

## **Online Appendix**

# **The Value of Smarter Teachers: International Evidence on Teacher Cognitive Skills and Student Performance**

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## Online Appendix A

### Data Appendix

This electronic appendix provides additional information on the datasets and the construction of variables used in the empirical analysis. As in Section 3, we begin with a discussion of teacher cognitive skills, followed by a description of parent cognitive skills, student performance data, and further control variables.

#### *Teacher Cognitive Skills*

The target population of the Programme for the International Assessment of Adult Competencies (PIAAC) was the non-institutionalized population aged 16-65 years, and samples included at least 5,000 participants in each country.

We use 31 out of the 33 countries that participated in PIAAC in our analysis: Australia, Austria, Belgium (Flanders), Canada, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Poland, the Russian Federation, the Slovak Republic, Spain, Sweden, the United Kingdom (England and Northern Ireland), and the United States (Round 1, conducted between August 2011 and March 2012) as well as Chile, Greece, Indonesia, Israel, Lithuania, New Zealand, Singapore, Slovenia, and Turkey (Round 2, conducted between April 2014 and March 2015). Cyprus, while participating in PIAAC, did not participate in PISA. In Indonesia, the PIAAC survey was administered only to the population in Jakarta. According to OECD (2013), data for the Russian Federation are preliminary, may still be subject to change, and are not representative of the entire Russian population because they do not include the population of the Moscow municipal area. Our results are not sensitive to dropping the Russian Federation from the sample.

The survey provides rich information about demographic, educational, and occupational characteristics for each respondent. It was administered by trained interviewers either in the respondent's home or in a location agreed upon between the respondent and interviewer. The

standard survey mode was to answer questions on a computer, but respondents without computer experience could opt for a pencil-and-paper interview. On average across countries, 70 percent of the participants took the computer-based assessment and 30 percent took the paper-based assessment. A field test suggests no impact of assessment mode (OECD 2013).

After providing the background information, respondents took a battery of cognitive assessments. PIAAC assessments are designed to be valid cross-culturally and cross-nationally and to provide internationally comparable measures of adult skills. The assessments measure key cognitive and workplace skills needed to advance in the job and to participate in society in three domains: numeracy, literacy, and problem solving in technology-rich environments (or ICT skills). The test questions are often framed as real-world problems, such as maintaining a driver's logbook (numeracy domain) or selecting key information from a bibliographic search (literacy domain). PIAAC measures each of the skill domains on a 500-point scale.<sup>1</sup>

*Literacy* is defined as the “ability to understand, evaluate, use and engage with written texts to participate in society, to achieve one’s goals, and to develop one’s knowledge and potential,” and *numeracy* is the “ability to access, use, interpret, and communicate mathematical information and ideas in order to engage in and manage the mathematical demands of a range of situations in adult life” (see OECD (2013) for more details). Because of our focus on students’ reading and math performance, we do not use the PIAAC skills in the domain “problem solving in technology-rich environments” in the main analysis.<sup>2</sup>

In the PIAAC Public Use File, information on occupation is available only at the two-digit code in some countries (Germany, Ireland, Singapore, Sweden, and the United States), while a few other countries (Austria, Canada, Estonia, and Finland) do not publicly report any occupational code. For

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<sup>1</sup> PIAAC tests were conducted in the official language of the country of residence. In some countries, the assessment was also conducted in widely spoken minority or regional languages. Respondents could take as much time as needed to complete the assessment.

<sup>2</sup> Five countries surveyed in PIAAC (Cyprus, France, Indonesia, Italy, and Spain) did not administer tests in this optional skill domain.

this study, however, we gained access through the OECD to the four-digit ISCO-08 (International Standard Classification of Occupations) codes for all but two countries, which allows us to identify teachers in fine categories. For Australia and Finland, we only have two-digit occupational codes and are therefore unable to exclude pre-kindergarten teachers and university professors/vocational school teachers from our teacher sample. However, analysis of the countries where teachers are defined using the four-digit code indicates that teacher skills based on the four-digit code are very similar to those defined using the two-digit code: The correlation of both skill measures is 0.97 for numeracy and 0.95 for literacy. On average, numeracy (literacy) skills based on the two-digit code are only marginally higher (by 0.5 (0.1) PIAAC points) than the respective skills based on the four-digit codes. The average absolute value of these differences is only 2.1 points in numeracy and 1.9 points in literacy. Moreover, simultaneously excluding Australia and Finland from the analysis does not qualitatively change our results.

Because PIAAC is not a teacher survey, we benchmark the PIAAC teacher samples against large administrative datasets in which detailed occupational information allows identifying teachers. Using the 2011 U.S. American Community Survey (ACS) which includes 55,000 teachers and the 2011 German Micro Census which includes about 6,400 teachers, we find similar demographic characteristics compared to the respective national PIAAC teacher samples. In the U.S. teacher samples, mean age is 41.1 years in PIAAC (44.3 years in the ACS), 67.5% (75.5%) of teachers are female, and 89.9% (88.6%) of teachers have a college degree. In the German teacher samples, mean age is 47.2 years in PIAAC (45.6 years in the Micro Census), 65.8% (74.4%) of teachers are female, and 85.2% (82.2%) of teachers have a college degree.

### *Parent Cognitive Skills*

When estimating the numeracy and literacy skills of the PISA parents from the PIAAC micro data, we collapsed the original 8 categories of the PIAAC education variable into 3 categories so that the education categories in PIAAC and PISA would exactly match. The 6 categories of the number of books at home variable are identical in PIAAC and PISA, so this variable was not

modified. We use number of books at home in addition to educational degree, since this variable has been shown to be the single strongest predictor of student test scores (Woessmann (2003)). Sample sizes range from 1,074 adults in the Russian Federation to 11,933 adults in Canada with an average sample size of 2,693 adults per country (see Table EA-1 in Online Appendix C).

### *Student Performance and Further Control Variables*

The Programme for International Student Assessment (PISA) contains both multiple-choice and open-answer questions and provides internationally comparable test scores. The tests emphasize understanding as well as flexible and context-specific application of knowledge, and hence they do not test curriculum-specific knowledge.

We use the two PISA cycles of 2009 and 2012 because the students have largely been taught by the teacher cohorts tested between 2011 and 2015 in PIAAC. Student cohorts of earlier PISA cycles (2000, 2003, and 2006) have partially been taught by some PIAAC teachers, but teacher turnover would introduce additional error in the teacher skill measures for students in these earlier cycles. Another reason for combining PISA 2009 and 2012 is that students provide information about the instructional practices of their teachers only for the focus subject in each round of PISA testing: reading in 2009 and math in 2012. From the survey information, we can compute country-specific indicators of instructional practice for reading (based on PISA 2009) and for math (based on PISA 2012). These instructional-practice indicators capture subject-specific pedagogical skills of teachers, a potentially important confounding factor for teacher cognitive skills. Alternatively, the subject-specific pedagogical skills might also mediate the impact of teacher cognitive skills if teachers with high skills also use better instructional practices in class (see Section 5.3).

Student characteristics (e.g., gender and migration status) and information about parents (e.g., education, occupation, and number of books at home) come from student background questionnaires. We use estimated parent cognitive skills, number of books at home, parents' highest educational degree, and parental occupation to control for family background (see Table EA-2 for

summary statistics of student performance and student characteristics and Table EA-3 for family background controls).

Based on student information, we can construct measures of weekly instructional time for both language and math classes. Following Lavy (2015), we aggregate this information across students to the school level. Following Hanushek, Link, and Woessmann (2013), we also control for various school-level determinants of student performance. For example, school principals provide information on whether the school is public or private, city size, total number of students in the school, the lack of qualified math teachers and language teachers, and different types of autonomy (see Table EA-4).

Country characteristics include variables that are direct educational measures, namely, cumulative educational expenditure per student between age 6 and 15 and school starting age. We also check the robustness of our results to including further country controls, for instance, GDP per capita to capture international differences in the state of development (see Table EA-5).

To construct indicators of subject-specific instructional activities, we use information from the PISA students about their teachers' activities in language and math classes. We follow the OECD (2010a) approach of measuring specific instructional practices through survey responses of students, while we aggregate these instructional practices to the school level. For *reading*, we use the following items (each measured on a 4-point scale ranging from "never or hardly ever" to "in all lessons"): asking students to explain the meaning of a text; asking questions that challenge students to get a better understanding of a text; giving students enough time to think about their answers; recommending books or author to read; encouraging students to express their opinion about a text; helping students relate the stories they read to their lives; and showing students how the information in texts builds on what they already know. For *math*, we use the following items (each measured on a very similar 4-point scale ranging from "never or rarely" to "almost or almost always"): asking questions that make students reflect on the problem; giving problems that require students to think for an extended time; presenting problems in different contexts so that students know whether they

have understood the concepts; helping students to learn from mistakes they have made; asking students to explain how they have solved a problem; and presenting problems that require students to apply what they have learnt to new contexts. Since instructional practices are asked only for the subject that was the focus in the respective PISA cycle (reading in 2009 and math in 2012), we impute the subject-specific instructional-practice indicator for the PISA cycle when a subject was not the focus. We impute the instructional-practice indicator by using the country-level measure from the other PISA survey, assuming that the instructional practices in a subject have not noticeably changed within a country over the three-year period between 2009 and 2012.

## Online Appendix B

### Validation of PIAAC Cognitive Skills Data with External Sources

The PIAAC data on teacher cognitive skills raise two potential concerns. First, the teacher skill measures are derived from relatively small samples. Second, they rely on a new battery of achievement tests. In order to validate these measures, we compare them with estimates from larger national surveys in the United States and Germany.

We first look at the U.S. National Longitudinal Survey of Youth (NLSY79 and NLSY97). The NLSY79 is a nationally representative sample of 6,111 young men and women who were born between 1957 and 1964. The NLSY97 is a nationally representative sample of 6,748 individuals born between 1980 and 1984. (Note that these age cohorts partly overlap with the age cohorts of the PIAAC participants.) We measure NLSY79 respondents' occupation (using four-digit Census codes) in 2010 (last available year) and NLSY97 respondents' occupation in 2011 to make this sample as comparable as possible to the PIAAC survey in 2011.<sup>3</sup>

We take the mathematics and language skills tested in the four AFQT subtests which are part of the Armed Services Vocational Aptitude Battery (ASVAB). The ASVAB was administered to 94 percent of NLSY79 respondents in 1980 and to 81 percent of NLYS97 respondents in 1997. We combine the scores from the mathematical knowledge and arithmetic reasoning tests into a numeracy skills measure and the scores from the word knowledge and paragraph comprehension tests into a literacy skills measure.<sup>4</sup> Based on these measures, teacher skills fall at the 67th (64th) percentile in the adult skill distribution in numeracy (literacy). This is quite close to the position of

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<sup>3</sup> Teachers are defined as in PIAAC (i.e., excluding pre-kindergarten teachers and university professors/vocational education teachers). We weight individual-level observations with the cross-sectional weights taken from the year in which the occupation is measured, giving each NLSY survey the same total weight.

<sup>4</sup> As respondents were born in different years, we take out age effects by regressing test scores on year of birth dummies first (separately for NLSY79 and NYS97). We control for age effects in the NLSY data because participants were still children or adolescents at the time of testing. In contrast, we do not take out age effects in the PIAAC data because most PIAAC participants have already completed their education when tested.



teacher skills in the PIAAC data for the USA (see Table 1): 70th (71st) percentile in numeracy (literacy).

We also compare teacher cognitive skills from PIAAC with those from Germany's adult cohort of the National Educational Panel Study (NEPS).<sup>5</sup> This dataset is a nationally representative dataset of 9,352 adults born between 1944 and 1986. NEPS has several advantages for our purpose. First, similar to PIAAC, the competency tests in NEPS aim at measuring numeracy and literacy skills in real-life situations which are relevant for labor market success and participation in society. Second, NEPS tested skills at about the same time (in 2010/2011) as PIAAC did. Third, almost the same age cohorts were tested in NEPS and PIAAC. Similar to PIAAC, we keep all adults aged 25–65 and identify teachers based on the four-digit ISCO-88 occupation codes, where occupation is measured in 2010/2011. Teacher skills in NEPS fall at the 68th (76th) percentile among the adult skill distribution in numeracy (literacy). Again, this is similar to the respective positions of teachers in the PIAAC sample for Germany: 72th (74th) percentile in numeracy (literacy).

The similarity of teacher cognitive skills in the adult skill distribution found in PIAAC and in these nationally representative datasets with larger sample sizes supports using the PIAAC scores as measures of the teacher cognitive skills in each country.

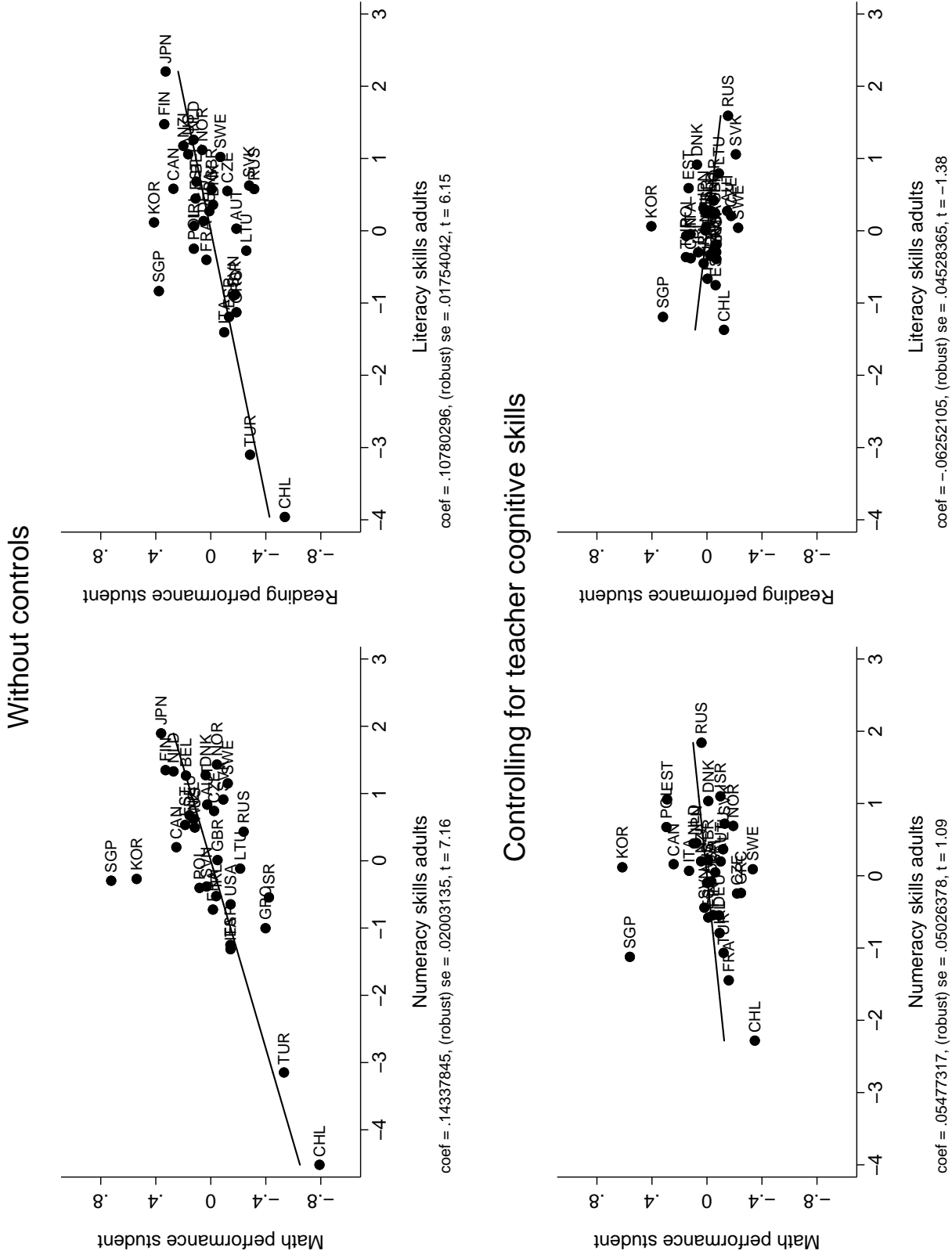
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<sup>5</sup> This paper uses data from the National Educational Panel Study (NEPS): Starting Cohort 6 – Adults, doi:10.5157/NEPS:SC6:3.0.1. From 2008 to 2013, NEPS data were collected as part of the Framework Programme for the Promotion of Empirical Educational Research funded by the German Federal Ministry of Education and Research (BMBF). As of 2014, the NEPS survey is carried out by the Leibniz Institute for Educational Trajectories (LifBi) at the University of Bamberg in cooperation with a nationwide network. See Blossfeld, Roßbach, and Maurice (2011).

# Online Appendix C

## Further Results

Figure EA-1: Student Performance and Adult Cognitive Skills



Note: The two graphs in the top panel do not include any controls. The two graphs in the bottom panel are added-variable plots that control for country-level teacher skills in numeracy and literacy, respectively. Data sources: PIAAC (2012, 2015) and PISA (2009, 2012).

Table EA-1: Summary Statistics for Parent Cognitive Skills

	Pooled	Australia	Austria	Belgium	Canada	Chile	Czech R.	Denmark	Estonia	Finland	France
						<b>Numeracy</b>					
Mean	278	287	291	301	282	223	276	293	276	299	275
Std. Dev.	29	21	22	22	20	30	27	21	16	18	26
Max – Min	115	128	140	108	120	139	109	141	87	102	132
						<b>Literacy</b>					
Mean	275	293	279	289	284	226	270	278	272	297	272
Std. Dev.	26	19	20	20	18	23	24	20	16	17	21
Max – Min	101	113	111	96	116	105	98	148	95	101	106
Observations	83,492	3,137	2,231	2,251	11,933	2,165	2,105	3,352	3,463	2,252	3,086
						<b>Numeracy</b>					
	Germany	Greece	Ireland	Israel	Italy	Japan	Korea	Lithuania	Netherl.	New Zealand	Norway
Mean	289	273	275	267	267	308	276	277	295	284	297
Std. Dev.	21	19	22	25	19	14	17	20	22	22	23
Max – Min	126	77	96	132	104	50	85	65	120	134	192
						<b>Literacy</b>					
Mean	279	268	280	260	264	307	281	271	293	288	290
Std. Dev.	19	16	18	23	16	12	15	13	21	19	19
Max – Min	109	75	86	117	86	44	76	46	109	109	162
Observations	2,293	2,128	2,371	1,882	1,789	2,103	3,361	2,364	2,276	2,504	2,228
						<b>Numeracy</b>					
	Poland	Russia	Singapore	Slovak R.	Slovenia	Spain	Sweden	Turkey	U.K.	U.S.	
Mean	264	271	261	281	268	265	295	240	281	267	
Std. Dev.	19	8	39	23	24	22	25	27	20	32	
Max – Min	103	32	149	139	149	94	174	100	109	135	
						<b>Literacy</b>					
Mean	267	277	253	275	261	266	290	237	285	277	
Std. Dev.	19	19	31	17	22	21	23	19	18	27	
Max – Min	92	35	116	129	120	87	156	69	95	122	
Observations	1,793	1,074	2,119	2,442	2,435	2,614	1,864	2,319	3,578	1,980	

*Notes:* Summary statistics of parents' cognitive skills (average skill of mother and father) based on actual parents of PISA students. See text for computation of parent cognitive skills. *Max-Min* indicates the difference between the maximum and minimum parent cognitive skills within a country. *Observations* refer to the number of adults in the PIAAC samples used for computing parents' skills. *Data sources:* PIAAC (2012, 2015) and PISA (2009, 2012).

Table EA-2: Summary Statistics for Student Performance and Student Characteristics

	Pooled	Australia	Austria	Belgium	Canada	Chile	Czech R.	Denmark	Estonia	Finland	France
Math performance	498 (97)	509 (95)	500 (94)	515 (103)	522 (88)	422 (80)	496 (94)	502 (84)	516 (81)	530 (85)	496 (100)
Reading performance	497 (97)	513 (98)	480 (96)	508 (102)	524 (91)	445 (81)	486 (91)	496 (84)	508 (82)	530 (91)	501 (108)
Age (in years)	15.8	15.8	15.8	15.8	15.8	15.8	15.8	15.7	15.8	15.7	15.9
Female	0.49	0.50	0.51	0.49	0.50	0.50	0.48	0.50	0.49	0.49	0.51
First-gen. migrant	0.06	0.12	0.06	0.09	0.13	0.01	0.02	0.04	0.01	0.02	0.05
Second-gen. migrant	0.05	0.12	0.11	0.08	0.15	0.00	0.01	0.06	0.07	0.01	0.10
Other language	0.09	0.09	0.11	0.22	0.16	0.01	0.02	0.05	0.04	0.04	0.08
Observations	490,818	28,732	11,345	17,098	44,751	12,525	11,391	13,405	9,506	14,639	8,911
	Germany	Greece	Ireland	Israel	Italy	Japan	Korea	Lithuania	Netherl.	New Zealand	Norway
Math performance	513 (97)	459 (89)	494 (86)	457 (105)	484 (93)	533 (94)	550 (94)	477 (88)	524 (90)	510 (99)	494 (88)
Reading performance	503 (93)	479 (97)	509 (92)	480 (113)	488 (96)	529 (100)	537 (83)	473 (87)	510 (91)	517 (104)	503 (96)
Age (in years)	15.8	15.7	15.7	15.7	15.7	15.8	15.7	15.8	15.7	15.8	15.8
Female	0.49	0.51	0.49	0.51	0.48	0.48	0.47	0.49	0.50	0.49	0.49
First-gen. migrant	0.05	0.07	0.12	0.07	0.06	0.00	0.00	0.01	0.04	0.19	0.05
Second-gen. migrant	0.11	0.04	0.02	0.12	0.02	0.00	0.00	0.01	0.08	0.09	0.04
Other language	0.09	0.05	0.05	0.11	0.14	0.00	0.00	0.04	0.06	0.15	0.07
Observations	9,980	10,094	8,953	10,816	61,978	12,439	10,022	9,146	9,220	8,934	9,346
	Poland	Russia	Slovak R.	Slovenia	Spain	Sweden	Turkey	U.S.			
Math performance	506 (90)	475 (86)	489 (99)	568 (105)	484 (89)	501 (93)	484 (89)	486 (93)	447 (92)	493 (91)	484 (90)
Reading performance	509 (89)	467 (90)	470 (98)	534 (100)	485 (90)	482 (91)	485 (90)	491 (103)	470 (84)	497 (96)	498 (94)
Age (in years)	15.7	15.8	15.8	15.8	15.8	15.7	15.9	15.7	15.8	15.7	15.8
Female	0.51	0.50	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.51	0.49
First-gen. migrant	0.00	0.05	0.05	0.12	0.01	0.03	0.10	0.06	0.00	0.07	0.07
Second-gen. migrant	0.00	0.07	0.00	0.05	0.00	0.06	0.01	0.08	0.01	0.05	0.13
Other language	0.01	0.09	0.06	0.57	0.18	0.06	0.18	0.09	0.05	0.07	0.14
Observations	9,524	10,539	9,233	10,829	51,200	12,066	9,303	9,303	9,844	24,838	10,211

Notes: Means and standard deviations (in parentheses) reported. *Other language* indicates a student who speaks a foreign language at home. *Observations* refer to the number of students in both PISA cycles. Statistics are based on student-level observations weighted with inverse sampling probabilities, giving each PISA cycle the same total weight. *Data sources*: PISA (2009, 2012).

Table EA-3: Summary Statistics for Parent Characteristics

	Pooled	Australia	Austria	Belgium	Canada	Chile	Czech R.	Denmark	Estonia	Finland	France
<b>Number of books at home</b>											
0-10 books	0.13	0.09	0.13	0.16	0.10	0.23	0.10	0.13	0.07	0.07	0.16
11-25 books	0.16	0.12	0.16	0.17	0.14	0.29	0.14	0.16	0.14	0.12	0.17
26-100 books	0.32	0.30	0.31	0.29	0.31	0.31	0.35	0.32	0.31	0.34	0.29
101-200 books	0.18	0.21	0.17	0.17	0.21	0.10	0.19	0.18	0.21	0.22	0.17
201-500 books	0.14	0.18	0.14	0.13	0.16	0.05	0.15	0.14	0.17	0.18	0.13
More than 500 books	0.08	0.10	0.09	0.08	0.08	0.02	0.07	0.07	0.09	0.06	0.07
<b>Highest educational degree</b>											
ISCED 0	0.01	0.00	0.00	0.01	0.00	0.02	0.00	0.00	0.00	0.00	0.01
ISCED 1	0.02	0.01	0.01	0.02	0.01	0.03	0.00	0.01	0.00	0.01	0.01
ISCED 2	0.06	0.05	0.04	0.03	0.02	0.18	0.01	0.05	0.03	0.02	0.09
ISCED 3B,C	0.09	0.07	0.29	0.05	0.00	0.00	0.18	0.13	0.02	0.08	0.19
ISCED 3A,4	0.29	0.32	0.18	0.28	0.25	0.43	0.49	0.15	0.38	0.09	0.19
ISCED 5B	0.19	0.13	0.28	0.22	0.24	0.12	0.09	0.41	0.22	0.27	0.22
ISCED 5A,6	0.34	0.42	0.20	0.40	0.48	0.22	0.23	0.24	0.35	0.53	0.30
<b>Highest occupational status</b>											
Blue collar-low skilled	0.07	0.05	0.05	0.09	0.06	0.16	0.07	0.05	0.06	0.03	0.07
Blue collar-high skilled	0.11	0.08	0.14	0.10	0.07	0.17	0.13	0.07	0.14	0.07	0.11
White collar-low skilled	0.24	0.17	0.26	0.23	0.21	0.28	0.27	0.25	0.23	0.20	0.26
White collar-high skilled	0.56	0.68	0.53	0.56	0.64	0.34	0.52	0.62	0.55	0.69	0.54

Table EA-3: Summary Statistics for Parent Characteristics (continued)

	Germany	Greece	Ireland	Israel	Italy	Japan	Korea	Lithuania	Netherl.	New Zealand	Norway
<b>Number of books at home</b>											
0-10 books	0.11	0.11	0.14	0.12	0.12	0.09	0.05	0.16	0.16	0.10	0.08
11-25 books	0.13	0.20	0.15	0.17	0.19	0.13	0.09	0.20	0.18	0.13	0.11
26-100 books	0.10	0.08	0.07	0.12	0.08	0.09	0.10	0.05	0.07	0.09	0.11
101-200 books	0.29	0.32	0.30	0.30	0.30	0.35	0.29	0.33	0.30	0.31	0.30
201-500 books	0.20	0.17	0.19	0.17	0.18	0.19	0.23	0.15	0.15	0.21	0.22
More than 500 books	0.17	0.12	0.15	0.13	0.13	0.15	0.24	0.10	0.13	0.17	0.19
<b>Highest educational degree</b>											
ISCED 0	0.02	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00
ISCED 1	0.00	0.03	0.02	0.01	0.01	0.00	0.01	0.00	0.02	0.01	0.00
ISCED 2	0.15	0.09	0.07	0.03	0.21	0.02	0.04	0.01	0.04	0.06	0.02
ISCED 3B,C	0.12	0.02	0.02	0.09	0.06	0.06	0.07	0.01	0.00	0.16	0.03
ISCED 3A,4	0.23	0.34	0.35	0.26	0.37	0.30	0.34	0.37	0.32	0.25	0.25
ISCED 5B	0.18	0.14	0.18	0.16	0.07	0.15	0.06	0.19	0.39	0.15	0.39
ISCED 5A,6	0.30	0.37	0.35	0.44	0.28	0.47	0.48	0.41	0.21	0.37	0.30
<b>Highest occupational status</b>											
Blue collar-low skilled	0.06	0.08	0.05	0.07	0.07	0.07	0.04	0.08	0.04	0.07	0.03
Blue collar-high skilled	0.10	0.14	0.09	0.06	0.17	0.08	0.06	0.18	0.06	0.07	0.04
White collar-low skilled	0.29	0.24	0.26	0.15	0.28	0.36	0.29	0.22	0.20	0.18	0.16
White collar-high skilled	0.53	0.51	0.58	0.68	0.45	0.48	0.59	0.49	0.68	0.66	0.75

Table EA-3: Summary Statistics for Parent Characteristics (continued)

	Poland	Russia	Singapore	Slovak R.	Slovenia	Spain	Sweden	Turkey	U.K.	U.S.
<b>Number of books at home</b>										
0-10 books	0.11	0.09	0.11	0.15	0.14	0.09	0.09	0.26	0.14	0.21
11-25 books	0.20	0.19	0.19	0.17	0.20	0.15	0.11	0.26	0.16	0.18
26-100 books	0.07	0.08	0.05	0.05	0.06	0.09	0.11	0.03	0.08	0.05
101-300 books	0.34	0.34	0.36	0.37	0.35	0.32	0.30	0.28	0.29	0.29
301-500 books	0.17	0.17	0.17	0.17	0.15	0.21	0.20	0.11	0.18	0.15
More than 500 books	0.11	0.13	0.12	0.10	0.10	0.15	0.19	0.06	0.15	0.11
<b>Highest educational degree</b>										
ISCED 0	0.00	0.00	0.01	0.00	0.00	0.02	0.01	0.04	0.00	0.01
ISCED 1	0.00	0.00	0.05	0.00	0.00	0.07	0.01	0.32	0.00	0.02
ISCED 2	0.01	0.05	0.02	0.04	0.18	0.04	0.24	0.03	0.05	
ISCED 3B,C	0.39	0.01	0.00	0.14	0.35	0.02	0.07	0.02	0.20	0.00
ISCED 3A,4	0.33	0.08	0.44	0.54	0.19	0.25	0.18	0.17	0.18	0.34
ISCED 5B	0.00	0.44	0.19	0.06	0.16	0.14	0.21	0.08	0.23	0.15
ISCED 5A,6	0.24	0.46	0.27	0.23	0.25	0.33	0.48	0.14	0.36	0.43
<b>Highest occupational status</b>										
Blue collar-low skilled	0.07	0.06	0.06	0.11	0.07	0.09	0.05	0.14	0.05	0.07
Blue collar-high skilled	0.27	0.11	0.04	0.16	0.14	0.18	0.05	0.25	0.05	0.06
White collar-low skilled	0.23	0.26	0.21	0.31	0.24	0.29	0.24	0.25	0.26	0.21
White collar-high skilled	0.43	0.54	0.67	0.40	0.53	0.43	0.65	0.28	0.62	0.64

Notes: Shares reported. Statistics are based on student-level observations weighted with inverse sampling probabilities, giving each PISA cycle the same total weight. Highest educational degree includes the following categories: ISCED 0: no educational degree; ISCED 1: primary education; ISCED 2: lower secondary; ISCED 3B,C: vocational/pre-vocational upper secondary; ISCED 3A,4: upper secondary or non-tertiary post-secondary; ISCED 5B: vocational tertiary; and ISCED 5A,6: theoretically oriented tertiary and post-graduate. Data sources: PISA (2009, 2012).



**Table EA-4: Summary Statistics for School Characteristics**

	Pooled	Australia	Austria	Belgium	Canada	Chile	Czech R.	Denmark	Estonia	Finland	France
Instructional time math	3.6	4.0	2.6	3.5	5.3	5.8	3.1	3.7	3.7	2.9	3.5
Instructional time reading	3.6	3.9	2.4	3.6	5.4	5.7	3.0	5.2	3.3	2.5	3.7
Shortage math teachers	1.52	1.89	1.33	1.92	1.44	2.05	1.25	1.23	1.45	1.16	1.35
Shortage language teachers	1.42	1.53	1.36	1.54	1.26	1.82	1.12	1.17	1.30	1.10	1.36
Private school	0.19	0.41	0.11	0.69	0.08	0.61	0.06	0.24	0.04	0.04	0.20
Students per school	735	981	559	718	1032	1013	450	480	557	429	821
Content autonomy	0.64	0.71	0.58	0.56	0.37	0.67	0.88	0.68	0.77	0.64	0.64
Personnel autonomy	0.42	0.39	0.08	0.38	0.30	0.63	0.88	0.58	0.54	0.24	0.06
Budget autonomy	0.82	0.93	0.86	0.69	0.75	0.78	0.79	0.96	0.84	0.92	0.97
	Germany	Greece	Ireland	Israel	Italy	Japan	Korea	Lithuania	Netherl.	New Zealand	Norway
Instructional time math	3.3	3.4	3.1	4.3	3.8	3.9	3.6	2.9	2.8	4.0	3.2
Instructional time reading	3.1	3.0	3.0	3.4	4.7	3.5	3.5	3.4	2.8	4.1	3.8
Shortage math teachers	1.78	1.13	1.40	1.90	1.69	1.27	1.57	1.14	2.10	1.72	1.73
Shortage language teachers	1.46	1.20	1.16	1.96	1.64	1.21	1.57	1.14	1.74	1.40	1.70
Private school	0.06	0.06	0.60	0.09	0.06	0.30	0.42	0.01	0.67	0.06	0.02
Students per school	702	283	593	770	752	750	1116	593	1023	1178	340
Content autonomy	0.63	0.04	0.69	0.53	0.72	0.92	0.89	0.80	0.93	0.88	0.49
Personnel autonomy	0.15	0.03	0.34	0.39	0.05	0.32	0.23	0.65	0.89	0.55	0.42
Budget autonomy	0.88	0.84	0.87	0.69	0.84	0.90	0.85	0.59	0.99	0.99	0.88
	Poland	Russia	Singapore	Slovak R.	Slovenia	Spain	Sweden	Turkey	U.K.	U.S.	
Instructional time math	3.4	3.6	5.4	3.0	2.7	3.5	3.1	2.9	3.7	4.3	
Instructional time reading	3.7	3.1	4.3	3.0	2.9	3.4	3.0	3.6	3.8	4.4	
Shortage math teachers	1.03	1.71	1.35	1.13	1.12	1.09	1.35	2.73	1.64	1.37	
Shortage language teachers	1.01	1.63	1.95	1.10	1.06	1.08	1.19	2.64	1.38	1.20	
Private school	0.03	0.00	0.02	0.09	0.03	0.33	0.12	0.01	0.26	0.08	
Students per school	324	566	1367	480	462	701	420	890	1062	1381	
Content autonomy	0.75	0.59	0.63	0.59	0.45	0.53	0.63	0.20	0.89	0.48	
Personnel autonomy	0.46	0.65	0.10	0.70	0.51	0.18	0.72	0.02	0.75	0.66	
Budget autonomy	0.26	0.58	0.89	0.72	0.79	0.94	0.93	0.77	0.96	0.76	

*Notes:* Country means reported. Student-level information on *instructional time* (hours per week) is aggregated to the school level for both math and reading (see also Lavy (2015)). *Shortage math/language teachers* is based on the following school principal question: "Is your school's capacity to provide instruction hindered by any of the following issues? A lack of qualified mathematics/test language teachers" Possible answer categories are: not at all (1), very little (2), to some extent (3), a lot (4). School autonomy measures are binary. *Data sources:* PISA (2009, 2012).

**Table EA-5: Summary Statistics for Country Characteristics**

	Pooled	Australia	Austria	Belgium	Canada	Chile	Czech R.	Denmark	Estonia	Finland	France
Expenditure per student	70.79	85.21	107.20	88.64	80.42	27.92	49.64	98.69	49.28	78.81	79.12
School starting age	6.12	5	6	6	5	6	6	7	7	7	6
Instruction practice math	0.61	0.66	0.57	0.56	0.70	0.67	0.62	0.64	0.59	0.58	0.59
Instruction practice reading	0.50	0.53	0.41	0.43	0.56	0.53	0.44	0.57	0.50	0.37	0.52
GDP per capita	35.34	41.43	43.24	39.78	40.45	18.80	27.87	41.93	23.06	38.99	36.13
Teacher gross hourly wage	18.9	21.4	19.6	23.6	26.6	14.2	9.4	22.9	9.1	22.6	21.1
Teacher performance pay	0.59	0	1	0	0	1	1	1	1	1	0
Central exit exams	0.70	1.0	0.0	0.0	0.7	0.0	0.5	1.0	1.0	1.0	1.0
	Germany	Greece	Ireland	Israel	Italy	Japan	Korea	Lithuania	Netherl.	New Zealand	Norway
Expenditure per student	72.05	53.29	84.52	55.17	80.86	83.70	65.07	41.20	87.71	59.64	112.43
School starting age	6	6	4	6	6	6	6	7	6	5	6
Instruction practice math	0.64	0.62	0.69	0.69	0.59	0.46	0.38	0.63	0.57	0.66	0.52
Instruction practice reading	0.44	0.49	0.51	0.40	0.49	0.44	0.34	0.58	0.37	0.53	0.37
GDP per capita	40.36	28.32	43.96	29.78	35.02	33.80	30.31	21.38	45.42	31.89	60.78
Teacher gross hourly wage	26.7	18.8	35.7	14.7	23.0	18.4	25.0	11.0	22.3	19.8	23.6
Teacher performance pay	0	0	0	0	0	0	0	.	1	1	1
Central exit exams	0.9	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Poland	Russia	Singapore	Slovak R.	Slovenia	Spain	Sweden	Turkey	U.K.	U.S.	
Expenditure per student	48.80	13.29	78.15	42.68	84.84	78.15	89.29	16.26	91.46	110.86	
School starting age	7	7	7	6	6	6	7	7	7	5	6
Instruction practice math	0.60	0.69	0.70	0.54	0.56	0.64	0.51	0.59	0.73	0.72	
Instruction practice reading	0.59	0.80	0.47	0.47	0.56	0.44	0.42	0.64	0.54	0.61	
GDP per capita	21.37	22.35	69.37	24.63	27.99	32.52	42.05	16.55	36.97	49.22	
Teacher gross hourly wage	12.8	4.7	22.4	8.6	11.7	19.8	16.4	19.7	21.2	20.0	
Teacher performance pay	1	1	.	1	1	0	1	1	1	1	
Central exit exams	1.0	.	.	1.0	1.0	0.0	0.0	0.0	1.0	0.1	

*Notes:* Expenditure per student and GDP per capita are expressed in 1,000 PPP-US\$. The *instruction practice* indicators are based on student information provided in PISA; in 2009 for language teachers and in 2012 for math teachers. See text for details on the construction of the instruction practice indicators. *Teacher performance pay* is a binary variable, taking the value 1 if salary adjustments are awarded to teachers with outstanding performance in teaching in a country; not available for Lithuania and Singapore. *Central exit exams* equals 1 if central exam examinations exist on the upper secondary level (ISCED 3) in a country, 0 otherwise; data are taken from Leschnig, Schwerdt, and Zigova (2016). Information on central exit exams is not available for the Russian Federation and Singapore. The remaining country characteristics come from OECD statistics. *Data sources:* Leschnig, Schwerdt, and Zigova (2016), OECD, PISA (2009, 2012).

**Table EA-6: Student Performance and Teacher Cognitive Skills from OLS  
Estimation: Results on Covariates not Reported in Table 2**

Dependent variable: student performance	Math	Reading
<b>Student characteristics</b>		
Age	0.137*** (0.018)	0.137*** (0.012)
Female	-0.145*** (0.011)	0.358*** (0.015)
First-generation migrant	-0.107*** (0.038)	-0.103** (0.038)
Second-generation migrant	-0.086** (0.035)	-0.021 (0.034)
Other language at home	-0.056* (0.029)	-0.179*** (0.031)
<b>Family background</b>		
Books at home		
11-25 books	0.186*** (0.021)	0.226*** (0.021)
26-100 books	0.420*** (0.033)	0.467*** (0.034)
101-200 books	0.588*** (0.043)	0.647*** (0.044)
201-500 books	0.776*** (0.049)	0.822*** (0.053)
More than 500 books	0.775*** (0.053)	0.801*** (0.059)
Parental education		
ISCED 1	0.175*** (0.042)	0.219*** (0.042)
ISCED 2	0.090 (0.065)	0.137** (0.054)
ISCED 3B,C	0.254*** (0.069)	0.242*** (0.060)
ISCED 3A, 4	0.249*** (0.062)	0.270*** (0.055)
ISCED 5B	0.169* (0.089)	0.244*** (0.074)
ISCED 5A, 6	0.261*** (0.085)	0.330*** (0.067)
Parental occupation		
Blue collar-high skilled	0.119*** (0.015)	0.097*** (0.018)
White collar-low skilled	0.190*** (0.016)	0.184*** (0.019)
White collar-high skilled	0.403*** (0.018)	0.405*** (0.020)

(continued on next page)

**Table EA-6 (continued)**

Dependent variable: student performance	Math	Reading
<b>School characteristics</b>		
School location		
Small Town	-0.008 (0.032)	0.019 (0.028)
Town	0.014 (0.042)	0.057 (0.035)
City	0.014 (0.040)	0.079** (0.034)
Large City	0.080* (0.045)	0.129*** (0.043)
Private school	0.140*** (0.038)	0.159*** (0.031)
No. students per school (in 1000)	0.281*** (0.062)	0.255*** (0.052)
School autonomy		
Content autonomy	0.069 (0.051)	0.002 (0.032)
Personnel autonomy	-0.148*** (0.048)	-0.167*** (0.031)
Budget autonomy	0.020 (0.039)	0.048 (0.036)
Shortage math teacher	-0.048*** (0.012)	
Shortage language teacher		-0.032** (0.013)
Weekly hours math classes	0.057** (0.027)	
Weekly hours language classes		-0.001 (0.018)
<b>Country-level measures</b>		
Educational expenditure per student	-0.000 (0.001)	0.000 (0.001)
School starting age	0.139*** (0.049)	0.080* (0.041)
Students	490,818	490,818
Countries	31	31
Adj. R2	0.29	0.30

*Notes:* The table reports results on all further covariates of the ordinary least squares estimations with the full set of control variables, corresponding to Column 3 (math) and Column 6 (reading) in Table 2. Omitted categories of family background and school characteristics: *0-10 books*; *parents have no educational degree*; *blue collar-low skilled*; and *village*. Significance levels: \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ . *Data sources:* OECD, PIAAC (2012, 2015), and PISA (2009, 2012).

**Table EA-7: Student Performance and Teacher Cognitive Skills (Heterogeneity)**

Panel A: Student Math Performance		Gender		Parental background		Migration background	
		Boys	Girls	High SES	Low SES	Natives	Migrants
Teacher cognitive skills	0.135*** (0.032)	0.155*** (0.032)	0.137*** (0.032)	0.144*** (0.033)	0.140*** (0.034)	0.107** (0.045)	
Parent cognitive skills	0.046*** (0.016)	0.040** (0.019)	0.079*** (0.020)	0.025 (0.019)	0.049** (0.018)	0.061** (0.026)	
Panel B: Student Reading Performance							
Teacher cognitive skills	0.081*** (0.021)	0.103*** (0.025)	0.068*** (0.024)	0.112*** (0.024)	0.082*** (0.023)	0.070* (0.038)	
Parent cognitive skills	0.016 (0.015)	0.013 (0.018)	0.052** (0.025)	0.004 (0.015)	0.022 (0.018)	0.017 (0.023)	
Students	246,649	244,169	250,954	239,864	424,419	24,232	
Countries	31	31	31	31	31	30	
Additional controls in Panels A + B							
Student characteristics	X	X	X	X	X	X	X
Parent characteristics	X	X	X	X	X	X	X
School characteristics	X	X	X	X	X	X	X
Country characteristics	X	X	X	X	X	X	X

*Notes:* Dependent variable: standardized student PISA test score in math (Panel A) and reading (Panel B), respectively. Parental background is measured by the PISA index of economic, social and cultural status (ESCS). This index captures a range of aspects of a student's family and home background that combines information on parents' education, occupations, and home possessions. Migrants refer to second-generation migrants. To account for the unequal distribution of migrants across countries, we re-weight regressions based on the sample of natives and migrants, respectively, giving equal weight to each country within each subsample. Korea has no second-generation migrants in the PISA sample and is therefore excluded. All cognitive skill measures in Panel A (Panel B) refer to numeracy (literacy). Student, parent, school, and country characteristics are the same as in the least squares models (see Table 2). All regressions include controls for respective imputation dummies and a dummy indicating the PISA wave. Specifications give equal weight to each country. Robust standard errors, adjusted for clustering at the country level, in parentheses. Significance levels: \* p<0.10, \*\* p<0.05, \*\*\* p<0.01. *Data sources:* OECD, PIAAC (2012, 2015), and PISA (2009, 2012).

**Table EA-8: Where Teachers Need to Be Drawn From to Get to the Skill Level of Finnish Teachers?**

	Numeracy			Literacy		
	Current position	Position to reach	Difference	Current position	Position to reach	Difference
	teachers	Finnish teachers		teachers	Finnish teachers	
(1)	(2)	(3)	(4)	(5)	(6)	
Australia	55	69	14	56	66	10
Austria	44	59	15	45	76	31
Belgium	48	56	8	47	68	21
Canada	55	73	18	62	74	12
Chile	60	92	32	59	93	34
Czech R.	45	55	10	46	72	26
Denmark	42	61	19	44	78	34
Estonia	45	75	30	53	79	26
Finland	59	59	0	60	60	0
France	54	69	15	50	77	27
Germany	55	61	6	56	76	20
Greece	52	80	28	60	87	27
Ireland	58	77	19	57	78	21
Israel	44	77	33	54	85	31
Italy	42	79	37	46	84	38
Japan	53	60	7	56	58	2
Korea	52	82	30	55	83	28
Lithuania	41	70	29	45	85	40
Netherlands	46	58	12	46	61	15
New Zealand	53	69	16	58	70	12
Norway	44	58	14	50	68	18
Poland	38	74	36	45	72	27
Russia	49	87	38	54	85	31
Singapore	55	69	14	60	81	21
Slovak R.	38	61	23	44	80	36
Slovenia	50	72	22	51	84	33
Spain	54	85	31	56	85	29
Sweden	47	55	8	50	63	13
Turkey	50	89	39	53	97	44
U.K.	51	73	22	54	74	20
U.S.	47	74	27	51	71	20

*Notes:* Position refers to percentile in cognitive skill distribution of college educated. *Data sources:* PIAAC (2012, 2015).

**Table EA-9: Student Performance and Position of Teachers in Adult Cognitive Skill Distribution (OLS)**

	Student Math Performance			Student Reading Performance		
	(1)	(2)	(3)	(4)	(5)	(6)
Position of teacher skills	0.015*** (0.005)	0.014*** (0.005)	0.013*** (0.005)	0.020*** (0.005)	0.014*** (0.004)	0.013*** (0.004)
Parent cognitive skills			0.029** (0.012)			0.026* (0.014)
Adult cognitive skills (country level)	0.184*** (0.022)	0.159*** (0.025)	0.140*** (0.026)	0.149*** (0.017)	0.083*** (0.020)	0.067*** (0.021)
Student characteristics		X	X		X	X
Parent characteristics		X	X		X	X
School characteristics		X	X		X	X
Country characteristics		X	X		X	X
Students	490,818	490,818	490,818	490,818	490,818	490,818
Countries	31	31	31	31	31	31
Adj. R2	0.04	0.29	0.29	0.03	0.30	0.30

*Notes:* Least squares regressions weighted by students' inverse sampling probability, giving each country the same weight. Dependent variable: student PISA test score in math (Columns 1–3) and in reading (Columns 4–6), respectively. Student test scores are z-standardized at the individual level across countries. *Position of teacher skills* is the country-specific percentile rank of teacher cognitive skills in the cognitive skill distribution all adults aged 25–65 years. Position of teacher skills, parent skills, and country-level adult skills refer to numeracy in Columns 1–3 and to literacy in Columns 4–6. Parent skills and country-level adult skills use teacher skills as “numeraire” scale. Control variables are the same as in the baseline least squares models (see Table 2). Robust standard errors, adjusted for clustering at the country level, in parentheses. Significance levels: \* p<0.10, \*\* p<0.05, \*\*\* p<0.01. *Data sources:* OECD, PIAAC (2012, 2015), and PISA (2009, 2012).

Table EA-10: Student Performance and Teacher Cognitive Skills: Including Additional Country Controls

	Student Math Performance					Student Reading Performance				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Teacher cognitive skills	0.145*** (0.032)	0.147*** (0.033)	0.134*** (0.030)	0.108*** (0.029)	0.123*** (0.028)	0.092*** (0.022)	0.101*** (0.023)	0.080*** (0.024)	0.070*** (0.021)	0.084*** (0.022)
Parent cognitive skills	0.044** (0.017)	0.045** (0.017)	0.047** (0.017)	0.052*** (0.014)	0.053*** (0.014)	0.015 (0.016)	0.012 (0.014)	0.022 (0.015)	0.032* (0.017)	0.026* (0.014)
Instructional practices		0.191 (0.191)			0.104 (0.164)		0.291 (0.211)			0.593*** (0.156)
GDP per capita (1,000 PPP-\$ )			0.003 (0.004)		-0.008** (0.003)			0.003 (0.003)		0.004* (0.002)
Central exit exams				0.167*** (0.056)	0.166*** (0.051)				0.095** (0.036)	0.095*** (0.034)
Student characteristics	X	X	X	X	X	X	X	X	X	X
Parent characteristics	X	X	X	X	X	X	X	X	X	X
School characteristics	X	X	X	X	X	X	X	X	X	X
Country characteristics	X	X	X	X	X	X	X	X	X	X
Students	490,818	490,818	490,818	469,450	469,450	490,818	490,818	490,818	469,450	469,450
Countries	31	31	31	29	29	31	31	31	29	29
Adj. R2	0.29	0.29	0.29	0.29	0.29	0.30	0.30	0.30	0.30	0.31

Notes: Dependent variable: standardized student PISA test score in math (Columns 1–5) and reading (Columns 6–10), respectively. Teacher and parent cognitive skills in Columns 1–5 (6–10) refer to numeracy (literacy). Columns 1 and 6 replicate the baseline models from Columns 3 and 6 in Table 2. Indicator for teacher instructional practices is based on the PISA data. See text for details on the construction of the instructional practices indicator. *Central exit exams* takes the value 1 if central exam examinations exist on the upper secondary level (ISCED 3) in a country; data are taken from Leschnig, Schwerdt, and Zigova (2016). Information on central exit exams is not available for the Russian Federation and Singapore. Student, parent, school, and country characteristics are the same as in the baseline least squares models (see Table 2). All regressions include controls for imputation dummies and the PISA wave. Specifications give equal weight to each country. Robust standard errors, adjusted for clustering at the country level, in parentheses. Significance levels: \* p<0.10, \*\* p<0.05, \*\*\* p<0.01. *Data sources*: OECD, Leschnig, Schwerdt, and Zigova (2016), PIAAC (2012, 2015), and PISA (2009, 2012).



**Table EA-11: Student Performance and Teacher Cognitive Skills with Continental Fixed Effects and in Country Subsamples (OLS)**

Panel A: Student Math Performance					
	Baseline	Continent		w/o ex-communist	Large
	(1)	Fixed effects	Europe only	& Turkey	teacher sample
	(1)	(2)	(3)	(4)	(5)
Teacher cognitive skills	0.145*** (0.032)	0.127*** (0.030)	0.104*** (0.030)	0.178*** (0.032)	0.171*** (0.045)
Parent cognitive skills	0.044** (0.017)	0.024** (0.012)	0.038** (0.014)	0.034** (0.014)	0.004 (0.010)
Panel B: Student Reading Performance					
Teacher cognitive skills	0.092*** (0.022)	0.088*** (0.025)	0.072** (0.029)	0.102*** (0.028)	0.118*** (0.020)
Parent cognitive skills	0.015 (0.016)	0.003 (0.012)	0.016 (0.015)	0.003 (0.018)	-0.019 (0.018)
Students	490,818	490,818	352,375	409,569	312,163
Countries	31	31	23	23	19
Additional controls in Panels A + B					
Student characteristics	X	X	X	X	X
Parent characteristics	X	X	X	X	X
School characteristics	X	X	X	X	X
Country characteristics	X	X	X	X	X

*Notes:* Dependent variable: standardized student PISA test score in math (Panel A) and reading (Panel B). All skill measures in Panel A (Panel B) refer to numeracy (literacy). Column 1 replicates the baseline least squares models from Columns 3 and 6 in Table 2. In Column 2, we add continental fixed effects and in Column 3, the sample is restricted to only European countries. In Column 4, we exclude countries with a communist heritage and Turkey, while we keep only countries with at least 150 teacher observations in PIAAC in Column 5. Student, parent, school, and country characteristics are the same as in the baseline least squares models (see Table 2). All regressions include controls for imputation dummies and the PISA wave. Specifications give equal weight to each country. Robust standard errors, adjusted for clustering at the country level, in parentheses. Significance levels: \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ . *Data sources:* OECD, PIAAC (2012, 2015), and PISA (2009, 2012).

**Table EA-12: Student Performance and Teacher Cognitive Skills (OLS):  
Same-Subject and Cross-Subject Effects**

Panel A: Teacher Numeracy Skills				
	Student Math Performance		Student Reading Performance	
	(1)	(2)	(3)	(4)
Teacher numeracy skills	0.145*** (0.032)	0.117** (0.051)	0.067** (0.028)	0.069* (0.038)
Parent cognitive skills	0.044** (0.017)	0.033** (0.012)	0.032 (0.022)	0.034* (0.017)
Cognitive skills of adults		0.036 (0.040)		-0.004 (0.031)
Adj. R2	0.29	0.29	0.30	0.30
Panel B: Teacher Literacy Skills				
	Student Math Performance		Student Reading Performance	
	(1)	(2)	(3)	(4)
Teacher literacy skills	0.116*** (0.029)	0.073* (0.042)	0.092*** (0.022)	0.148*** (0.044)
Parent cognitive skills	0.061*** (0.015)	0.045*** (0.015)	0.015 (0.016)	0.035** (0.015)
Cognitive skills of adults		0.051 (0.036)		-0.064 (0.041)
Adj. R2	0.29	0.29	0.30	0.30
Panel C: Teacher Numeracy and Literacy Skills				
	Student Math Performance		Student Reading Performance	
	(1)	(2)	(3)	(4)
Teacher numeracy skills	0.127* (0.069)	0.117 (0.073)	0.013 (0.052)	0.011 (0.049)
Teacher literacy skills	0.023 (0.065)	-0.000 (0.065)	0.082 (0.050)	0.139** (0.064)
Parent cognitive skills	0.043** (0.017)	0.033** (0.013)	0.015 (0.016)	0.034** (0.015)
Adult cognitive skills (country level)		0.037 (0.039)		-0.064 (0.041)
Adj. R2	0.29	0.29	0.30	0.30
Additional controls in Panels A–C				
Student characteristics	X	X	X	X
Parent characteristics	X	X	X	X
School characteristics	X	X	X	X
Country characteristics	X	X	X	X
Students	490,818	490,818	490,818	490,818
Countries	31	31	31	31

*Notes:* Least squares regressions weighted by students' inverse sampling probability, giving each country the same weight. Dependent variable: student PISA test score in math (Columns 1–2) and in reading (Columns 3–4), respectively. Student test scores are z-standardized at the individual level across countries. Teacher skills are z-standardized across countries. Parent skills and country-level adult skills refer to numeracy in Columns 1–2 and to literacy in Columns 3–4. Parent skills and country-level adult skills use teacher skills as “numeraire” scale. Control variables are the same as in the baseline least squares models (see Table 2). Robust standard errors, adjusted for clustering at the country level, in parentheses. Significance levels: \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ . *Data sources:* OECD, PIAAC (2012, 2015), and PISA (2009, 2012).

**Table EA-13: Falsification Check Using Teacher ICT Skills (OLS)**

	Student Math Performance			Student Reading Performance		
	(1)	(2)	(3)	(4)	(5)	(6)
Teacher ICT skills	0.081*	0.057	0.053	0.040	0.041	0.037
	(0.045)	(0.048)	(0.047)	(0.033)	(0.032)	(0.033)
Parent cognitive skills	0.076***		0.041**	0.041*		0.034*
	(0.018)		(0.015)	(0.021)		(0.019)
Adult cognitive skills (country level)		0.099***	0.077**		0.032	0.012
		(0.027)	(0.029)		(0.027)	(0.028)
Student characteristics	X	X	X	X	X	X
Parent characteristics	X	X	X	X	X	X
School characteristics	X	X	X	X	X	X
Country characteristics	X	X	X	X	X	X
Students	368,729	368,729	368,729	368,729	368,729	368,729
Countries	28	28	28	28	28	28
Adj. R2	0.28	0.28	0.29	0.30	0.30	0.30

*Notes:* Dependent variable: student PISA test score in math (Columns 1–3) and in reading (Columns 4–6), respectively. Student test scores are z-standardized at the individual level across countries. ICT skills were not tested in France, Italy, and Spain. Parent cognitive skills are computed as the maximum of mother’s and father’s skills in numeracy (Columns 1–3) or literacy (Columns 4–6). Country-level adult skills refer to numeracy in Columns 2–3 and to literacy in Columns 5–6. Parent skills and country-level adult skills use teacher skills (either in numeracy or in literacy) as “numeraire” scale. Control variables are the same as in the baseline least squares models (see Table 2). Robust standard errors, adjusted for clustering at the country level, in parentheses. Significance levels: \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ . *Data sources:* OECD, PIAAC (2012, 2015), and PISA (2009, 2012).

Table EA-14: Teacher Wage Premiums around the World: Regression Output

	Australia	Austria	Belgium	Canada	Chile	Denmark	Finland	France	Germany	Greece	Ireland	Israel
Teacher	-0.034 (0.027)	0.009 (0.034)	0.037 (0.025)	0.171*** (0.025)	0.079 (0.091)	-0.094*** (0.016)	0.129*** (0.021)	0.127*** (0.032)	0.165*** (0.042)	0.408*** (0.064)	0.457*** (0.040)	0.055 (0.052)
Numeracy	0.124*** (0.019)	0.015 (0.027)	0.058** (0.017)	0.082*** (0.013)	0.174*** (0.049)	0.046*** (0.014)	0.103*** (0.014)	0.076*** (0.017)	0.062** (0.026)	0.027 (0.042)	0.095*** (0.025)	0.133*** (0.022)
Literacy	-0.013 (0.020)	0.105*** (0.026)	0.016 (0.017)	0.073*** (0.013)	-0.007 (0.054)	0.040*** (0.014)	-0.009 (0.015)	0.013 (0.018)	0.073*** (0.026)	0.014 (0.037)	0.037 (0.026)	0.050** (0.023)
Female	-0.120*** (0.021)	-0.113*** (0.030)	-0.036* (0.019)	-0.113*** (0.016)	-0.210*** (0.060)	-0.116*** (0.016)	-0.162*** (0.017)	-0.061*** (0.020)	-0.168*** (0.029)	-0.071 (0.048)	0.004 (0.029)	-0.102*** (0.035)
Pot. experience	0.036*** (0.003)	0.026*** (0.005)	0.026*** (0.003)	0.039*** (0.003)	0.035*** (0.009)	0.026*** (0.003)	0.024*** (0.003)	0.031*** (0.003)	0.046*** (0.006)	0.042*** (0.009)	0.052*** (0.005)	0.051*** (0.006)
Pot. experience <sup>2</sup>	-0.001*** (0.000)	-0.000** (0.000)	-0.000*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)	-0.000*** (0.000)	-0.000*** (0.000)	-0.000*** (0.000)	-0.001*** (0.000)	-0.000* (0.000)	-0.001*** (0.000)	-0.001*** (0.000)
		Italy	Japan	Korea	Netherl.	New Zeal.	Norway	Singapore	Spain	Sweden	U.K.	U.S.
Teacher		0.226*** (0.055)	0.116** (0.049)	0.295*** (0.052)	-0.047 (0.030)	-0.025 (0.033)	-0.116*** (0.016)	-0.008 (0.043)	0.234*** (0.035)	-0.222*** (0.021)	0.035 (0.039)	-0.220*** (0.039)
Numeracy		0.106*** (0.035)	0.245*** (0.025)	0.099*** (0.036)	0.025 (0.022)	0.096*** (0.018)	0.055*** (0.015)	0.224*** (0.023)	0.094*** (0.031)	0.028* (0.016)	0.134*** (0.025)	0.112*** (0.030)
Literacy		-0.017 (0.034)	-0.091*** (0.027)	0.056 (0.036)	0.081*** (0.021)	0.047** (0.020)	0.021 (0.016)	-0.016 (0.023)	0.035 (0.026)	0.034** (0.015)	0.043 (0.026)	0.061** (0.031)
Female		-0.133*** (0.045)	-0.334*** (0.025)	-0.203*** (0.035)	-0.078*** (0.022)	-0.092*** (0.022)	-0.117*** (0.015)	-0.048* (0.025)	-0.111*** (0.029)	-0.110*** (0.017)	-0.131*** (0.028)	-0.108*** (0.033)
Pot. experience		0.041*** (0.007)	0.037*** (0.004)	0.024*** (0.006)	0.042*** (0.003)	0.035*** (0.003)	0.030*** (0.002)	0.076*** (0.004)	0.036*** (0.006)	0.024*** (0.003)	0.042*** (0.004)	0.046*** (0.005)
Pot. experience <sup>2</sup>		-0.000** (0.000)	-0.001*** (0.000)	-0.000 (0.000)	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)	-0.000*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)

Notes: Least squares regressions (weighted by sampling weights). Dependent variable: log gross hourly wage. All country samples include workers with a college degree. Numeracy and literacy scores are standardized with standard deviation 1 across countries. *Pot. experience* is age - years of schooling - 6. Robust standard errors in parentheses. Significance levels: \* p<0.10, \*\* p<0.05, \*\*\* p<0.01. Data sources: PIAAC (2012, 2015).