2) High Income Countries	(3) Low Income Countries	(4) Arab States & SSA	(5) Asian Countries	(6) Latin American Countries
A- OLS						
Cognitive skills	1.510	0.899	1.600	0.892	1.710	-0.062
	(10.50)	(7.68)	(8.18)	(2.96)	(16.22)	(0.23)
Adj. R^2 (Observations)	0.729	0.717	0.765	0.424	0.958	0.524
	(80)	(40)	(40)	(25)	(14)	(17)
B1- IV-GMM						
Cognitive skills	1.875	1.306	1.833	2.500	1.236	0.542
	(10.45)	(8.12)	(10.16)	(2.26)	(5.30)	(1.71)
F statistic (observations)	42.62	29.46	19.33	1.56	13.27	7.06
	(79)	(39)	(40)	(25)	(14)	(17)

Results III. Sensitivity to sub-samples of countries

	(1) All countries	(2) High Income Count.	(3) Low Income Count.	(4) Arab States & SSA	(5) Asian Countries	(6) Latin Ame. Count.
B2- IV-GMM						
Cognitive skills	2.051	1.225	2.074	1.886	1.650	1.497
	(9.80)	(7.11)	(9.87)	(4.20)	(6.19)	(2.43)
F statistic (observations)	27.51	13.76	9.45	6.87	4.97	1.97
	(74)	(35)	(35)	(25)	(11)	(17)
B3- IV-GMM						
Cognitive skills	1.994	1.254	2.064	1.965	1.743	0.423
	(10.12)	(7.70)	(10.69)	(4.57)	(7.42)	(2.08)
F statistic (observations)	27.80	21.23	11.17	6.28	4.79	4.36
	(73)	(34)	(39)	(25)	(11)	(17)

Empirical strategy IV. Elites or Education for All?

- We now focus not only on mean scores, but also on proportion of students reaching the advanced level and the minimum level of proficiency scores.
- We consider the advanced level as the threshold of 600 points (i.e. equivalent to the Level 5 in PISA mathematics study)
- We suppose that the minimum level is equal to approximately 400 (i.e. equivalent to the level 1 in PISA mathematics study)
- We follow the same steps as before
- Part 1. We use baseline OLS regression
- Part 2. We employ IV-GMM regression technique

Results IV. Elites or Education For All? (1/3)

	(1)	(2)	(3)	(7) [b]	(8) [c]	(9) [d]
Advanced level	6.070		4.186	3.064	1.829	2.346
	(9.25)		(5.64)	(2.63)	(1.32)	(2.09)
Minimum level		5.091	2.108	1.903	3.000	5.094
		(8.80)	(2.00)	(2.00)	(3.10)	(4.51)
Years of schooling 1960	0.259	0.197	0.164	0.177	0.151	0.198
	(3.04)	(3.06)	(2.42)	(2.50)	(2.46)	(1.43)
GDP pc 1960	-0.309	-0.317	-0.322	-0.325	-0.246	-0.342
	(7.38)	(7.74)	(8.13)	(7.21)	(6.43)	(1.25)
Observations	80	80	80	80	40	40
R-squared (adj.)	0.542	0.685	0.703	0.751	0.718	0.746

Results IV. Elites or Education For All? (2/3)

	(1) All countries	(2) High Income Countries	(3) Low Income Countries	(4) Arab States & SSA	(5) Asian Countries	(6) Latin American Countries	(7) Other countries
A- OLS							
Advanced level	2.108	1.889	2.346	-17.694	4.143	16.165	-2.712
	(2.00)	(1.32)	(2.09)	(1.62)	(2.98)	(1.84)	(2.02)
Minimum level	4.186	2.997	5.095	6.230	4.460	-3.537	3.665
	(5.64)	(3.10)	(4.51)	(2.77)	(3.15)	(2.31)	(1.35)
Adj. R^2 (Observations)	0.703	0.718	0.746	0.346	0.955	0.650	0.830
	(80)	(40)	(40)	(28)	(14)	(17)	(24)

Results IV. Elites or Education For All? (3/3)

	(1) All countries	(2) High Income Countries	(3) Low Income Countries	(4) Arab States & SSA	(5) Asian Countries	(6) Latin American Countries
B1- IV-GMM						
Advanced level	1.983	5.558	2.655	-51.739	-1.393	28.499
	(0.77)	(2.54)	(0.73)	(1.70)	(0.40)	(2.58)
Minimum level	6.412	2.322	7.939	13.396	10.514	-2.748
	(4.59)	(1.82)	(4.05)	(3.46)	(2.07)	(1.08)
F statistic (observations)	7.83	11.17	2.77	2.47	35.48	6.11
	(77)	(38)	(39)	(28)	(12)	(17)
F statistic (observations)	38.27	7.17	11.76	5.01	9.93	3.68
	(77)	(38)	(39)	(28)	(12)	(17)

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  i. While the quantity of schooling (measured as initial years of education) is not robust in our estimates, **coefficient associated with our updated cognitive skills variable is quite strong over most estimations**.
  ii. Our results show that **including more developing countries increases the overall impact of cognitive skills** on economic growth from 1.3 standard deviation to 1.5 standard deviation.
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  iv. In the panel data analysis, we find that the amplitude of cognitive skills on economic growth remains positive and significant for a larger sample of countries

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– We find five main results.

v. Lastly, the focus on the share of basic and top performers within each country highlights different effects between subsamples.

- While in **high income countries, the share of top performers** in student achievement tests has a strong and positive effect on economic growth,
- this is the **share of student reaching the minimum level which has the most important impact on economic growth for countries from Arab States and Sub-Saharan Africa**.
- Indeed, investing in the quality of education may enhance economic growth of countries, even if we take into account potential reversal causality issues, measurement error and omitted variable bias.