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Skills, parental background, and changes in educational institutions

Jani Erola
Valeria Breuker

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Skills, parental background, and changes in educational institutions

Jani Erola & Valeria Breuker
University of Turku, University of Milan[1]

Abstract

In this study, we test how educational expansion, prolonging education, and educational reforms have contributed to the improvement of skills in developed societies in recent decades. We expect that the growing openness of the educational system is associated with higher gains in cognitive skills, but that there are several multiplicative and compensatory processes related to both family background and the educational institutions involved that can alter these trends, depending on family background. We test the assumptions with the first wave (2013) of the Program for the International Assessment of Adult Competencies (PIAAC) data, linked with birth-cohort-specific, macro-level information on the changes in educational institutions in each country. The results suggest that the growing proportion of those with a tertiary education as well as the prolonging of education are associated with the improvement of skills, partially because these changes are also associated with the increased effectiveness of education in the improvement of skills. However, the growing number of reforms in general tend to harm the skill development especially of those with poorly educated parents, even if the reforms were intended to remove educational dead-ends.

Keywords: skills, competencies, education, institutions, educational expansion, reforms, social change, PIAAC

Introduction

Educational expansion has been one of the key changes influencing educational attainment in contemporary societies. While educational institutions have become more inclusive at the same time (Breen and Jonsson, 2005), many have argued that this has led to educational inflation, so that one needs to achieve higher levels of education for similar returns as before (Arrow, 1973; Van de Werfhorst, 2009; Werfhorst and Andersen, 2005).

[1] Correspondence: jani.erola@utu.fi, valeria.breuker@unimi.it

While many have considered the socioeconomic returns of education, there is much less research on how changes in education have influenced skills. Although the level of education rises, it does not follow automatically that competencies improve at the same pace. Educational inflation may result from growing competition among the educated in the labor market, but it also occurs if education at a specific level leads to weaker skill development than before. This may occur for several reasons: perhaps being more inclusive has meant that those with lower initial abilities make it to higher levels of education more often, or perhaps that teaching resources allocated to each student have become too meager to guarantee that, on average, students would reach the same skill levels as before.

It seems that skills have nonetheless improved quite dramatically during the period of educational expansion. In the last forty years, the psychological literature has shown a substantial IQ gain of approximately 0.3 points per year in developed countries. The phenomenon, called the Flynn Effect, has shown that there are substantial improvements in cognitive competencies related to planning, organization, working memory, integration of experience, spatial reasoning, unique problem-solving, and skills for goal-directed behaviors over time (Flynn, 1984, 2009, 2013). Many researchers have identified educational expansion as one of the potential factors behind the effect, but acknowledge that most likely there have been several overlapping and correlating processes that have contributed to it. For instance, Blair et al.(2005) argue that there are several institutional changes linked to the openness of the educational system that contribute to the secular improvement in IQ and fluid intelligence (see also Teasdale and Berliner, 1991; Williams, 1998).

The processes linked to the Flynn effect seem to overlap with factors that in the previous literature have been linked with the weakening effect of family background origin on educational attainment

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(e.g., Bernardi and Ballarino, 2016b; Breen et al., 2009; Breen and Jonsson, 2007; Doorn et al., 2011; Shavit and Blossfeld, 1993). This literature suggests that the changes in educational institutions have also weakened the link between socioeconomic family origin and educational destination of the children. However, the same literature also suggests that educational expansion or the other changes done to the educational systems do not necessarily lead to a weakening effect of family background in education. Theories on relative risk aversion (Breen and Goldthorpe, 1997), maximally maintained inequality (Raftery and Hout, 1993), multiplication of advantages (Erola and Kilpi-Jakonen, 2017), and compensatory advantage (Bernardi, 2012) suggest that advantaged families often have the means (and motivation) to increase the importance of family background for educational achievement. Consequently, the importance of family background in skills may also become weaker at a much slower pace than we assume, or it may even become stronger.

The aim of our study is to test how educational expansion, the prolonging of education, and educational reforms have contributed to the changes in skills in developed societies during recent decades. Our starting assumption is that the growing openness of an educational system is associated with higher gains in cognitive skills. However, we also assume that there are several multiplicative and compensatory processes related to both family background and educational institutions that can alter these trends by family background in important ways. To test the assumptions, we analyze the first wave (2013) of the Program for the International Assessment of Adult Competencies (PIAAC) data that we have linked with birth-cohort-specific, macro-level information on the changes in educational institutions.

Theoretical background

The fact that social background matters today less than previously for educational attainment suggests that modern societies are becoming more meritocratic. Education is seen as a *great equalizer* that ensures equal opportunities to achieve the occupational position, regardless of gender, social background and ethnic origin (Bernardi and Ballarino, 2016a). However, despite the openness, literature from recent decades (Bernardi and Ballarino, 2016a; Breen and Goldthorpe, 2001; Goldthorpe, 2003; Hout, 1988; Pöyliö et al., 2018) consistently shows the same results: individuals from advantaged families still achieve higher socioeconomic statuses than others in all known societies. The level of equality of opportunity also varies by the level of education. It seems that on terms of the achievement in the labor market, family background matters less among the tertiary educated than others (Breen and Jonsson, 2007; Mastekaasa, 2011; Torche, 2011). Further, the literature has shown that the direct effect of social origin on destination has remained relatively stable over time, despite the changes in educational institutions (Bernardi and Ballarino, 2016b). This may be explained by the fact that the impact of family background depends both on the family environment and genetic inheritance: while more equal access to education is likely reducing the importance of the first, there are indications that the importance of genes may grow at the same time (Engzell and Tropf, 2019).

How are changes in skills related to these trends? Previous studies suggest that at least some changes in educational institutions have had an impact on skill development. For instance, findings using administrative data on Finnish compulsory school renewal that took place during the 1970s (Pekkala Kerr et al., 2013) indicated that improving access to basic levels of education has improved skills, particularly among the children of low-educated parents. The findings from a similar renewal that took place in Sweden during the previous decade indicates that these

advantages may have extended beyond one generation only; mothers' increased education due to compulsory school renewal had a positive effect on children's cognitive skills (Lundborg et al., 2014). Further, also using PIAAC data, Lindberg and Silvennoinen (2018) found that simply increasing access to higher education across the countries covered in the data was associated with increased skills among higher education graduates. So, overall, it seems that the many changes in educational institutions that made access to different levels of education easier, also contributed to the observed overall improvement in skills.

While there are plenty of studies that consider the association between social origin and education, there is less research that considers how they are linked to skills, and further, to institutional changes. One of the few examples is the comparative study by Liu (2018) using PIAAC data. It showed that other types of important changes in educational institutions also extend beyond compulsory education; increasing access to vocational schooling and later-occurring educational tracking seem to have reduced educational inequalities in skills by family background. Yet we can formulate a set of hypotheses on the likely processes involved. To begin with, there is a great deal of research showing that some of the skills are relatively strongly biologically inherited, and if those skills mattered for parents' attainment, they alone should lead to a correlation between social origins and the skills of the children (Bowles and Gintis, 1976; Farkas, 2003). Because of this, we should expect the following:

> *Social origins are associated with skills, even when controlling for children's educational attainment and the changes in educational institutions* (Hypothesis 1).

Referring to Figure 1, we should observe association A also when changes in educational institutions and education are controlled for.

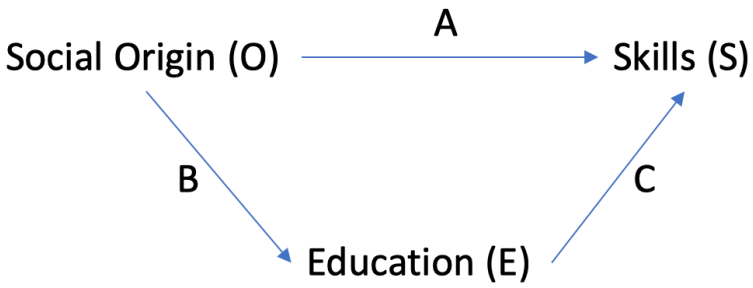

Figure 1. Social origin, education and skills (OES) triangle

Following Liu, we should nonetheless expect that institutional changes have an impact on the association between origin and the observed skills as well. Many educational reforms, such as removing the dead-ends in the pathways to higher education and raising the age of compulsory school, aimed explicitly at being more inclusive by family background (Brunello et al., 2009; Brunello and Checchi, 2007; Checchi and van de Werfhorst, 2018; Pfeffer, 2008; Pöyliö et al., 2018). While these changes reduced the importance of family background on educational attainment, in particular the association between family background and tertiary education (covered by association B in Figure 2), it is likely that at the same time, they also reduced the importance of social background on skills (association A in Figure 1), net of education, by leading to increasing the overall level of skills, in particular among those from low-educated family backgroun ds (cf. Pekkala Kerr et al., 2013). We can, therefore, assume the following:

> *Changes in educational institutions have weakened the association between origin and skills, net of education* (Hypothesis 2a).
>
> *Changes in educational institutions improved the skills of those with low-educated family background* (Hypothesis 2b).
>
> *Changes in educational institutions have reduced the proportion that education accounts for the association between social origin and skills* (Hypothesis 2c).

However, the changes in educational institutions do not necessarily lead to a weakening of the effect of social origin; rather, they can multiply or boost the impact of family background (Erola and Kilpi-Jakonen, 2017). Perhaps the most often described example of this in the context of the changes in educational institutions is *maximally maintained inequality* (MMI) theory (Raftery and Hout, 1993). The theory claims that increasing higher education will benefit more children from advantaged backgrounds because they have better chances to access higher education to begin with. Further, the *relative risk aversion* (RRA) theory assumes that families from different social backgrounds try to maximize the opportunities of the children, ensuring them at least the same social position as their parents (Breen and Goldthorpe, 1997; Holm and Jæger, 2008). Families use social, cultural, and economic resources primarily to avoid social downgrading and only secondarily to improve their social position as related to the status of the parents. The literature on compensatory advantage has shown that to avoid social downgrading, the advantaged parents try to *compensate* for the low skills or resources of their children with different means at the exposal (Bernardi, 2012; Bernardi and Boado, 2013; Bernardi and Grätz, 2015). For example, children who are not successful at school receive extra parental support and have second opportunities (Bernardi and Ballarino, 2016a). Further, parents react in the same way to the changes in educational institutions; when the importance of social origin in educational attainment is reduced with institutional changes, parents try to find ways to increase the importance of family background in other ways (Pöyliö et al., 2018). A similar compensatory effect may be associated with the institutional changes that influence the association between skills and social background.

Thus, based on the MMI, compensatory advantage, and RRA, we may assume:

> *Changes in educational institutions have strengthened the association between origin and skills, net of education* (Hypothesis 3a).

Changes in educational institutions have improved the skills of the children of higher educated parents (Hypothesis 3b).

Changes in educational institutions have creased the proportion that education accounts for the association between social origin and skills (Hypothesis 3c).

These hypotheses may be confirmed, even if the overall skill levels in societies improve. The described situations may occur simply because of the structural advantages without any specific input from the parents, as in the example of Raftery and Hout (1993), but also if the advantaged parents are more capable of exhausting the new conditions for the good of their children (Ayalon and Shavit, 2004; Kloosterman et al., 2009; Lucas, 2001). Also, while Hypotheses 2a–c seem to be competing with Hypotheses 3a–c, the results will show that the reality is more complex: the impact of the educational changes can have an impact on opposite ends of the socioeconomic distribution, and can vary between the types of institutional changes.

Data, variables, and methods

To test the importance of institutional changes, we needed data with a sufficient amount of institutional variation, in addition to comparable skills and family background measurements. The first wave (2013) of the PIAAC data meets these criteria. It includes individual-level information on social origins and skills gathered from 21 developed countries: Austria, Belgium, Canada, the Czech Republic, Estonia, Finland, France, Germany, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Poland, Russia, Slovakia, Spain, Sweden, the United Kingdom (UK), and the United States. We focus on individuals aged 25–65 (born 1947–1987), so that in addition to between-country variation, we also have within-country variation in our institutional change variables, depending on which of the birth cohorts experienced institutional changes.

We use cognitive competence measures for literacy and numeracy as the dependent variables for our analyses. These measurements of competencies have also been the most frequently used indicators of skills in the earlier literature, especially because of their strong connection to educational attainment (Anger, 2012; Anger and Heineck, 2010; Borgna, 2017). In the data, competencies are estimated through so-called *plausible values*. To reduce the time and effort needed to respond to each question in the questionnaire, the respondents were only asked to respond to a previously specified subset of them. For both domains of competencies, there are ten plausible values, which have been drawn independently from the *a posteriori* distribution for each respondent. Following the item response theory, the data providers have then imputed values for all items without responses, also adjusting for the standard errors of the full population model. The final scores of the competencies are placed on a scale ranging from 0 to 500 points, which reflects the proficiency of the respondents in competencies (OECD, 2012). As the results are very similar for both outcomes, we report them only those for literacy in the main text. The results for numeracy can be found in Appendix 1.

The independent, individual level variables are the educational attainment of the respondents and their parents (in three categories for both: tertiary, upper-secondary, and basic or less). Additionally, we control for the 10-year age groups (dummies), sex, and the country of birth in all models (also, when not reported in the text, tables, or figures). The age-period approach we follow allows us to observe how the association between competencies and education changes, assuming that conditional selectivity of the types of education does not vary over time; it also shows how competencies vary by education and age (Hanushek et al., 2015).

The variables capturing changes in educational institutions include the proportion of the tertiary educated, the age of finishing highest education, and educational reforms. The first of these reflects educational expansion, particularly at the top of the educational distributions; the second considers the expansion throughout the educational strata; and the third reflects country- and system-specific changes. Similar indicators have been used several times previously to grasp key changes in educational institutions.

The proportion of the tertiary educated ranges between 0–100 and refers to a country-level proportion at the year of enrollment for each respondent. The age of finishing the highest level of education is an individual-level categorical variable in the PIAAC data (age 15 or younger, 15–19, 20–24, 25–29, 30–34, and 35 or older). However, in our case, it also reflects overall institutional changes in the length of education—to some extent, the changes in compulsory schooling, but especially the expansion of education at the tertiary level. To simplify the interpretation and modeling, we use the variable as if it was continuous, so the estimates in the models for this variable indicate the change in the competencies attributable to a five-year change in the age at which education is finished.

In the case of reforms, we used the data collected by Salonen and Pöyliö (2017), which we completed for the missing countries and years using similar information as the original authors. The data record any major education reforms that influence track choices by reducing dead-ends in secondary and tertiary education, occurring in a given country and influencing specific five-year birth cohorts (for instance, all birth cohorts going through a renewed compulsory schooling system and only making track choices in the end of it). The data used in this study cover all these types of reforms taking place in individual countries between 1955–2010. The original reform data, covering only the cohorts from 1955–1980, was top-coded into two reforms at the maximum. However, as

the number of reforms increases substantially toward the current date, we allowed the number of reforms to grow by one for each subsequent five-year period. After this, the reform variable ranges from 0–7.

At the macro level, we also control for the yearly level and growth of GDP according to the country and the enrollment year in tertiary education to account for variations in the business cycle and the risk of unemployment. It may be expected that during economic booms, students are interested in entering job markets earlier, and vice versa during downturns.

All analyses in this paper were conducted using the REPEST module for Stata (Avvisati and Keslair, 2019), which computes the plausible values for both descriptive and multivariate analyses. Most of the multivariate OLS-regression analyses presented in the main text are based on the pooled data with country-fixed effects.

The summary statistics for the variables used are shown below in Table 1. Further, Table 2 shows the correlations across the three institutional measures. Correlations are surprisingly low, suggesting that they truly cover different aspects of the changes in educational systems. The low correlations also mean that multicollinearity should not bias our findings, even if the variables are entered into the models at the same time.

Table 1. Summary statistics

Variables varying at individual level						
	Obs	%	Mean	Std. Dev.	Min	Max
Parental education						
Basic or less	40 619	39,4				
Upper secondary	39 594	38,4				
Tertiary	22 916	22,2				
Education						
Basic or less	33 499	32,8				
Upper secondary	35 628	34,9				
Tertiary	31 011	30,1				
Age						
25-29	12 556	12,2				
30-34	12 268	11,9				
35-39	12 743	12,4				
40-44	12 978	12,6				
45-49	13 381	13,0				
50-54	12 886	12,5				
55-59	12 319	12,0				
60-65	13 998	13,6				
Gender						
Males	48 254	46,8				
Females	54 874	53,2				
Enrolment age						
21	12 319	11,95				
22	12 886	12,50				
23	13 381	12,98				
24	12 978	12,58				
25	12 743	12,36				
26	12 268	11,90				
27	12 556	12,18				
28	13 998	13,57				
Born in country						
yes	94 585	91,72				
no	8 540	8,28				
Age of finishing education						
15 or younger	8 603	8,34	2,92	1,29	1	6
16-19	37 120	35,99				
20-24	30 507	29,58				
25-29	13 734	13,32				
30-34	5 116	4,96				
35 or older	7 501	7,27				

Table 1 continued

Variables varying by birth cohort/country						
	Obs	%	Mean	Std. Dev.	Min	Max
Reforms						
0	60	20,41	2,12	0,63	0	8
1	77	26,19				
2	61	20,75				
3	30	10,2				
4	24	8,16				
5	24	8,16				
6	10	3,4				
7	6	2,04				
8	2	0,68				
Proportion of tertiary educated	103 129		47,31	17,43	11,11	92,93
GDP	103 129		40928,10	18406,29	133,45	101668,20
GDP growth	103 129		0,68	0,13	.-87	0,47

Table 2. Correlation matrix for the three institutional variables

	Proportion of the tertiary educated	Age of finishing education	Reforms
Proportion of the tertiary educated	1		
Age of finishing education	0,2165	1	
Reforms	-0,3133	-0,0505	1

Empirical evidence

Results by cohorts and countries

In our first set of analyses, we estimate average literacy scores across the groups by age, the individuals' own tertiary education, and their parents' tertiary education. The estimates are retrieved from a pooled OLS model with country-fixed effect, controlling for gender, the country of residence, and the country of birth. These results are reported in Figure 2. They indicate a steady

improvement in literacy skills when moving toward the younger birth cohorts. The tertiary educated with tertiary educated parents fare consistently better, and their differences with the tertiary educated without highly educated parents also seems rather constant across the age groups, which was expected only among the very youngest age groups. Those without a tertiary education but with educated parents have a consistently lower score among the cohorts age 35 or above, a finding similar to the increased compulsory schooling in Sweden (Lundborg et al., 2014). The youngest age groups most likely include many of those still being educated. Because of this, the score differences should be expected to increase among the youngest birth cohorts in the future.

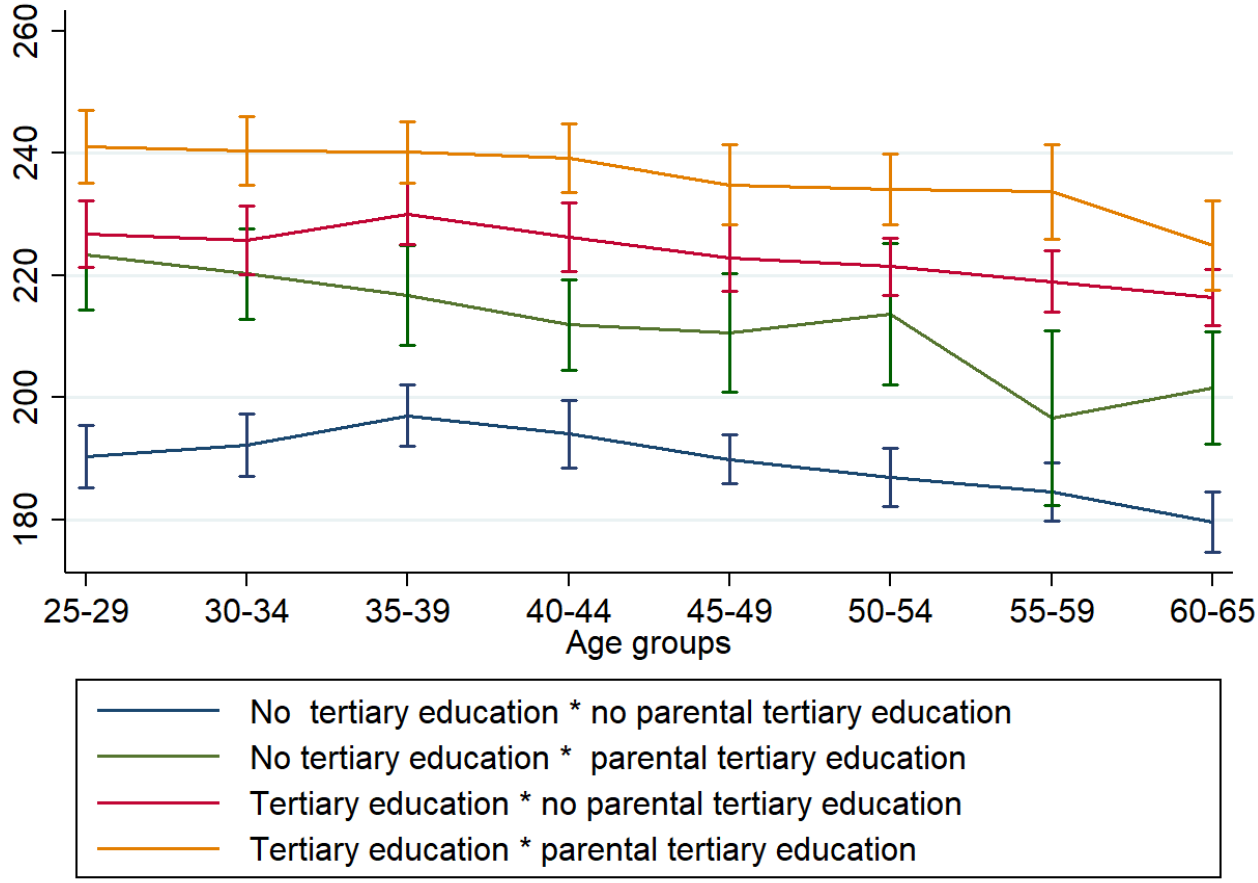

Figure 2. The literacy score by age, children's education, and parents' education. Pooled PIAAC 2013 data, an OLS model with country-fixed effects.

To get a better understanding of how the effect of each institutional change variable varies across countries, we next plotted the regression estimate for each of them. The estimates are drawn from a

series of country-specific OLS models, in each case controlling also for parental education. Figure 3 shows how much the literacy score grows when the proportion of the tertiary educated increases by one percent. The figure indicates that in all countries, the higher proportion of those tertiary educated is associated with higher skill levels. The association is especially strong in the Netherlands (1.93), Austria (1.74), and Germany (1.58). The association is weaker in Slovakia (0.09), Russia (0.16), and Poland (0.43). The other countries show effects closer to the mean across the countries (0.93). The effect size is substantial in the countries with the biggest effects, especially if we consider how much the proportion of the tertiary educated has changed across birth cohorts—the most in Finland (4.76) from 1968–1977 and the least in Austria (-25.08) from 1957–1947. In a similar manner, Figure 4 shows the change in literacy by an additional five years in the age of finishing the highest educational degree by country. Except for the UK, the increased age of finishing education is positively associated with higher skill levels in all countries. We observed the strongest effect in Belgium (17.46) and Japan (17.11).

Finally, Figure 5 reports the associations between educational reforms on literacy, controlling for parental education. The results show relevant cross-country variation. The strongest associations are shown in Korea (23.51); the Czech Republic (18.85); and Japan (14.99). Somewhat surprisingly, the figure also shows that in seven countries, reforms have reduced the skill levels. The weakest associations are negative, and were observed in the Netherlands (-26.74), Finland (-26.25), and the UK (-23.13). This indicates that quite often, educational reforms have weakened rather than improved skill levels in different societies.

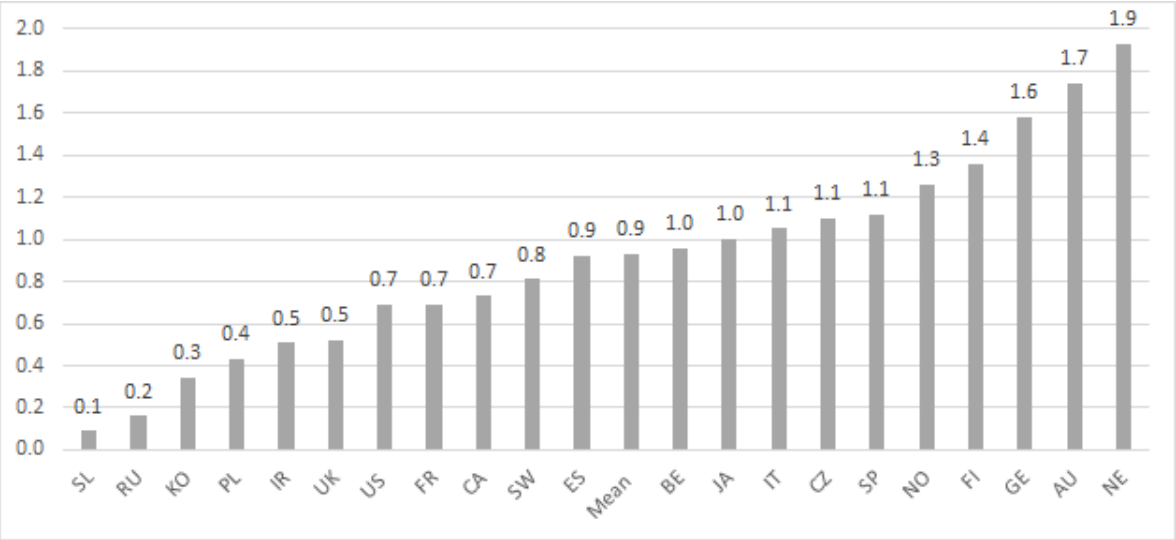

Figure 3. The change in literacy score by the proportion of the tertiary educated by country. OLS estimates from single country models.

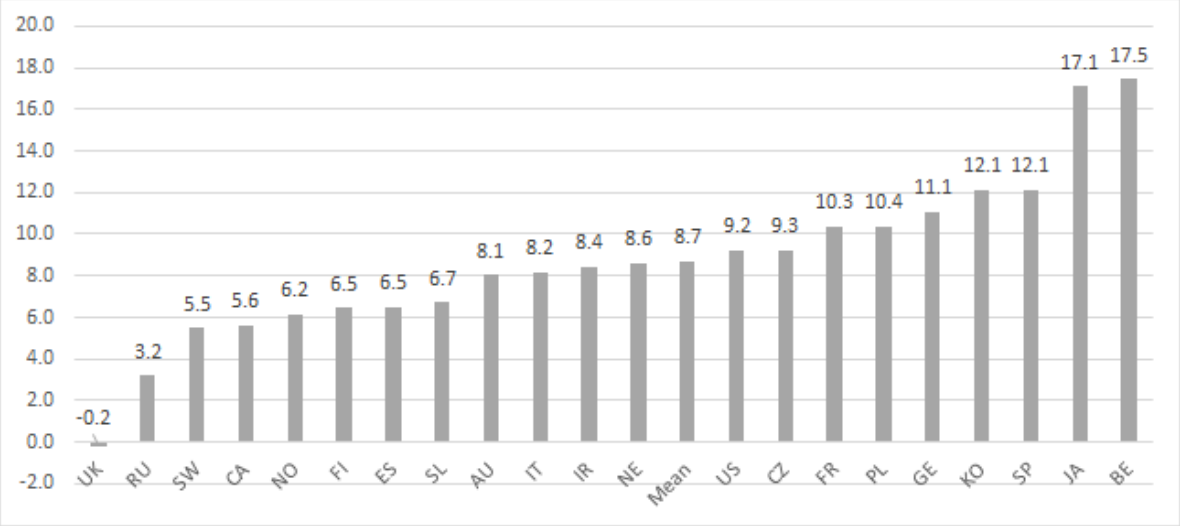

Figure 4. The change in literacy score by the age of finishing the highest educational level, by the increase of 5 years. OLS estimates from single country models.

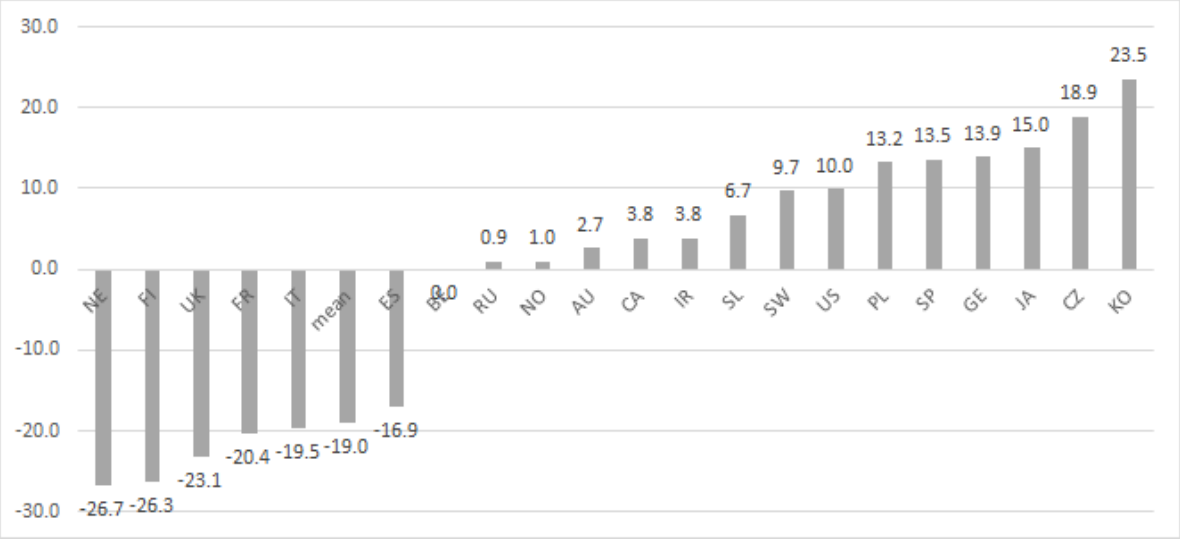

Figure 5. The change in literacy score by the number of educational reforms. OLS estimates from single country models.

Multivariate analyses

We now move on to report the analyses from multivariate models on pooled data covering all countries. Table 3 shows the estimates for parental education, before and after controlling for institutional change variables. The upper part of the table reports the estimates without adjusting for respondents' own education, while the lower part shows the adjusted coefficients. The comparison of models M1.1 and M2.1 suggests that approximately half the advantage of having better educated parents is mediated by the educational attainment of the respondents (for upper-secondary educated parents, 22.7 vs. 12.3, and for tertiary educated parents, 38.2 vs. 19.7). In Models M1.2–M1.4 and M2.2–M2.4, each of the institutional change variables is included separately, and M1.5 and M2.5 include all of them at the same time. Confirming our first hypothesis, parental education always contributes to skills, including when controlling for the children's own education or any of the institutional factors. Further, the three macros are always statistically significantly associated with skills when they are included separately. Before controlling for education, two of them have positive estimates (the proportion of the tertiary educated and the age of finishing the highest educational level), but the estimates for the reforms are negative. This confirms what was already observed in Figure 5: many of the reforms that have taken place to remove the educational dead-ends have had a negative effect on skills. The comparison of the estimates for parental education between M1.1 and M1.4 also suggests that the reforms have not managed to reduce skill differences by parental background. The estimates for parental education do not change beyond the confidence intervals.

Table 3. The literacy score by parental education, changes in educational institutions, and respondents' own education. Pooled PIAAC data, OLS with country-fixed effects.

	M1.1	M1.2	M1.3	M1.4	M1.5
Parental education					
Upper secondary [ref. Basic or less]	22.69***	20.53***	18.28***	22.55***	18.26***
	(21.08 - 24.31)	(18.77 - 22.30)	(16.63 - 19.93)	(20.93 - 24.17)	(16.57 - 19.95)
Tertiary	38.12***	35.44***	31.13***	37.50***	30.54***
	(35.80 - 40.44)	(33.09 - 37.80)	(28.82 - 33.45)	(35.16 - 39.84)	(28.23 - 32.85)
Proportion of tertiary education		0.23***			-0,03
		(0.16 - 0.30)			(-0.10 - 0.03)
Age finishing education			7.77***		8.12***
			(7.16 - 8.38)		(7.46 - 8.77)
Reforms				-10.05***	-11.44***
				(-11.65 - -8.45)	(-12.62 - -10.27)
Constant	256.59***	243.01***	241.63***	261.62***	248.75***
	(251.44 - 261.74)	(240.00 - 246.02)	(236.08 - 247.18)	(255.85 - 267.39)	(244.54 - 252.96)

	M2.1	M2.2	M2.3	M2.4	M2.5
Parental education [ref. Basic or less]					
Upper secondary	12.34***	12.46***	12.14***	12.61***	13.56***
	(10.57 - 14.12)	(10.64 - 14.28)	(10.38 - 13.90)	(10.83 - 14.38)	(11.78 - 15.34)
Tertiary	19.72***	19.84***	19.54***	20.01***	21.03***
	(17.24 - 22.20)	(17.41 - 22.27)	(17.05 - 22.03)	(17.48 - 22.54)	(18.56 - 23.50)
Proportion of tertiary education		-0,02			-0.20***
		(-0.10 - 0.05)			(-0.27 - -0.13)
Age finishing education			1.38***		2.13***
			(0.64 - 2.13)		(1.41 - 2.85)
Reforms				-6.32***	-9.90***
				(-7.94 - -4.69)	(-11.13 - -8.67)
Respondent's education [ref. Basic or less]					
Upper secondary	18.12***	18.38***	16.72***	17.70***	17.82***
	(16.59 - 19.66)	(16.81 - 19.95)	(15.03 - 18.40)	(16.22 - 19.19)	(16.28 - 19.36)
Tertiary	42.10***	42.44***	39.34***	40.59***	38.75***
	(40.26 - 43.94)	(40.58 - 44.30)	(36.95 - 41.73)	(38.83 - 42.36)	(36.66 - 40.84)
Constant	239.68***	240.83***	238.49***	243.44***	253.87***
	(234.75 - 244.62)	(237.72 - 243.93)	(233.08 - 243.89)	(237.73 - 249.15)	(249.67 - 258.07)

All models have 103129 observations. *** p<0.01, ** p<0.05, * p<0.1, 95% confidence intervals in parentheses. Estimates for country fixed effects, age group, gender, GDP, GDP change and enrolment year omitted.

Before controlling for respondents' own education, only the age of finishing education and reforms remain statistically significant in the joint Model M1.5. This suggests that the age of finishing education seems to be the only institutional change indicator that has a positive effect on skills. As indicated by earlier studies (e.g., Liu, 2018), simply staying longer in education seems to be an important reason that higher education matters for skills.

In M1.2, the proportion of the tertiary educated is significant in the joint model before controlling for respondents' own education, but not after that in M2.2. This is understandable: the rising level of education is naturally reflected in the educational distribution of the respondents. The effect size for the age of finishing education is reduced by about one-fourth after respondents' own education is controlled for, whereas the estimate for reforms is reduced by one-third. Thus, the two other macros are also linked with the changing levels of education of the respondents.

The results of Table 3 indicate that none of the three types of institutional changes covered had any statistically significant impact on the skill differences by origin. None of the estimates for parental education show any change from one model to another after controlling for them. These findings refute Hypotheses 2a and 3a.

Let us consider next whether the contribution of the institutional factors on literacy skills vary by family background, as assumed in Hypotheses 2b and 3b. Table 4 shows the models that include the interaction terms between parental educational levels and each institutional change variable. Model M3.1, on the left side, indicates that the increasing proportion of the tertiary educated mostly contributed to the literacy skills of the children of low-educated parents (the reference group estimate was 0.42), not at all to the children of the tertiary educated parents (0.42 - 0.40 = 0.02), and in between to those with upper secondary educated parents (0.42 - 0.19 = 0.23). Interestingly, a

comparison to the same but education-controlled estimates on the left side of the table suggests that this advantage would prevail over and above the level of educational attainment. Similarly, the increasing age of finishing education has provided the greatest advantages to the children of the poorly educated. However, in this case, the children of the tertiary educated have benefited as well, although somewhat less. In addition, in this case, the advantage holds even after controlling for respondents' own education.

In the case of the reforms, the pattern is almost exactly the opposite. The reforms have mostly hurt the skill development of the lowest-educated and had little impact on the children of the tertiary educated. In addition, this advantage prevails also after taking respondents' own education into account. Thus, both Hypotheses 2b and 3b gain support, but with different types of institutional changes. Educational expansion and prolonging education primarily benefited the children of low-educated parents, whereas educational reforms have done the opposite.

Finally, to test Hypotheses 2c and 3c, about how the institutional changes have contributed to the effectiveness of education in contributing to skill differences by family background, we need to extract the mean differences in the estimates of parental education before and after controlling for the level of education of the respondents. In essence, this comparison is similar to a usual difference-in-difference approach, although the contrasts are acquired by controlling for education rather than a time-varying treatment.

Table 4. The effect of the interaction among parental education and macros on literacy competencies, controlling for tertiary education.

	M3.1	M3.2	M3.3	M4.1	M4.2	M4.3
Parental education [ref. Basic or less]						
Upper secondary	30.01***	22.33***	16.34***	19.91***	15.73***	8.85***
	(24.91 - 35.11)	(18.42 - 26.25)	(13.36 - 19.33)	(14.60 - 25.22)	(11.92 - 19.54)	(5.79 - 11.90)
Tertiary	57.67***	34.54***	27.36***	34.34***	20.58***	13.59***
	(49.19 - 66.15)	(29.50 - 39.59)	(23.30 - 31.41)	(25.54 - 43.14)	(15.35 - 25.81)	(9.38 - 17.81)
Proportion of tertiary educated	0.42***			0.11**		
	(0.33 - 0.51)			(0.02 - 0.21)		
Par. upper secondary *Proportion tertiary ed.	-0.19***			-0.14***		
	(-0.29 - -0.09)			(-0.24 - -0.04)		
Par. tertiary * Proportion Tertiary ed.	-0.40***			-0.25***		
	(-0.56 - -0.23)			(-0.42 - -0.08)		
Age of finishing education		8.71***			2.00***	
		(7.82 - 9.60)			(1.01 - 2.99)	
Par. upper secondary* Age of finishing ed.		-1.71***			-1.03*	
		(-2.93 - -0.49)			(-2.12 - 0.06)	
Par.tertiary * Age of finishing ed.		-1.47*			-0,01	
		(-2.95 - 0.01)			(-1.51 - 1.49)	
Reforms			-18.33***			-15.72***
			(-21.02 - -15.64)			(-18.41 - -13.04)
Par. upper secondary* Reforms			8.67***			7.06***
			(6.08 - 11.26)			(4.37 - 9.76)
Par. tertiary * Reforms			14.07***			11.55***
			(10.64 - 17.50)			(8.07 - 15.04)
Respondent's education [ref. Basic or less]						
Upper secondary				18.36***	17.51***	19.97***
				(16.78 - 19.94)	(15.92 - 19.10)	(18.51 - 21.44)
Tertiary				42.06***	39.57***	42.16***
				(40.21 - 43.91)	(37.20 - 41.95)	(40.36 - 43.97)
Constant	238.27***	240.75***	274.05***	239.09***	240.67***	255.33***
	(233.09 - 243.46)	(236.84 - 244.65)	(270.20 - 277.89)	(233.89 - 244.28)	(236.91 - 244.43)	(251.43 - 259.22)

All models have 103129 observations. *** p<0.01, ** p<0.05, * p<0.1, 95% confidence intervals in parentheses. Estimates for country fixed effects, age group, gender, GDP, GDP change and enrolment year omitted

These contrasts, along with the differences in the institutional chance variables before and after controlling for education, are computed by comparing the estimates reported in Table 3, and the results are reported in Table 5. The first comparison, M1.1 vs. M2.1, indicates that education contributed most to the literacy skills at the top—and almost as much at the bottom—of the parental educational distribution. Among the children of the basic or less-educated parents, the children's education accounted for 16.88 points in the literacy score, and for the children of tertiary educated parents, 18.4 points; however, it was only 10.4 for the children of upper secondary educated parents.

Comparisons across the models are otherwise similar to M1.1 vs. M2.1, but in these cases, the models also control for institutional change variables, the first one at the time, then all three together. The figures in the difference-in-difference lines of Table 5, referring to the contrasts between the contribution of education between the parental education groups, change substantively and statistically significantly once any of the institutional change variables have been controlled for. In the case of the difference between the children with parental tertiary and secondary education, it seems that the age of finishing education matters most, the difference-in-difference estimate being reduced from 8.1 to 5.45. Note, however, after controlling, this difference does not grow but rather becomes smaller. Thus, the changes in educational institutions seem to have increased the advantage of education for the children of the tertiary educated.

The difference-in-difference estimates tell a very different story in the case of the contrasts between the children of the basic or less-educated and upper-secondary educated parents. If compared to the comparison between M1.1 and M2.1, controlling either the proportion of the tertiary educated or the age of finishing education flips the difference-in-difference estimate in the opposite direction, more in the first case, from the advantage of the children from low-educated families with 6.53 points in

the literacy score to the advantage of the upper-secondary educated parents' children of 5.89 points. Thus, unless there was either type of changes in educational institutions, the children of low-educated parents would benefit less from education in their skill development. The case is the opposite for reforms: without them, the advantage from education would be even higher for children from low-educated families (6.53 vs. 8.24 in the controlled model).

Interestingly, it seems that both the expansion of tertiary education and prolonging education in general have made it more advantageous for skill formation, both in the top and the bottom of the educational distribution. However, the reforms have mostly benefited the children of tertiary educated parents and have even reduced the advantage of education for children from low-educated families. Thus, the analyses seem to confirm Hypotheses 2c and 3c.

Table 5. The mean differences in the estimates of parental education and institutional change variables for literacy before and after controlling for the level of education of the respondents

	M1.1 vs. M2.1	M1.2 vs. M2.2	M1.3 vs. M2.3	M1.4 vs. M2.4	M1.5 vs. M2.5
Parental education [ref. Basic or less]	16,88	2,18	3,14	18,18	-5,12
	(16.69 - 17.12)	(2.28 - 2.09)	(3 - 3.29)	(18.12 - 18.24)	(-5.13 - -3.11)
Upper secondary	10,35	8,07	6,14	9,94	4,70
	(10.51 - 10.19)	(8.13 - 8.02)	(6.25 - 6.03)	(10.55 - 9.79)	(4.79 - 4.61)
Tertiary	18,40	15,60	11,59	17,49	9,51
	(21.56 - 18.24)	(15.68 - 15.53)	(11.77 - 11.42)	(17.68 - 17.30)	(9.67 - 9.35)
Difference in difference, parental education					
Tertiary vs. Upper secondary	8,13	7,53	5,45	7,55	4,87
	(11.05 - 8.05)	(7.55 - 7.51)	(5.52 - 5.39)	(7.13- 7.51)	(4.88 - 4.74)
Basic or less vs. Upper secondary	6,53	-5,89	-3,00	8,24	-9,82
	(6.18 - 6.93)	(-5.13 - -5.93)	(-3.25 - -2.74)	(7.57 - 8.45)	(-9.92 - 7.72)
Institutional change variables					
Proportion of tertiary education		0,21			-0,17
		(0.06 - 0.25)			(-0.17 - -0.10)
Age of finished education			6,39		5,99
			(6.52 - 6.25)		(6.05 - 5.92)
Reforms				-3,73	-0,55
				(-3.71 - -3.96)	(-1.49 - -1.60)

Conclusions

The aim of this study has been to study the relationship between social origin, education, and the changes in educational institutions on cognitive skills using international PIAAC data. It was assumed that the changes that have increased the openness of educational systems have also contributed positively to skills, but that these advantages vary by family background. As indicated in the previous literature, in our analyses the competencies of the younger cohorts are also higher than those of the older ones. The correlation between age and skills exists across the groups of parents' and children's groups of education, with the youngest children of the non-tertiary educated parents somewhat deviating from this pattern.

The country-specific descriptive analyses showed a considerable variation in the contribution of different institutional characteristics on skills. The proportion of the tertiary educated in a country was always associated with increasing skill levels. This was also true for the age of the highest educational level completed in all countries but the UK. Interestingly, this did not seem to be the case for the reforms. In seven of the 21 countries included in the data, the effect of reforms was negative after controlling for parental background.

In our hypotheses, we expected the education of the parents to contribute to skills over and above the effects of children's own education or institutional changes (Hypothesis 1). Not surprisingly, this hypothesis was supported by our findings. Even if all the educational system-related social inequalities were removed, the differences by genetic inheritance would still cause the association

between the skills of the children and parental education to remain or even become stronger (cf. Guo and Stearns, 2002).

Based on earlier research, we had a set of hypotheses on how changes in educational institutions have influenced the associations between skills, and educational and parental background. First, we had two alternative hypotheses: that changes in institutions had either weakened or strengthened the associations between origins and skills, net of origin (Hypotheses 2a and 3a). Neither of these hypotheses was supported by our analyses.

We then moved on to test hypotheses on who actually were advantaged most by the changes in educational institutions. Here we had first two working hypotheses: that either the children of the low-educated or the higher-educated parents benefited most from the changes (Hypotheses 2b and 3b). The analyses suggested that findings depended on the type of change that was considered and the groups that were compared. Increasing the proportion of the tertiary educated as well as prolonging education had the greatest effect on the skills of low-educated parents. Expanding tertiary education did not benefit the skill development of the children of parents with higher education, whereas prolonging education did so, to some extent. The pattern was almost the opposite for reforms, reducing the skill development of the children of low-educated parents but not doing much at all for the children of the tertiary educated parents.

Finally, we considered how institutional changes influenced the relationship between skills, social origins, and education. Our last two hypotheses assumed that these changes had either reduced or increased the mediating role of education for the association between skills and origin (Hypotheses 2c and 3c). Again, the results appeared to depend on the parental education group and the institutional change type. As a starting point, the analyses indicated that education benefited the

children of both the low- and high-educated parents more that those with upper secondary-level-educated parents. Taking into account changes in the institutions indicated that the children of the tertiary educated parents always benefited more from education with any types of institutional changes, also including reforms. For the children of the low-educated parents, both the expansion of the tertiary education and prolonging education made education more effective for skill development, whereas reforms actually seemed to reduce the effectiveness of education in this group.

The negative association between reforms and skills was a surprise for us. It is hard to imagine that policy-makers would have aimed for those kinds of results. The reforms covered in the indicator were limited to those aiming at removing educational dead-ends. In the previous literature (e.g., Pöyliö et al., 2018), this type of reform is often linked with the reduced importance of family background in educational attainment. It may be that the effects of removing dead-ends in skills have simply not been considered sufficiently when reform policies are implemented if the focus has been in improving the accessibility of education. The country variation in the effect of reforms suggests nonetheless that the findings vary quite a bit from one country context to another; they also vary by the reform in question. The results suggest that more detailed studies be done on the different types of educational reforms and for a closer assessment of their importance for skill development.

Our findings can also be interpreted from the point of view of the theories on family background and education. The finding of the positive association with all types of institutional changes and the effectiveness of education for tertiary educated children fits well with the idea of multiplication or the boosting effect of an advantageous family background (Erola and Kilpi-Jakonen, 2017); it also fits well with the theory of maximally maintained inequality (Raftery and Hout, 1993). The children

of the tertiary educated parents find faster ways to navigate the changing educational environments and thereby also benefit from most of them. Further, the second chances provided by the alternative routes to higher levels of education seem to be particularly accessible for the same group, indicating that there are perhaps compensatory advantages involved.

The results suggest that the growing number of reforms *harms* skill development at the lower end of the strata. This may be because multiple changes make the outcomes of the educational system particularly hard to predict without insider information about the system that tertiary-educated parents can perhaps provide. This seems to be in line with relative risk aversion theory—when the predictability of the choice becomes harder, families focus on maintaining their current status (Holm and Jæger, 2008).

On the other hand, we did not find that institutional changes having a positive direct effect on skills would lead to a growing direct effect of parental background on them. This is in contrast with the previous results on socioeconomic attainment in Europe (Pöyliö et al., 2018), and suggests that in the case of the socioeconomic attainment, the parents perhaps have a broader array of methods for influencing their children's attainment than they do in the case of skill development. Rather, it seems that both prolonging education and increasing tertiary education has effectively compensated for the skill deficiencies stemming from the family background among the children of the low-educated parents.

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Appendix. Results for numeracy skills.

Figure A1. The numeracy score by age, children's, and parents' education. Pooled PIAAC 2013 data, an OLS model with country-fixed effects.

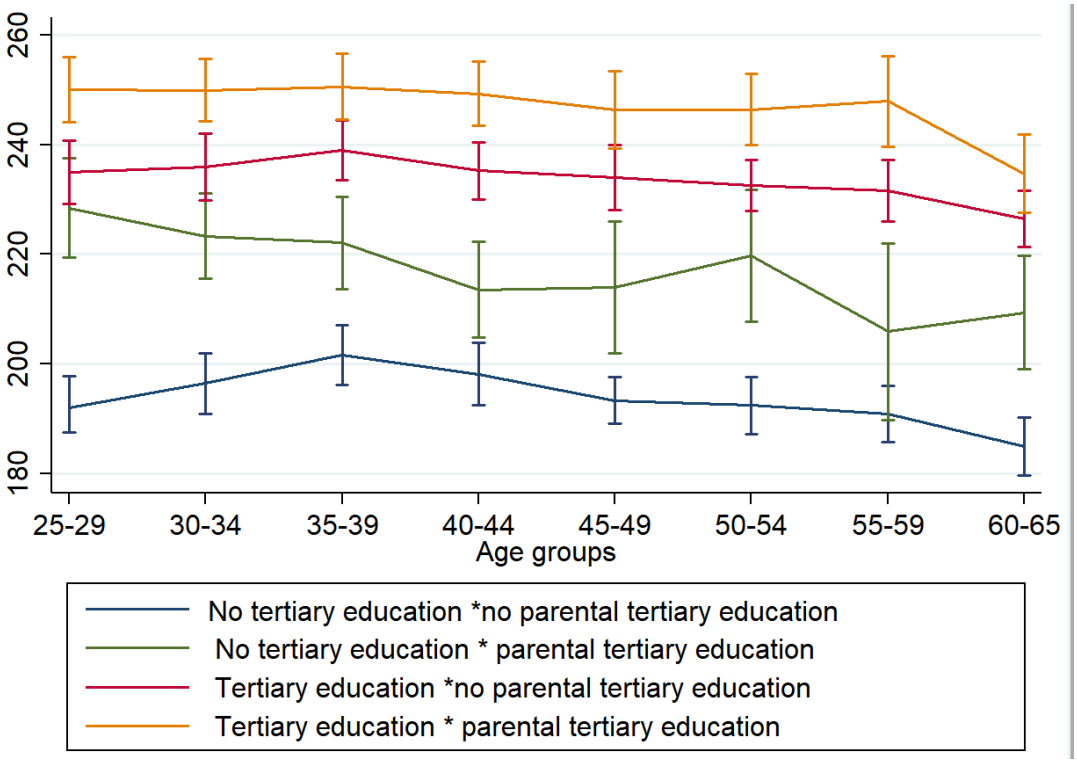

Figure A2. The change in numeracy score by the proportion of the tertiary educated by country. OLS estimates from single country models.

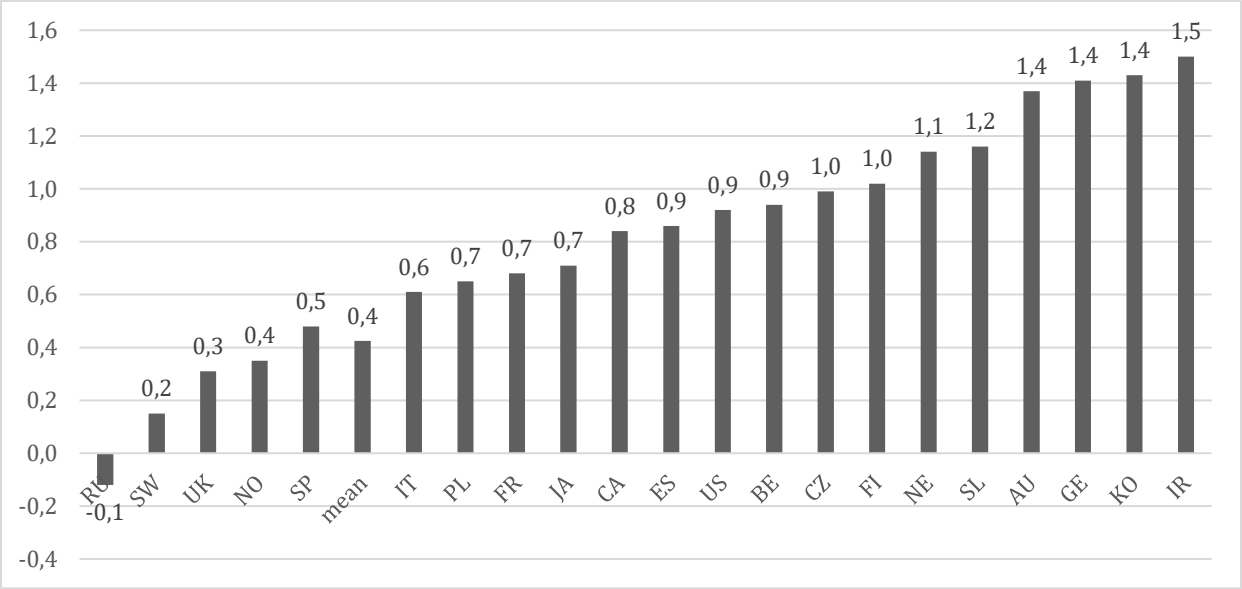

Figure A3. The change in numeracy score by the age of finishing the highest level of education by country. OLS estimates from single country models.

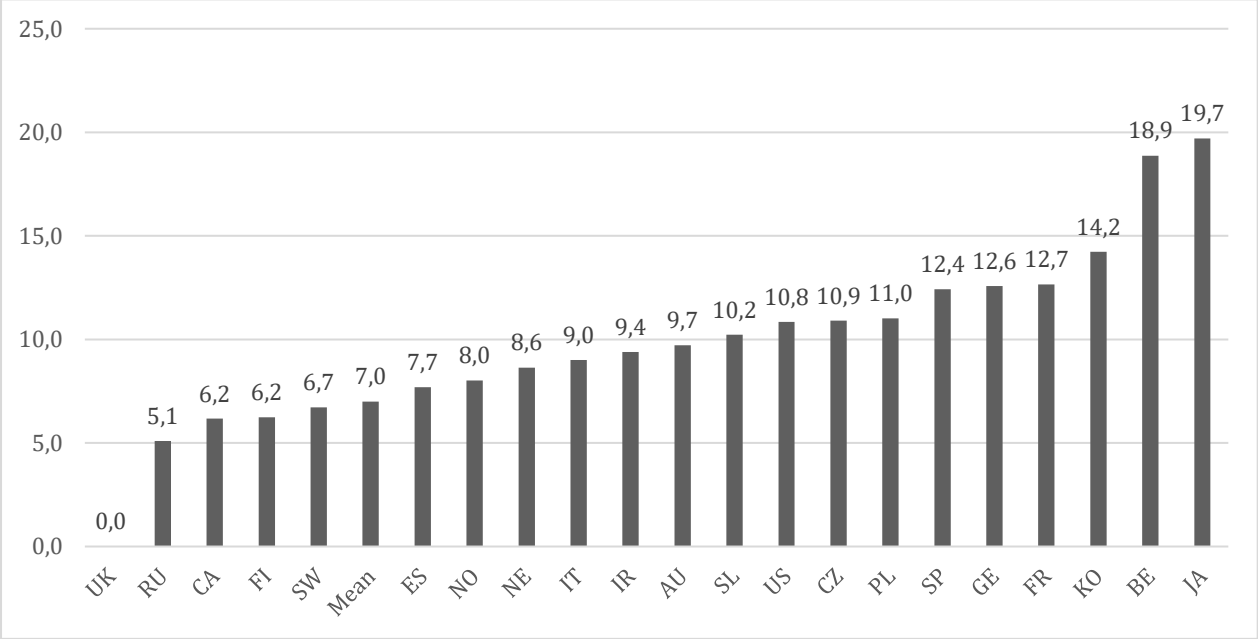

Figure A4. The change in numeracy score by the number of educational reforms. OLS estimates from single country models.

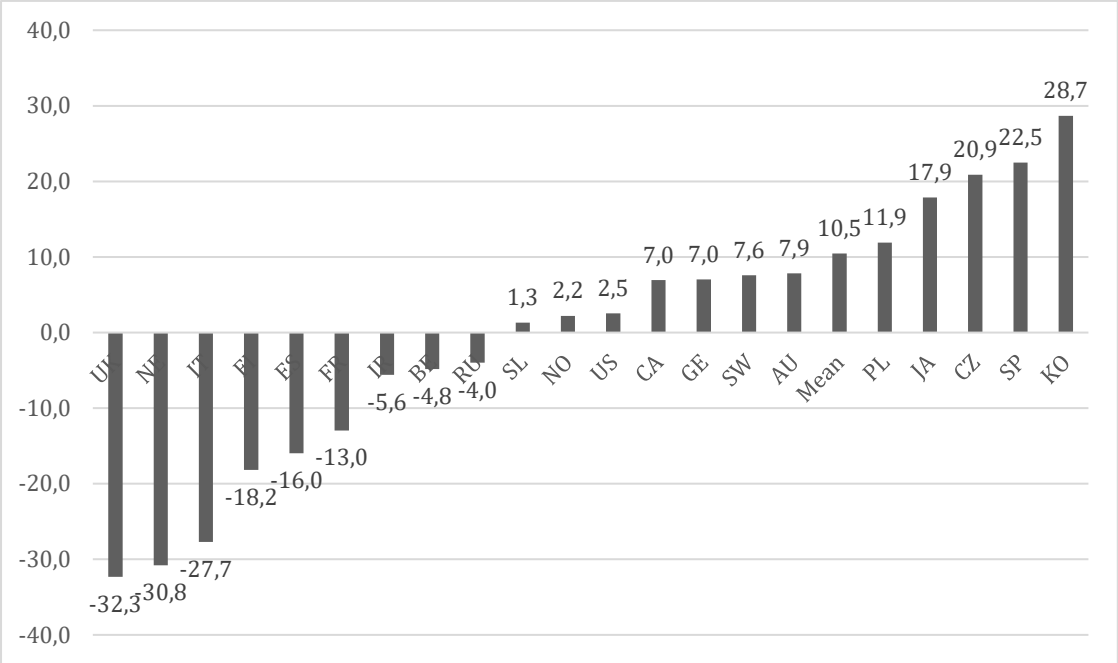

Table A2. The numeracy score by parental education, changes in educational institutions, and respondents' own education. Pooled PIAAC data, OLS with country-fixed effects.

	M1.1	M1.2	M1.3	M1.4	M1.5
Parental education					
Upper secondary [ref. Basic or less]	23.69*** (21.78 - 25.59)	22.63*** (20.63 - 24.62)	19.01*** (17.15 - 20.87)	25.65*** (23.79 - 27.50)	20.33*** (18.44 - 22.23)
Tertiary	40.67*** (38.16 - 43.18)	39.79*** (37.27 - 42.32)	33.11*** (30.68 - 35.55)	43.02*** (40.45 - 45.58)	34.76*** (32.28 - 37.24)
Proportion of tertiary education		0.41*** (0.30 - 0.53)			0.23*** (0.12 - 0.34)
Age finishing education			8.62*** (7.91 - 9.34)		9.27*** (8.56 - 9.98)
Reforms				-11.53*** (-13.60 - -9.45)	-13.20*** (-14.99 - -11.40)
Constant	264.93*** (261.58 - 268.28)	241.30*** (234.78 - 247.83)	246.25*** (242.47 - 250.03)	272.89*** (268.96 - 276.81)	240.94*** (235.40 - 246.48)

	M2.1	M2.2	M2.3	M2.4	M2.5
Parental education [ref. Basic or less]					
Upper secondary	13.16*** (11.15 - 15.17)	13.03*** (10.98 - 15.09)	12.94*** (10.97 - 14.91)	14.81*** (12.85 - 16.78)	14.70*** (12.69 - 16.70)
Tertiary	21.37*** (18.86 - 23.87)	21.42*** (18.93 - 23.91)	21.13*** (18.63 - 23.62)	23.66*** (21.08 - 26.23)	23.64*** (20.91 - 26.36)
Proportion of tertiary education		0.11* (-0.02 - 0.23)			0 (-0.13 - 0.14)
Age finishing education			1.05** (0.25 - 1.85)		2.11*** (1.33 - 2.88)
Reforms				-10.14*** (-12.34 - -7.95)	-10.71*** (-12.24 - -9.18)
Respondent's education [ref. Basic or less]					
Upper secondary	23.22*** (21.62 - 24.83)	22.85*** (21.11 - 24.58)	21.99*** (20.30 - 23.69)	24.80*** (23.25 - 26.35)	22.95*** (21.32 - 24.58)
Tertiary	51.37*** (49.31 - 53.43)	50.64*** (48.61 - 52.68)	49.13*** (46.57 - 51.68)	51.23*** (49.20 - 53.27)	47.12*** (44.80 - 49.44)
Constant	245.09*** (241.85 - 248.33)	239.32*** (232.65 - 246.00)	244.02*** (240.39 - 247.66)	251.49*** (247.77 - 255.21)	250.18*** (245.06 - 255.29)

All models have 103129 observations. *** p<0.01, ** p<0.05, * p<0.1, 95% confidence intervals in parentheses. Estimates for country fixed effects, age group, gender, GDP, GDP change and enrolment year omitted.

Table A3. The effect of the interaction among parental education and macros on numeracy competencies, controlling for tertiary education.

	M3.1	M3.2	M3.3	M4.1	M4.2	M4.3
Parental education [ref. Basic or less]						
Upper secondary	33.16***	24.72***	14.12***	21.18***	16.55***	5.12***
	(28.55 - 37.77)	(20.31 - 29.13)	(11.15 - 17.08)	(16.53 - 25.83)	(12.33 - 20.77)	(2.02 - 8.22)
Tertiary	60.37***	40.14***	27.52***	32.48***	23.03***	10.94***
	(53.16 - 67.58)	(34.00 - 46.28)	(24.10 - 30.95)	(24.98 - 39.98)	(16.72 - 29.33)	(7.43 - 14.46)
Proportion of tertiary educated	0.56***			-0.08*		
	(0.47 - 0.65)			(-0.17 - 0.01)		
Par. upper secondary *Proportion tertiary ed.	-0.22***			-0.18***		
	(-0.31 - -0.13)			(-0.27 - -0.08)		
Par. tertiary * Proportion Tertiary ed.	-0.40***			-0.24***		
	(-0.53 - -0.26)			(-0.37 - -0.10)		
Age of finishing education		10.04***			1.77***	
		(9.10 - 10.98)			(0.76 - 2.78)	
Par. upper secondary* Age of finishing ed.		-2.18***			-1.34**	
		(-3.57 - -0.80)			(-2.59 - -0.09)	
Par.tertiary * Age of finishing ed.		-2.50***			-0.75	
		(-4.15 - -0.85)			(-2.47 - 0.96)	
Reforms			-23.10***			-19.88***
			(-25.86 - -20.34)			(-22.73 - -17.04)
Par. upper secondary* Reforms			13.51***			11.62***
			(11.06 - 15.95)			(9.10 - 14.14)
Par. tertiary * Reforms			18.15***			15.16***
			(15.20 - 21.10)			(12.16 - 18.16)
Respondent's education [ref. Basic or less]						
Upper secondary				21.23***	21.67***	23.70***
				(19.53 - 22.92)	(19.92 - 23.42)	(22.16 - 25.24)
Tertiary				49.83***	48.95***	50.55***
				(47.74 - 51.93)	(46.36 - 51.53)	(48.50 - 52.60)
Constant	235.25*** (229.70 - 240.80)	242.62*** (238.33 - 246.90)	282.99*** (278.90 - 287.07)	253.72*** (249.74 - 257.69)	242.38*** (238.41 - 246.35)	260.52*** (256.41 - 264.63)

All models have 103129 observations. *** p<0.01, ** p<0.05, * p<0.1, 95% confidence intervals in parentheses. Estimates for country fixed effects, age group, gender, GDP, GDP change and enrolment year omitted

Table A4. The mean differences in the estimates of parental education and institutional change variables for numeracy before and after controlling for the level of education of the respondents

	M1.1 vs. M2.1	M1.2 vs. M2.2	M1.3 vs. M2.3	M1.4 vs. M2.4	M1.5 vs. M2.5
Parental education [ref. Basic or less]	19,84	1,98	2,23	21,40	-9,24
	(19.37 - 19.95)	(2.13 - 1.83)	(2.08 - 2.37)	(21.19 - 21.6)	(-9.66 - -8.81)
Upper secondary	10,53	9,06	6,07	10,84	5,63
	(10.63 - 10.42)	(9.65 - 9.53)	(6.18 - 5.96)	(10.94 - 10.72)	(5.75 - 5.53)
Tertiary	19,30	18,37	11,98	19,36	11,12
	(19.3 - 19.31)	(18.34 - 18.41)	(12.05 - 11.93)	(19.08 - 19.35)	(11.37 - 10.88)
Difference in difference, parental education					
Tertiary vs. Upper secondary	8,77	9,31	5,91	8,52	5,49
	(9.33 - 9.11)	(8.87- 8.88)	(5.87 - 5.97)	(14.11 - 8.63)	(5.62 - 5.35)
Basic or less vs. Upper secondary	9,31	-7,08	-3,84	10,56	-14,87
	(8.74 - 9.53)	(-7.52 - -7.7)	(-4.1 - -3.59)	(10.25 - 10.88)	(-15.41 - -14.34)
Institutional change variables					
Proportion of tertiary education		0,30			0,23
		(0.28 - 30)			(0.01- 0.2)
Age of finished education			7,57		7,16
			(7.76 - 8.08)		(7-23 - 7.10)
Reforms				-21,67	-23,91
				(-25.34 - -17.4)	(-27.23 - -20.58)