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Adult skills and labor market conditions during teenage years: cross-country evidence from international surveys

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Abstract

Do individuals finishing compulsory school in economic downturns end up with higher skills in adulthood than comparable individuals that finish compulsory school in economic upturns? This article answers this question by exploring data on country unemployment rates combined with individual data on educational attainment and adult skills in numeracy and literacy from the Program for the International Assessment of Adult Competencies. We find that completed education is countercyclical, and the same pattern is found for adult skills in numeracy and literacy. The results are fairly robust across different model specifications including fixed country and cohort effects and country-specific cohort trends. The results indicate that the labor market conditions at the time when young people make crucial educational decisions have long-lasting effect on skills and potential earnings in adulthood.

JEL classifications: E24, I21, J24

1. Introduction

It is well known that recessions have direct short-run costs in terms of output lost and potential long-run cost because workers who are unemployed for a long period lose skills and hence decrease the production capacity in the future. However, there are also some mechanisms that may work in the other direction. According to Barr and Turner (2013), college enrollment in the USA increased by more than 2.5 million students during the great recession from 2007 to 2010 and indicates counteracting effects in terms of increased propensity to enroll in post-secondary schooling during recessions. This and similar experiences from other countries and time periods combined with the fact that human capital is a crucial determinant of economic growth suggest the need for more knowledge of the relationship between human capital accumulation and the business cycle conditions when young people make critical educational choices. This article contributes to the literature by providing

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cross-country evidence on the potential long-run effects on cognitive skills measured in adulthood of high unemployment during teenage years.

The human capital model as formulated by Becker (1964) suggests that educational investments decrease (increase) in business cycle upturns (downturns) due to higher (lower) opportunity costs of education. This opportunity cost effect may be counteracted by an income effect if the existence of credit constraints makes the number of families affording post-compulsory education to vary pro-cyclically. However, the majority of empirical studies suggest that educational attainment is countercyclical. Studies mostly from UK and USA find that high school and college enrollment increases when regional unemployment as measured when students are 16–18 years old, increases, see Betts and McFarland (1995), Dellas and Sakellaris (2003), and Clark (2011). Similarly, using regional panel data on upper secondary school completion and regional unemployment from 1981 to 2004, Reiling and Strøm (2015) find that completion of upper secondary education in Norway is countercyclical. In addition to these short-run effects, another strand of the literature has studied how labor market conditions affect the choice of major in college and long-run outcomes as income in adulthood.[1] An important question is to what extent countercyclical patterns in enrollment and subsequent educational choices and later income gains are reflected in similar patterns in adult cognitive skills. Except for Emery *et al.* (2012), all previous studies of the relationship between educational investments and business cycles have used formal education levels as outcome variables. Our study using cross-country data represents an extension and generalization of the analysis in Emery *et al.* (2012) who consider the effect of a specific labor market shock (1973–81 oil price shock) on short-run and long-run educational outcomes and skills in a specific country (Canada).

Research in the last decade suggests that direct skill measures accounting for quality such as test scores and traditional skill measures in quantitative terms (years of schooling) contributes equally to economic growth differences across countries as well as across US states, see Hanushek and Woessmann (2012) and Hanushek *et al.* (2017). Thus, an important question is to what extent the countercyclical pattern found in acquisition of formal education translates into a similar pattern in adult skills. This article extends the literature by providing cross-country empirical evidence on the effect of unemployment rates during a person's teenage years on adult cognitive skills.

Traditional human capital theory deals with demand side effects of business cycles through changed individual opportunity cost of education and changes in the bite of credit constraints. In addition to the traditional effects via returns to education and opportunity costs, business cycles may also directly affect students' effort in school. Supply side effects may also be important. While first-order demand effects due to opportunity costs (possibly modified by income effects, student effort effects and supply side effects) can plausibly predict countercyclical patterns in enrollment in post-compulsory education, it is an open question whether this quantity effect is mirrored by a similar pattern in cognitive skill quality as measured in adulthood. Asked differently: will individuals that happen to finish compulsory school in an economic downturn, end up with more years of completed education and higher cognitive skills in adulthood than comparable individuals that finish compulsory school in an economic upturn?

1 See for example Emery *et al.* (2012), Bensnes and Strøm (2019), Cascio and Nayaran (2020), Weinstein (2020), and Blom *et al.* (2021).

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First, it is possible that temporal change in opportunity cost and returns to education only affect the timing of educational investments, and not the final level as measured in adulthood. Individuals leaving education at a young age due to high opportunity costs induced by a business cycle upturn may compensate by taking more formal and informal education as adults. Second, business cycles can affect the quality composition of students enrolling in post-compulsory education. If a business cycle downturn generates enrollment of many weak students in terms of motivation and initial skills into post-compulsory education, the effect of business cycle conditions on completed education and in particular on skills measured in adulthood may be small or nonexisting.

Data on adult competencies from the Organization for Economic Cooperation and Development (OECD) by the Program for the International Assessment of Adult Competencies (PIAAC) and earlier data from the study of Adult Literacy and Life Skills (ALL) study make it possible to provide cross-country evidence on this issue. We explore individual data on completed education and adult competencies in literacy and numeracy matched with cross-country data series on national unemployment rates to study the effect of business cycle conditions at the age of 16–18 years on both completed education and adult skills in terms of competency in literacy and numeracy. In this way, the article represents an extension of previous national studies of the relationship between post-compulsory school enrollment and business cycles.

Credit-constrained families may experience increased resources available during economic upturns which can mitigate a general countercyclical pattern in enrollment in post-compulsory education. It is possible that families with high educated parents are less likely to be credit-constrained than families with low educated ones. As a further contribution, we therefore study whether the relationship between educational attainment and cognitive skills, and unemployment in teenage years depends on parental education.[2]

We find a statistically and economically significant countercyclical pattern in both completed education and measured cognitive skills. This pattern is fairly robust across a series of empirical specifications including country-specific trends in addition to individual controls and country and cohort-fixed effects. The results suggest that 5 percentage point increase in country unemployment at the age of 16–18 years leads to an increase of 0.1 years of completed education. Furthermore, the estimated effect on measured skills implies that 5 percentage points increase in country unemployment as young increase numeracy test scores by a statistically significant 7.5% of a standard deviation. The countercyclical patterns are most pronounced for individuals with highly educated parents.

The article is organized as follows: Section 2 presents a short overview of the theoretical background in addition to a review of the existing empirical literature. Section 3 presents the empirical strategy and describes the data. Empirical results follow in Section 4, while Section 5 concludes.

2 Alessandrini (2018) uses Canadian data and show that unemployment stimulates university enrollment especially among individuals with highly educated parents. Christian (2006) uses US data and find no differences in the cyclicality of enrollment with respect to households home-owning status, while enrollment appears to be more procyclical among people in households expected to have lower income.

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2. Theoretical issues and literature review

2.1 Theoretical background

The basic human capital model formulated by Becker (1964) is a natural point of departure for an analysis of the relationship between educational attainment and skills in adulthood and labor market conditions at a young age when important educational choices are made. According to the model, individuals increase their education up to the point when the benefit in terms of expected net future earnings premium is higher than the cost in terms of expected foregone earnings (opportunity cost) and eventual direct costs. In this framework, a business cycle upturn (downturn) in terms of low (high) unemployment rate increase (decrease) the opportunity cost and leads to a countercyclical pattern in educational attainment. However, if families are credit constrained, this opportunity cost effect may be counteracted by the increased (decreased) probability for families to afford further education for their children in economic upturns (downturns). Thus, allowing for credit constraints makes the prediction from the demand side human capital approach ambiguous. Beyond the effects predicted by the traditional human capital model, cohorts experiencing a recession may work harder to obtain better grades and exert the effort necessary to gain employment, as noticed in Bicakova *et al.* (2021) and building on research in social psychology.

However, the supply side in the educational market may also affect the relationship between realized educational attainment and the labor market conditions. One possibility is those funds available for education and other public services decrease (increase) in a downturn (upturn) because of decreasing (increasing) tax revenue leading to reduced access to study places in post-compulsory education. However, an active government may actively try to counteract the impact of economic downturns by increasing expenditure on education and other services typically provided by the public sector. If this is the case, more people may gain access to post-compulsory education in a downturn than in an upturn. Thus, supply side responses may moderate the demand-induced countercyclical pattern in educational attainment as measured by years of education.

While first-order demand effects possibly moderated by supply effects may lead to countercyclical enrollment patterns in post-compulsory education, the natural question to ask is whether this also means a countercyclical pattern in skills in adulthood. Framed differently: is it the case that individuals that happen to finish compulsory school in an economic downturn end up with more years of completed education and higher skills in adulthood than comparable individuals that finish compulsory school in an economic upturn? This is the question we want to answer in this article. Several mechanisms may be at work. First, individuals leaving education at a young age due to high opportunity costs induced by a business cycle upturn may compensate by taking more formal and informal education as adults. Second, business cycles can affect the quality composition of students enrolling in post-compulsory education. If a business cycle downturn generates enrollment of many weak students in terms of motivation and initial skills into post-compulsory education, the effect of business cycle conditions on completed education and skills measured in adulthood may be small or nonexisting. Due to these possible timing and composition mechanisms, it is thus an empirical question to what extent countercyclical enrollment in post-compulsory education typically found in the literature, translates into completed education and skills in adulthood.

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2.2 Review of existing empirical evidence

Several studies examine the impact of business cycle conditions on enrollment, both in high school and higher education, as well as completed education and further outcomes. This section reviews the literature.

US evidence in Card and Lemieux (2001) and Black *et al.* (2005) and UK evidence in Rice (1999) and Clark (2011) all suggest a countercyclical pattern in high school enrollment, although the quantitative effects differ. The effect in terms of the elasticity of enrollment with respect to unemployment varies from 0.3 (Clark, 2011) to 0.05 (Card and Lemieux, 2001). Reiling and Strøm (2015) use regional panel data on upper secondary school completion and regional unemployment from 1981 to 2004 and find that completion of upper secondary education in Norway is countercyclical. Their results imply an elasticity of completion with respect to unemployment of approximately 0.04.

Enrollment into higher education also appears to be positively associated with unemployment in the USA, as shown in Betts and McFarland (1995), Dellas and Sakellaris (2003), and Bedard and Herman (2008), and in Sweden as shown in Fredriksson (1997). The results in Betts and McFarland imply enrollment elasticities of 0.4 and 4 with respect to youth and total unemployment, respectively. The Swedish results imply comparable enrollment elasticities of 0.24 and 0.16 (own calculations based on results in Fredriksson (1997), Columns 2 and 3 in Table 1, p. 137). Charles *et al.* (2018) use across-city variations in housing booms in the USA and find positive employment effects and a subsequent reduction in college enrollment.

Countercyclical enrollment has also motivated the use of regional unemployment rates at the time of leaving compulsory education as instruments for schooling in studies of the returns to education, as in Arkes (2010) and Carneiro *et al.* (2011). The first stage equation in Arkes' analysis indicates that one percentage point increase in state unemployment increases completed education by a statistically significant 0.04 years.

A growing literature following Black *et al.* (2005) studies how booms and busts in natural resource industries during adolescence affect short-run educational outcomes as well as long-run outcomes like educational attainment, wages, and employment in adulthood. Emery *et al.* (2012) find that expanding petroleum activity in Canadian provinces in the 1990s increased dropout rates in the short run, while leaving educational attainment, cognitive skills, and wages nearly unchanged in the long run. Cascio and Narayan (2020) show that the introduction of fracking technology in oil production in the USA increased school dropout, while Marchand and Weber (2020) find that student achievement in terms of test scores decreased following the Texas boom in shale oil and gas drilling.

Other studies have examined the impact of changed labor market opportunities in the retail industry originating from removal of opening hours restrictions. Lee (2013) finds that repealing Sunday closing laws in some US states increased school dropout and reduced subsequent earnings. Bensnes and Strøm (2019) find that increased opening hours in the Norwegian retail industry led to increased employment opportunities for young unskilled workers, significant drop in high school completion and years of schooling, but a modest drop in earnings in adulthood.

Furthermore, recent studies demonstrate that labor market conditions at enrollment have important effects on choice of major in college that contributes to subsequently improved labor market performance, see and Han and Winters (2020), Weinstein (2020), Bicakova *et al.* (2021), and Blom *et al.* (2021). Allesandrini (2018) shows that

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unemployment especially stimulates university enrollment of individuals with highly educated parents and thus contributes to reduced social mobility. The focus on the effect on enrollment and choice of major in these studies modifies the results in previous studies finding negative effects of entering the labor market in recessions on outcomes later in life, see Oreopoulos *et al.* (2012) for Canada, Kahn (2010) for the USA, Genda *et al.* (2010) for USA, and Japan and Raaum and Røed (2006) for Norway.

To sum up, while numerical effects vary a lot, most studies find recessions in adolescence to increase enrollment into post-compulsory education and selection of majors in higher education that may have positive effects on later labor market performance. However, few studies available so far provide evidence on whether this pattern is accompanied by similar patterns in measured skill in adulthood which is the focus of this article.[3]

3. Data description and empirical specification

3.1 Empirical specification

We want to investigate the influence of unemployment on different outcomes within a cross-country framework. As argued above, both theory and empirical evidence indicates that enrollment in post-compulsory education is countercyclical, while the research question we ask is to what extent this pattern translates into a similar pattern in adult skills. Our baseline approach is to link unemployment to a set of educational attainment and cognitive skills measures in adulthood in a reduced form framework.

To investigate the research questions proposed in the introduction, we estimate variants of the reduced form relationships as formulated in Equation (1).

$$y_{icj} = \alpha_0 + \alpha_1 - \text{UNEMP}(16-18)_{\text{cj}} + Z_{cj}\alpha_2 + X_{icj}\ \alpha_3 + \beta_c + \gamma_j + \varepsilon_{icj} \quad (1)$$

y_{icj} represents our outcome variables; the number of years of formal education and cognitive skills in numeracy and literacy that individual i of cohort j in country c has obtained as measured in PIAAC. In models using data extended by the survey in ALL, we also add a survey dummy.

The variable of main interest is $-\text{UNEMP}\ (16-18)_{\text{cj}}$. This variable is our indicator of business cycle conditions and measures the mean unemployment in the 3 years when individuals of cohort j in country c are between 16 and 18 years old. X_{ijc} is a (row) vector of individual control variables with α_3 as the corresponding coefficient vector. In order to interpret the effect of unemployment as causal and avoid the 'bad control problem', we include a limited set of individual controls and only include variables that are arguably determined at the time the individual was born.[4] Thus, the individual controls include dummy variables for mothers' education, fathers' education, and gender and dummy variables for parents being born in country. The dummy variable for parental education takes the value 1 if mother (father) has an education level above high school, and it takes the value 0 if mother's (father's) highest education level is high school or below. The gender dummy takes the value 1 if the individual is a male.

Many studies find that reforms changing the compulsory school length affects length of schooling and subsequently other outcomes, see Oreopoulos (2006) and Black *et al.* (2005) among others. If the length of compulsory schooling varies between cohorts within the

3 One exception is Emery *et al.* (2012) on the effect of booms in the oil and gas industry in Canada.

4 See Angrist and Pischke (2009, pp. 64–68) for a discussion of the 'bad control problem'.

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country over time and is correlated with the unemployment rate at the age of 16–18 years, our estimates would be biased. To avoid this, we include a (row) vector of indicator variables Z_{cj} representing the length of compulsory schooling that individuals of cohort j in country c experienced. α_2 is the corresponding coefficient vector. Brunello *et al.* (2009) and Murtin and Viarengo (2011) document the reforms that have taken place in Western countries. Our indicator variables contained in the Z_{cj} vector is based on this information. Supplementary Appendix Table A1 presents an overview of the education system for the countries represented in our study.

β_c and γ_j refer to the fixed country and cohort effects, respectively, and are included in all variants of the model. By including these fixed effects, we purge our regressions of omitted unobservables that are fixed over time within countries as well as omitted unobservables that affect individuals in cohorts over time in all countries. However, we are still concerned that changing characteristics of the countries that could be correlated with unemployment are omitted from the model. As we exploit unemployment data that covers a long period—from 1960 to 2002—in subsequent specification checks, we add country-specific linear and quadratic cohort trends to the model in an attempt to capture as much as possible of the influence of omitted country-specific variables that evolve over time. The estimated standard errors reported in the results sections in the main text are clustered at the country level.[5]

3.2 Data sources

We exploit three sources of data in this study: our primary data source on cognitive skills and education is PIAAC data. To increase the number of observations, PIAAC data are extended with ALL data for some countries. The source for unemployment data is the OECD Annual Labor Force Statistics (ALFS) database.

PIAAC and ALL are both surveys that are designed to measure the level and distribution of adult cognitive skills across countries for a representative sample of the adult population, including individuals at the age of 16–65 years. PIAAC was conducted in 23 countries in 2011.[6] ALL was undertaken in 2003 and 2006 in 10 countries.[7] PIAAC provides links to ALL in the domain of literacy and in the domain of numeracy. While PIACC data are primary data source, this make it possible to pool the two data sets in order to enlarge the

5 It is a question whether clustering at the country level is the appropriate method; see the arguments in Abadie *et al.* (2017). Clustering at the country level may not be appropriate if the sampling is clustered within each country. It appears that the sampling design in the surveys we use varies across countries with some countries using a non-clustered sampling design while others have used a multistage sampling design based on clusters, see the description in Chapter 14 in OECD (2013b). Since the sampling design varies across countries, we have chosen to follow the empirical literature using these type of data, that is, Hanushek *et al.* (2015) and clustered standard errors at the country level. Estimated standard errors without adjusting for clustering are smaller as expected and these results are available from the authors on request.

6 Participating countries in the first round of PIAAC are: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, Finland, France, Germany, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Poland, Russian Federation, Slovak Republic, Spain, Sweden, UK, and USA.

7 Participating countries in ALL (2003) are: Bermuda, Canada, Italy, Norway, Switzerland, the USA and, the Mexican State of Nuevo Leon; and in (2006): New Zealand, the Netherlands, and Hungary.

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number of observations in the analysis of skills and to investigate the robustness of our results. In addition to the measure of skills, both surveys include background information such as educational attainment, family background, and outcome variables such as labor market status and income.

To measure unemployment, we use the rate of unemployment as percent of civilian labor force. By using the civilian labor force instead of total labor force, the comparability between OECD countries increases. The main reason for this is that, in a majority of OECD Member countries, labor force surveys only cover private households.[8]

3.3 Restrictions to the sample

In order to match data on adult competencies with cross-country data on unemployment at the time when the individuals were approximately 16–18 years old, we restrict our sample to include the countries with information about unemployment, as well as exact information about the respondent's age.[9] This restriction excludes Austria, Canada, Germany, and the USA where the publicly available data files, we used only include age intervals for the respondents. This gives us a sample consisting of 14 countries.

As we can see from Table 1, we have a sample of 12 countries if we only use PIAAC data. By adding ALL data to the sample, we extend the sample to include two extra countries, and we add extra observations to three of the countries that are present in the PIAAC sample.

Furthermore, we only include the individuals that are born in the country. This excludes immigrants from the sample. By this sample restriction, we include in the sample only individuals that are likely to have been exposed to the country's educational system and labor market conditions during their educational career. As we are interested in how unemployment at the age of 16–18 years affects investment in education and long-term cognitive skills, we also restrict our sample to include only individuals that were 25 years or older at the time of the survey. This captures the idea that most of the individuals have finished education by the age of 25 years. Although we also have information about education activity at the time of the survey, we do not exploit this information as this is a potential outcome variable. Since we only use unemployment rates from 1960 and onwards, this excludes the oldest respondents in the ALL data set. Thus, the oldest respondent from the ALL dataset is 62 years old.

3.4 Data description

The PIAAC survey is our primary data base and assesses cognitive skills in three domains: numeracy, literacy, and problem-solving in technology-rich environments (PS-TRE). Our primary choice is to use numeracy as our skills measure similar to Hanushek *et al.* (2015) among others. In robustness checks, results are also shown for literacy.[10] According to OECD (2013a), PIAAC uses the following definition of literacy and numeracy domains

8 See the full documentation of the ALFS Summary tables, OECD: http://www.oecd.org/employment/labour-stats/2771299.pdf, last assessed 12 May 2021.

9 The information about the respondent's age at the time of testing together with the year the survey was undertaken makes it possible to calculate the year of birth, and further calculate the years the respondent was 16–18 years old.

10 We have chosen not to use the domain PS-TRE partly because Spain, Italy and France did not participate in this domain and partly because individual respondents were allowed to opt out of the PS-TRE test, see also Hanushek *et al.* (2015, p. 113). We also follow Hanushek *et al.* (2015) and use plausible value 1 to represent the skills.

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Table 1. List of countries in our sample

Country	Survey data source
Belgium	PIAAC
Denmark	PIAAC
Finland	PIAAC
France	PIAAC
Ireland	PIAAC
Italy	PIAAC and ALL
Japan	PIAAC
Netherlands	PIAAC and ALL
New Zealand	ALL
Norway	PIAAC and ALL
Spain	PIAAC
Sweden	PIAAC
Switzerland	ALL
UK	PIAAC

competences. Literacy: 'The ability to understand, evaluate, and engage with written texts to participate in society to achieve one's goals and to develop one's knowledge and potential'. Numeracy: '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 real life'. Since the number of countries and observations are somewhat limited when using PIAAC data only, we also provide results when ALL data from some countries are added to the PIAAC data. PIAAC provides links to ALL in the domain of literacy and in the domain of numeracy. We, therefore, focus only on these two types of adult competencies. The definition and assessment of numeracy are fairly equal in PIAAC and ALL. PIAAC defined literacy more broadly than ALL, encompassing the domains of prose and literacy which were assessed separately in ALL. Moreover, in PIAAC literacy include the reading of digital texts in addition to the print-based used in ALL, see pp. 9–10 in Paccagnella (2016).[11] Tables 3 and 4 provide descriptive statistics for the PIAAC sample and the merged PIAAC and ALL sample, respectively.

Using only PIAAC data, the pooled sample of all 12 countries, has a total of 47,054 observations. Sample size for each country varies between 2,860 for Sweden and 4,868 for Denmark. Information about the length of formal education is available in the PIAAC data set. Table 2 shows the distribution of years of schooling between countries for respondents above the age of 25 years. As we can see, mean length of education varies between a minimum of 11.5 for Spain, and a maximum of 14.8 for Ireland. To facilitate comparison with other data sources, Table 2 also add estimated years of education in the database in Barro and Lee (2013).[12] As we can see from the table, there are both some within and between country variations.

11 We use the average of prose and document to measure literacy in ALL data.

12 The numbers taken from Barro and Lee (2013) are estimated years of education for 5-year intervals and the numbers reported here are the estimates for 2010, downloaded from http://www.barrolee.com/, last assessed 12/05/2021

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Table 2. Descriptive statistics—PIAAC sample

	Pooled	Italy	Netherlands	Norway	Belgium	Denmark	Finland	France	Ireland	Japan	Spain	Sweden	UK
Unemployment (16–18)	6.41	9.05	5.33	2.79	7.67	4.62	6.10	5.80	10.14	2.37	12.70	3.61	6.41
	(4.78)	(2.34)	(3.51)	(1.55)	(4.07)	(3.25)	(4.21)	(3.07)	(4.38)	(1.08)	(7.56)	(2.50)	(3.20)
Years of formal education	13.07	11.83	13.54	14.65	12.67	13.27	12.89	11.88	14.83	13.45	11.48	12.83	13.42
	(3.12)	(4.01)	(2.52)	(2.32)	(2.87)	(2.57)	(3.09)	(3.55)	(3.36)	(2.31)	(3.71)	(2.37)	(2.33)
Share of mothers with education above high school	0.11	0.03	0.07	0.17	0.12	0.16	0.09	0.10	0.10	0.18	0.05	0.22	0.12
	(0.32)	(0.17)	(0.26)	(0.37)	(0.33)	(0.36)	(0.29)	(0.30)	(0.30)	(0.38)	(0.21)	(0.41)	(0.32)
Share of fathers with education above HS	0.16	0.05	0.18	0.25	0.17	0.19	0.11	0.14	0.11	0.23	0.09	0.23	0.15
	(0.36)	(0.21)	(0.38)	(0.43)	(0.38)	(0.39)	(0.32)	(0.34)	(0.31)	(0.42)	(0.29)	(0.42)	(0.36)
Share of mothers born in country	0.96	0.99	0.96	0.97	0.96	0.97	0.99	0.91	0.97	0.99	0.99	0.93	0.92
	(0.19)	(0.11)	(0.20)	(0.18)	(0.20)	(0.16)	(0.10)	(0.28)	(0.18)	(0.07)	(0.12)	(0.26)	(0.27)
Share of fathers born in country	0.96	0.99	0.96	0.98	0.96	0.98	0.99	0.90	0.97	0.99	0.99	0.94	0.92
	(0.19)	(0.09)	(0.19)	(0.15)	(0.20)	(0.14)	(0.10)	(0.30)	(0.17)	(0.08)	(0.11)	(0.24)	(0.26)
Age	45.63	44.03	46.47	45.39	45.65	49.61	45.85	45.98	44.14	45.42	43.91	46.30	44.16
	(11.43)	(10.20)	(11.38)	(11.38)	(11.31)	(11.34)	(11.70)	(11.58)	(11.43)	(11.55)	(10.65)	(11.91)	(11.31)
Share male	0.48	0.49	0.49	0.52	0.50	0.50	0.51	0.49	0.46	0.47	0.49	0.51	0.41
	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.49)
Years compulsory schooling	8.93	9	9.65	8.58	9.58	8.12	7.56	9.64	8.75	9	7.59	8.87	10.76
	(1.33)	(0)	(1.24)	(0.82)	(1.96)	(0.99)	(1.50)	(0.77)	(0.43)	(0)	(0.81)	(0.34)	(0.43)
Literacy score	278.48	257.32	287.60	288.15	278.45	274.66	291.57	268.40	269.48	297.97	253.86	291.37	284.30
	(46.12)	(43.37)	(44.53)	(41.20)	(45.32)	(42.75)	(47.77)	(45.57)	(46.17)	(39.29)	(48.36)	(41.58)	(42.53)
Numeracy score	276.25	254.63	285.80	291.17	283.57	285.56	287.99	264.00	258.27	291.56	248.15	293.08	274.30
	(50.80)	(49.49)	(46.27)	(47.09)	(49.58)	(46.83)	(48.70)	(52.88)	(52.22)	(42.88)	(50.88)	(46.14)	(47.90)
Observations	47041	3338	3722	3385	3565	4868	4178	4163	3989	4114	4033	2860	4826
Years of education (Barro and Lee (2013)	11.19	9.54	11.60	11.80	10.78	11.53	10.21	10.64	12.20	11.52	10.3	11.89	12.32

Note: Means, standard deviations (in parenthesis) and number of observations for the variables used in our baseline regression. The samples consist of respondents above the age of 25 years that are born in the country.
Source: Authors' calculations and estimated years of education for 5-year intervals for 2010 from Barro and Lee (2013).

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Table 3. Descriptive statistics—merged PIAAC and ALL sample

	Pooled	Italy	Netherlands	Norway	Switzerland	New Zealand
Unemployment (16–18)	5.89	8.75	5.43	2.63	0.58	3.50
	(4.62)	(2.37)	(3.64)	(1.58)	(0.79)	(3.28)
Share of mothers with education above high school	0.11	0.02	0.08	0.15	0.07	0.19
	(0.31)	(0.15)	(0.27)	(0.36)	(0.25)	(0.39)
Share of fathers with education above high school	0.16	0.04	0.19	0.23	0.24	0.13
	(0.36)	(0.20)	(0.39)	(0.42)	(0.42)	(0.34)
Share of mothers born in country	0.95	0.99	0.96	0.97	0.81	0.88
	(0.21)	(0.12)	(0.20)	(0.17)	(0.39)	(0.33)
Share of fathers born in country	0.96	0.99	0.97	0.98	0.84	0.85
	(0.24)	(0.09)	(0.18)	(0.14)	(0.36)	(0.36)
Age	44.64	41.62	45.39	43.46	41.36	42.78
	(11.09)	(9.51)	(10.77)	(10.64)	(8.66)	(10.39)
Share male	0.48	0.48	0.47	0.51	0.49	0.42
	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.49)
Years of compulsory schooling	8.98	9	9.49	8.50	8.73	10
	(1.22)	(0)	(1.13)	(0.87)	(0.44)	(0)
Literacy score	278.38	244.07	288.50	296.60	283.83	286.18
	(47.31)	(51.49)	(40.67)	(41.98)	(36.40)	(42.80)
Numeracy score	277.08	245.09	291.08	293.63	297.21	278.79
	(50.65)	(50.31)	(43.98)	(44.10)	(36.93)	(48.57)
Observations	64,324	7,268	7,672	6,735	2,557	3,496

Note: Means, standard deviations (in parenthesis) and number of observations for the variables used in our baseline regression. The samples consist of respondents above the age of 25 years that are born in the country.
Source: Authors' calculations.

Respondents in Japan (Sweden) achieve the highest average literacy (numeracy) score, and respondents in Spain lowest for both type of skills. When we merge data from PIAAC with ALL (Table 3), then Italy is the country with the lowest average literacy and numeracy score, and Norway (Switzerland) is the country with the highest average literacy (numeracy) score. The average pooled numeracy and literacy scores are only slightly changed when ALL data are appended to the PIAAC sample.

To increase comparability over countries, we normalize the score (both numeracy and literacy) to have a mean of zero and standard deviation one, within each country and survey (ALL and PIAAC).

Our main variable of interest is the country unemployment rate when the individuals were 16–18 years old. Figure 1 shows the development in the unemployment rate for the countries in our sample in the relevant period from 1960 to 2002. From the graphs, we see that the development in unemployment varies between countries over the relevant period, but the main picture is that unemployment is quite flat for most countries from 1960 until 1970. In Supplementary Appendix Table A2, we report some descriptive statistics on the unemployment rates. It turns out that most countries experienced substantial variations in unemployment in the post-1970 period, partly due to the macroeconomic shocks induced by the increase in energy prices in the 1970s (OPEC I) and 1980s (OPEC II) . Furthermore, some countries experienced marked unemployment increases in the 1990s, for example, Finland due to the collapse of the Soviet Union.

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Fig. 1. The development in unemployment rates (%) for the period 1960–2002.

Importantly, for our empirical strategy, there are substantial variations in the timing of unemployment shocks across countries. To illustrate, while the unemployment rate was at an average of 3.8% (4.7%) and 2.2% (2.7%) in Finland (Sweden) in the 1971–9 and 1980–9 periods, respectively, it increased dramatically to 11.9% (7.5%) in the period 1990–2002. In comparison, the unemployment rate in UK increased from an average of 3.9% in 1970–1979 period to 9.87% in the 1980–1989 period and subsequently decreased to an average of 7.4% in the 1990–2002 period. These numbers show that there is substantial variation across countries in the unemployment variable, which is a necessary condition for obtaining credible estimates for the unemployment effect on the outcome variables using our empirical strategy.

4. Empirical results

4.1 Completed formal education

We start out by investigating the relationship between unemployment and the number of years of completed formal education using the PIAAC dataset. Table 4 presents the results for three different specifications. The model in Column (1) does not include trends, while Column (2) extends the model to include linear and quadratic country-specific cohort trends to capture possible omitted country-specific variables evolving in a smooth fashion over time. In Column (3), we include the interaction between parental education and unemployment to the specification in Column (2) in order to investigate the hypothesis that unemployment effects on formal education completed are heterogeneous with respect to parental education.

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Table 4. The effect of unemployment at the age of 16-18 years on completed formal education

	Years of formal education		
	(1)	(2)	(3)
Unemployment (16–18)	0.0712**	0.0430**	0.0304*
	(0.0260)	(0.0162)	(0.0144)
Parent's ed. Ref. cat.: ed. below high school			
Mother's education: above high school	0.891***	0.997***	0.624***
	(0.131)	(0.164)	(0.0953)
Father's education: above high school	1.772***	1.826***	1.552***
	(0.242)	(0.258)	(0.186)
Mother born in country	−0.0756	−0.0296	−0.0255
	(0.0457)	(0.0329)	(0.0300)
Father born in country	0.166	0.169	0.154
	(0.220)	(0.237)	(0.239)
Set of dummies for compulsory ed. Ref. cat.: 5–7 years of comp. ed.			
8 years	0.102	0.590***	0.587***
	(0.475)	(0.105)	(0.105)
9 years	−0.0739	0.0555	0.0672
	(0.506)	(0.212)	(0.205)
10–12 years	0.471	0.102	0.106
	(0.748)	(0.180)	(0.172)
Interaction between parental ed. and unemployment			
Interaction with mother's	–	–	0.0685**
education	–	–	(0.0253)
Interaction with father's education	–	–	0.0495**
	–	–	(0.0197)
Gender (male = 1)	0.0669	0.0631	0.0615
	(0.193)	(0.196)	(0.197)
Constant	10.92***	2.867**	3.000**
	(0.449)	(1.128)	(1.028)
Observations	47,041	47,041	47,041
R^2	0.221	0.244	0.246
Number of countries	12	12	12
Country fixed effects	Yes	Yes	Yes
Cohort dummies	Yes	Yes	Yes
Country specific linear and quadratic cohort trends	No	Yes	Yes

*Note:*Regressions using the stata command areg weighted by sampling weights. Robust standard errors clustered at the country level in parentheses.
***p < 0.01,
**p < 0.05,
*p < 0.1.
Source: Authors' calculations.

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Reading across the columns of Table 4, we see that unemployment has a positive and significant influence on completed formal education. In the specification with no trend variables in Column (1), we find that an increase of one percentage point in the average unemployment rate a person faced in the 3 years between 16 and 18 is estimated to increase the number of years of formal education completed by 0.07. The estimate is statistically significant at the 5% level.

When we include country-specific linear and quadratic trends in Column (2), we find a somewhat weaker, but still positive and statistically significant effect of unemployment. The estimate of 0.04 implies that an increase in the unemployment rate of one percentage points lead to an increase in completed years formal education by 0.04. The estimate indicates that if one country's unemployment rate rises by one percentage point relative to other countries, and if this change influences the decision to invest in one more year of education or not, then about 4% of the individuals in the country (over 25 years and born in the country) would acquire one more year of schooling. This result is in line with the finding in Arkes (2010), who finds—in the first stage equation of the analysis—that one percentage point increase in state unemployment increases completed education by a statistically significant 0.04 years. To set this number in perspective, if a country experiences an increase in unemployment by 5 percentage points relative to other countries, which typically happened in many European countries from the 1970s to the 1980s, then about 20% of the individuals in the country would acquire one more year of schooling, all else equal.

The effect of the control variables is mainly as expected. Males and individuals with highly educated parents complete more years of education than female individuals with lower educated parents, respectively. We also find that having 8 years of compulsory schooling increase formal education by 0.59 years compared to those having less than 8 years. Although positive in sign in Column (2), coefficients for dummy variables for having 9 and 10–12 years of compulsory schooling are not significant.

4.1.1 Heterogeneous effects As discussed in the theory section, the countercyclical pattern in educational attainment due to the opportunity cost mechanism can be counteracted if more families become credit constrained in the education market during economic downturns. While our empirical strategy and data do not allow us to study the role of credit constraints *per se*, the argument motivates an investigation of possible heterogeneity in the unemployment effects between individuals with high versus low educated parents. If individuals with low (high) educated parents are more (less) likely to be credit constrained, we would expect the countercyclical pattern to be less pronounced for the former group. A counter-argument, however, is that individuals with high educated parents have more inherent motivation for education in the first place and thus react less to changes in the opportunity costs than individuals with low educated parents being closer to the margin between investing in further education or not.

To study possible heterogeneous effects with respect to parental education, Column (3) in Table 4 extends the model to include interaction terms between unemployment rate at the age of 16–18 years and a dummy for mother and father having more than high school education. The model results suggest a significant positive interaction term for mother's and father's education. The largest interaction effect is found for mother's education. This indicates that a rise in unemployment during teenage years has the largest effect on completed formal education for individuals with high educated parents. Taken literally, the estimates in Column (3) suggest that a one percentage point increase in unemployment

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increase formal education by 0.03 years (0.099 years) for a person with a mother having education at or below high school level (above high school level). Broadly speaking, this is consistent with the credit constraints story, but further research is needed to confirm this conclusion.

4.2 Adult skills and unemployment

The key and novel question asked in this article is whether the countercyclical pattern found in educational attainment translates into a similar pattern in cognitive skills in adulthood measured by tests of competence in literacy and numeracy.

Table 5 presents the results for analysis of the influence of unemployment rate on skills (literacy or numeracy) when we use the PIAAC sample. Columns (1) and (3) estimate the baseline model in Equation (1), while Columns (2) and (4) extends the model by adding country by cohort linear and quadratic trends.

Reading across the columns of Table 5, we find that unemployment rate when teenager has an effect on numeracy skills regardless of model specification in Columns (1) and (2) of Table 5. For literacy skills in Columns (3) and (4) of Table 5, we find only a significant effect in Column (4) where linear and quadratic trends are included. Comparing Columns (2) and (4), we see that when trends are included, the estimates of unemployment on numeracy and literacy are almost the same.

Evaluated for numeracy skills in the specification where both linear and quadratic trends are included in Column (2) of Table 5, we find that a one percentage point increase in unemployment when teenager leads to an increase in numeracy skills as an adult of about 1.5% of a standard deviation. One way to illustrate the economic impact of the unemployment rate in teenage years is to combine our estimates with the estimated income returns to skills found in Hanushek *et al.* (2015) using PIAAC data. Assume for a moment that skills measured by the PIACC tests fully capture human capital differences between individuals. Further, assume that the average estimated earnings return to a one standard deviation increase in numeracy of 18% as found in Hanushek *et al.* (2015) is representative of the sample used in our analysis.[13] This estimate is likely to be downward biased if the difference between skills as measured in PIACC and the true human capital of an individual can be thought of as classical measurement error, as discussed in Hanushek *et al.* (2015). Thus, a conservative estimate is that an unemployment increase of 5 percentage points at the age of 16–18 years, translates into approximately 1.3% increase in earnings in adulthood, all else constant.

To check how robust our results are, we extend our sample to include ALL data in addition to PIAAC data. The estimates in Table 6 are based on the sample of both PIAAC and ALL. The regression models are similar to those of Table 5, the only difference being the sample.

Reading across the two tables, we see that we get the most robust estimates of unemployment on numeracy skills in Columns (1) and (2) of Tables 6 and 7. If we compare the models that include trends—Columns (2) and (4) of Tables 6 and 7 —we see that the magnitude of the effect is similar regardless of the type of skill used as dependent variable.

13 The 18% earnings return to cognitive skills in numeracy reported in Hanushek *et al.* (2015) is based on prime aged (35–54 years old). When we run a similar log earnings equation as in Hanushek *et al.* (2015) on the PIACC data set used in our article including the same control variables as in Tables 4 and 6 above, we find comparable earnings return to numeracy at 16%.

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Table 5. The effect of unemployment at the age of 16–18 years on adult numeracy skills and literacy skills using PIAAC

	PIAAC		PIAAC	
	Numeracy		Literacy	
	(1)	(2)	(3)	(4)
Unemployment (16–18)	0.00859*	0.0150**	−0.00626	0.0147***
	(0.00400)	(0.00549)	(0.00602)	(0.00467)
Parent's ed. Ref. cat.: ed. below high school				
Mother's education: above high school	0.204***	0.220***	0.167**	0.174**
	(0.0216)	(0.0232)	(0.0582)	(0.0585)
Father's education: above high school	0.414***	0.419***	0.413***	0.411***
	(0.0301)	(0.0281)	(0.0289)	(0.0284)
Gender (male = 1)	0.263***	0.264***	0.0434*	0.0449*
	(0.0224)	(0.0224)	(0.0233)	(0.0228)
Mother born in country	0.152***	0.155***	0.113**	0.109**
	(0.0398)	(0.0408)	(0.0469)	(0.0470)
Father born in country	0.151***	0.151***	0.157***	0.152***
	(0.0389)	(0.0351)	(0.0406)	(0.0402)
Set of dummies for compulsory ed. Ref. cat.: 5–7 years of comp. ed.				
8 years	0.114	0.0353	0.129	0.125**
	(0.0646)	(0.0510)	(0.0733)	(0.0517)
9 years	0.0493	−0.0789	0.0121	−0.0132
	(0.0855)	(0.0576)	(0.114)	(0.0577)
10–12 years	0.136	−0.0408	0.0718	0.0545
	(0.126)	(0.0803)	(0.156)	(0.0521)
Constant	−0.917***	−512.4	−0.904***	−1,627***
	(0.0751)	(370.5)	(0.0727)	(255.9)
Observations	47,041	47,041	47,041	47,041
R^2	0.130	0.137	0.150	0.156
Country fixed effects	Yes	Yes	Yes	Yes
Cohort dummies	Yes	Yes	Yes	Yes
Country-specific linear and quadratic cohort trends	No	Yes	No	Yes
ALL included	No	No	No	No
Number of countries	12	12	12	12

Note: Regressions using the stata command areg weighted by sampling weights. Robust standard errors clustered at the country level in parentheses.

***p < 0.01,

**p < 0.05,

*p < 0.1.

Source: Authors' calculations.

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Table 6. The effect of unemployment at the age of 16–18 years on adult numeracy and literacy skills using the pooled dataset with PIAAC and ALL

	PIAAC+ALL		PIAAC+ALL	
	Numeracy		Literacy	
	(1)	(2)	(3)	(4)
Unemployment (16–18)	0.00936**	0.0133**	−0.00467	0.0125***
	(0.00315)	(0.00507)	(0.00533)	(0.00391)
Parent's ed. Ref. cat.: ed. below high school				
Mother's education: above high school	0.211***	0.226***	0.171**	0.178***
	(0.0256)	(0.0242)	(0.0577)	(0.0563)
Father's education: above high school	0.417***	0.421***	0.412***	0.409***
	(0.0284)	(0.0274)	(0.0273)	(0.0266)
Gender (male = 1)	0.274***	0.275***	0.0514***	0.0531***
	(0.0181)	(0.0184)	(0.0158)	(0.0157)
Mother born in country	0.120**	0.123**	0.0933**	0.0897*
	(0.0456)	(0.0456)	(0.0430)	(0.0422)
Father born in country	0.145***	0.147***	0.153***	0.150***
	(0.0344)	(0.0318)	(0.0373)	(0.0380)
Set of dummies for compulsory ed. Ref. cat.: 5–7 years of comp. ed.				
8 years	0.0974*	0.00868	0.113*	0.0992*
	(0.0503)	(0.0459)	(0.0581)	(0.0496)
9 years	0.0920	−0.0258	0.0359	0.0171
	(0.0666)	(0.0491)	(0.0894)	(0.0500)
10–12 years	0.141	−0.0411	0.0985	0.0621
	(0.107)	(0.0684)	(0.136)	(0.0515)
Constant	−0.905***	870.0**	−0.897***	66.92
	(0.0737)	(353.2)	(0.0674)	(241.8)
Observations	64,324	64,324	64,324	64,324
R^2	0.118	0.124	0.131	0.137
Country fixed effects	Yes	Yes	Yes	Yes
Cohort dummies	Yes	Yes	Yes	Yes
Country-specific linear and quadratic cohort trends	No	Yes	No	Yes
ALL included	Yes	Yes	Yes	Yes
Number of countries	14	14	14	14

Note: Regressions using the stata command areg weighted by sampling weights. Robust standard errors clustered at the country level in parentheses.

***p < 0.01,

**p < 0.05,

*p < 0.1.

Source: Authors' calculations.

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The estimates get slightly smaller when we extend the sample to include ALL data in addition to PIAAC data in Columns (2) and (4) of Table 6. Evaluated for numeracy skills in the extended sample in Column (2) in Table 6, we find that the effect of a one percentage point increase in the unemployment rate is 1.3% of a standard deviation.

4.2.1 Heterogenous effects As for the education attainment regressions, we extend the model to include interaction terms between unemployment rate at the age of 16–18 years and a dummy for mother and father having more than high school education. Table 7 presents the results for numeracy skills in Columns (1) and (2) and literacy skills in Columns (3) and (4). As we can see from reading across the columns of Table 7, only the interaction term for mother's education is positive and significant. The interaction term for father's education is positive in most of the model specifications, but not statistically significant. The result indicates that a rise in unemployment during teenage years have the largest effect on completed formal education for individuals with high educated mother. The results are strongest for numeracy skills.

An interesting question is to what extent the effects of unemployment during teenage years on cognitive skills vary with the respondent's age. To analyze this question, we follow the robustness analysis in Hanushek *et al.* (2015) who study whether earnings return to cognitive skills varies between entry age (25–34 years), prime age (35–54 years), and exit age (55–65 years) respondents. They estimate returns to numeracy skills to be 14% for entry age and around 18% for prime age and exit aged individuals. Their results suggest that the wage return to skills is broadly independent of respondents' age with somewhat lower return for entry aged persons as expected. However, this does not mean that high unemployment rate experienced in a person's teenage years continue to affect skills in all future ages. The effect of labor market conditions as young may decline as people grow older. To investigate this issue, we estimate a cognitive skills equation with interaction terms between prime age and exit age and unemployment at the age of 16–18 years using entry age as the reference group.

In a specification with full set of cohort dummies and trends, little variation is left for the separate identification of interaction terms between age groups and the unemployment variable. Thus, we report in Table 8 the results from specifications including dummies for exit age and prime age, while cohort dummies and trends are replaced by interaction terms between prime age and exit age and unemployment at the age of 16–18 years. While the unemployment effect turns out to be somewhat higher than in the main specification, the coefficients in front of the interaction terms are not significantly different from zero.[14] Thus, we conclude that the effect of unemployment in teenage years seems to be fairly independent of the age of the respondents, but more definitive conclusions on this issue requires more data with longer time spans and is left for future research.

In all the models reported so far, we have only included control variables that are arguably predetermined at the point in time when students make educational decisions. Our results so far indicate that high unemployment during teenage years increases both

14 If the full set of cohort dummies and trends are included, the results for the interaction with prime age is similar to that in Table 8, while the interaction with exit age turns significantly negative. However, based on the arguments above, we believe that this result may reflect the small variation left to identify the interaction terms in this very demanding specification rather than a real effect. Results from this specification are available from the authors on request.

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Table 7. Interaction between parent's education and unemployment

	Numeracy		Literacy	
	PIAAC (1)	PIAAC+ALL (2)	PIAAC (3)	PIAAC+ALL (4)
Unemployment (16–18)	0.0142**	0.0124**	0.0126**	0.0107***
	(0.00524)	(0.00481)	(0.00420)	(0.00343)
Parent's ed. Ref. cat.: ed. below high school				
Mother's education: above high school	0.166***	0.175***	0.0869	0.0990
	(0.0173)	(0.0210)	(0.0566)	(0.0597)
Father's education: above high school	0.422***	0.413***	0.382***	0.380***
	(0.0268)	(0.0242)	(0.0152)	(0.0141)
Interaction between parental ed. and unemployment				
Interaction with mother's education	0.0102***	0.00951***	0.0163*	0.0146*
	(0.00306)	(0.00305)	(0.00860)	(0.00747)
Interaction with father's education	−0.000749	0.00126	0.00497	0.00501
	(0.00211)	(0.00199)	(0.00386)	(0.00385)
Constant	−489.7	842.1**	−1,593***	17.25
	(361.3)	(336.9)	(233.4)	(221.1)
Observations	47,041	64,324	47,041	64,324
R^2	0.137	0.124	0.157	0.138
Number of countries	12	14	12	14
Gender dummy	Yes	Yes	Yes	Yes
Compulsory school length dummies	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes
Cohort dummies	Yes	Yes	Yes	Yes
Country-specific linear and quadratic cohort trends	Yes	Yes	Yes	Yes
ALL included	No	Yes	No	Yes

Note: Regressions using the stata command areg weighted by sampling weights. Robust standard errors clustered at the country level in parentheses.
***p < 0.01,
**p < 0.05,
*p < 0.1.
Source: Authors' calculations.

individual's completed education as well as cognitive skills in adulthood. An interesting question is to what extent unemployment also works through the intensive margin as students may exert more effort in school during recessions to obtain better grades as discussed in Section 2.1 above. Including realized formal education among the explanatory variables in the cognitive skill equations would however raise a 'bad control problem' using the language of Angrist and Pischke (2009, p. 64), since formal education is obviously an outcome variable. Nevertheless, in order to shed some light on the effects through the intensive margin, we include an analysis where we estimate the model on subsamples defined by educational attainment.

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Table 8. Interaction between age-intervals and unemployment

	PIAAC Numeracy	PIAAC+ALL Numeracy	PIAAC Literacy	PIAAC+ALL Literacy
Unemployment (16–18)	0.0275***	0.0260***	0.0171***	0.0157***
	(0.00803)	(0.00663)	(0.00389)	(0.00328)
Exit age (55–65)	−0.304***	−0.292***	−0.705***	−0.676***
	(0.0566)	(0.0482)	(0.106)	(0.114)
Prime age (35–54)	0.00879	−0.00198	−0.136*	−0.148**
	(0.116)	(0.104)	(0.0721)	(0.0653)
Interaction with exit age	−0.00805	−0.0119	0.0434	0.0360
	(0.0174)	(0.0155)	(0.0271)	(0.0259)
Interaction with prime age	−0.0122	−0.0104	−0.00288	−0.000721
	(0.0116)	(0.0101)	(0.00616)	(0.00554)
Constant	−358.1	47.39	−1,504***	−668.6
	(383.9)	(221.5)	(293.5)	(382.2)
Observations	47,041	64,324	47,041	64,324
R^2	0.137	0.124	0.157	0.137
Control variables	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes
Cohort dummies	No	No	No	No
Country-specific linear trend	No	No	No	No
Country-specific quadratic trend	No	No	No	No
ALL included	No	Yes	No	Yes
Number of countries	12	14	12	14

Note: Regressions using the stata command areg weighted by sampling weights. Robust standard errors clustered at the country level in parentheses.
***p < 0.01,
**p < 0.05,
*p < 0.1.
Source: Authors' calculations.

We define three different subsamples: individuals that have acquired (i) less than high school, (ii) high school, or (iii) more than high school education. The results are reported in Table 9. The results suggest that the significant positive effect of unemployment on numeracy skills is found for students with completed high school education and above, while no effect is found for students not completing high school education. The absence of effects for the respondents with low formal education may indicate that the intensive margin (student effort channel) is of less importance. But more research is needed to confirm this conclusion since it is based on less credible specifications due to endogenous selection problems as formal education is arguably an outcome variable.

4.2.2 Controlling for country-level macro variables The model used so far does not include observed country-level variables other than unemployment. Specifications with

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Table 9. Subsample by educational attainment

	Less than HS education		Completed HS education		More than HS education	
	Numeracy	Literacy	Numeracy	Literacy	Numeracy	Literacy
Unemployment (16–18)	0.00241	0.00551	0.0156***	0.0195***	0.00814*	0.00200
	(0.00493)	(0.00739)	(0.00301)	(0.00447)	(0.00410)	(0.00445)
Parent's ed.						
Ref. cat.: ed. below HS						
Mother's ed.: above HS	0.161	0.178	0.136***	0.0865*	0.106***	0.0550
	(0.123)	(0.135)	(0.0195)	(0.0438)	(0.0127)	(0.0496)
Father's ed.: above HS	0.372***	0.386***	0.222***	0.194***	0.180***	0.185***
	(0.0885)	(0.104)	(0.0279)	(0.0216)	(0.0287)	(0.0154)
Gender (male = 1)	0.182***	−0.0123	0.255***	0.0265	0.370***	0.140***
	(0.0156)	(0.0247)	(0.0288)	(0.0206)	(0.0218)	(0.0110)
Mother born in country	0.147	0.107	0.0816*	0.0478	0.175***	0.141**
	(0.110)	(0.129)	(0.0425)	(0.0428)	(0.0519)	(0.0497)
Father born in country	0.141***	0.153*	0.151***	0.171**	0.100*	0.0845**
	(0.0375)	(0.0734)	(0.0415)	(0.0669)	(0.0558)	(0.0326)
Dummies for comp. ed.						
Ref. cat.: 5–7 years of comp. ed.						
8 years	−0.132	−0.0826	−0.0652*	−0.00300	0.127**	0.276***
	(0.0974)	(0.0900)	(0.0356)	(0.0396)	(0.0509)	(0.0717)
9 years	0.0330	0.0155	−0.0691	−0.0664	0.0346	0.112
	(0.118)	(0.0914)	(0.0488)	(0.0422)	(0.0516)	(0.0706)
10–12 years	0.0308	0.101	−0.0915	−0.0304	0.110**	0.178**
	(0.0986)	(0.0898)	(0.0713)	(0.0505)	(0.0485)	(0.0763)
Constant	1.735***	−219.1	176.0	−593.6**	741.5	1,277
	(459.3)	(260.6)	(321.7)	(231.0)	(533.0)	(1,122)
Observations	12,609	12,609	23,309	23,309	28,312	28,312
R^2	0.105	0.107	0.112	0.126	0.122	0.115
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Cohort dummies	Yes	Yes	Yes	Yes	Yes	Yes
Country-specific linear trend	Yes	Yes	Yes	Yes	Yes	Yes
Country-specific quadratic trend	Yes	Yes	Yes	Yes	Yes	Yes
ALL included	Yes	Yes	Yes	Yes	Yes	Yes
Number of countries	14	14	14	14	14	14

Note: Regressions using the stata command areg weighted by sampling weights. Robust standard errors clustered at the country level in parentheses.
***p < 0.01,
**p < 0.05,
*p < 0.1.
Source: Authors' calculations.

country fixed effects and country-specific cohort trends account for the influence of variables at the country level that is constant over time or evolves smoothly over time. Only individuals born in country are included, but all regressions include dummy variables for parents born in country or not. To some extent, the inclusion of these dummies should account for changes in the share of immigrants over time that could possibly correlate with

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unemployment rates. The regression results are very similar whether or not these dummy variables are included.

However, we are still concerned whether the results are robust to the inclusion of observable variables at the country level that may be correlated with the unemployment rates. Macro variables as the post-secondary education wage premium, tuition costs, or government resources allocated to the postsecondary education at the time when individuals are 16–18 years may affect cognitive skills acquired. If these variables are correlated with the unemployment rate in the country, and omitted from the regression model, the unemployment effects we estimate will be biased.

To exemplify, a rise in the post-secondary education wage premium or an increase in the returns to education would likely increase incentives to acquire skills. If the postsecondary wage premium is countercyclical (procyclical), omission of the wage premium partially leads to an upward (downward) bias in the unemployment effect. On the other hand, higher public spending on education (including increased subsidies of tuition costs) may lead individuals to acquire more skills. If public spending on education is procyclical (countercyclical), omission of an education spending variable will bias the unemployment effect downward (upward). A final example is possible cyclical variation in the quality of teachers. Evidence from several countries suggests that centralized and rigid pay setting in the public sector can lead to shortages of qualified personnel in the public sector in periods with strong external labor markets.[15]

Data availability limits the possibility to include many country-specific control variables. For example, education expenditure as a percentage share of GDP from OECD or World Bank only exists for a subset of countries and years. Nevertheless, Supplementary Appendix Table A3 report results from estimated cognitive skill equations extended by government education expenditure as percentage share of GDP for the limited number of years and countries where data on this variable are available.[16]

Due to the limited time span for the government spending variable, these regressions do not include country-specific time trends. To facilitate comparison with the earlier results, Columns (1) and (2) in Supplementary Appendix Table A3 present the results from specifications without the spending variable for this limited sample, while Columns (3) and (4) report results when the spending variable is included in the equations for numeracy and literacy skills, respectively. Public education expenditure as a share of GDP does not appear to affect cognitive skills and the results in Supplementary Appendix Table A3 show that our previous finding of a countercyclical relationship between cognitive skills and unemployment rates in teenage years is fairly robust to the inclusion of the education spending variable.

15 Ammermueller *et al.* (2009) using German data find that increased regional unemployment significantly decreases the wage returns to education. Evidence in Barr and Turner (2013) and Humphreys (2000) suggests that spending on higher education in US states is procyclical. Evidence for military personnel, nurses, and teachers in Carrell (2007), Propper and Van Reenen (2010), and Falch et al. (2009), respectively, show that qualified personnel tend to leave the public sector in periods with strong overall labor markets.

16 We use the variable 'Government expenditure on education as % of GDP' from the World Bank Data Bank on Education Statistics.

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4.2.3 Controlling for country unemployment rates at the age of 22–24 years As a final robustness check, we extend our baseline model to include country unemployment rates at the age of 22–24 years. The age of the individual in the PIAAC survey ranges from 18 to 62 years. In our main specifications, we use unemployment rate at the age of 16–18 years to capture labor market conditions when decisions about investment in human capital are made. Labor market conditions when students typically graduate from college can affect skill acquisition via learning by doing or on-the-job training. To the extent that unemployment rates are correlated over time within countries, it is a possibility that our results partly reflect country unemployment rates in periods well after individuals finished compulsory school, for instance when they finish college. To capture this possibility, we run regressions with the unemployment rate at the age of 22–24 years to capture labor market conditions when individuals typically finish college. Detailed results from these regressions are presented in Supplementary Appendix Table A4.

Columns 1 and 2 in Supplementary Appendix Table A4 report regression results when unemployment rate at the age of 22–24 years is included in addition to unemployment rate at the age of 16–18 years. Columns 3 and 4 only include unemployment rate at the age of 22–24 years. When included as the only labor market variable in Columns (3) and (4), the estimated effect of unemployment rate at the age of 22–24 years is small and far from statistically significant. However, when included together with unemployment at the age of 16–18 years, the estimated effect of unemployment 22–24 years is positive, but numerically smaller than that for the age of 16–18 unemployment, which has roughly the same effect as in the benchmark model. Thus, we conclude that our results on the effect of unemployment during teenage years (16–18) on cognitive skills in adulthood are robust to the inclusion of unemployment in the years when students typically finish college.

5. Concluding remarks

The article explores data from the PIAAC and the ALL survey to provide cross-country evidence on the relationship between individuals completed education and skills in adulthood and country unemployment rates during teenage years. In line with the majority of previous country-level studies of post-compulsory school enrollment, we find that higher unemployment in teenage years has a positive effect on completed years of education. A novel finding is that we document a similar counter cyclical pattern in numeracy and literacy as measured by the tests in PIACC. Our econometric results show that a one percentage point increase in unemployment increases length of education by 0.04 years and nearly 1.5% of a standard deviation in numeracy skills. This means that an increase in unemployment by 5 percentage points, which typically many European countries experienced from the 1970s to the 1980s, lead to an increase in years of formal education by 0.2 years and approximately 7.5% of a standard deviation increase in adult skills in numeracy. Our cross-country results indicate that labor market conditions in teenage years have long-run effects on human capital acquisition. Thus, our results differ from the findings in Emery *et al.* (2012) that resource booms in Canada reduced human capital investments in the short run, while leaving long-run educational attainment and cognitive skills unchanged.

Our article is related to the study of Hanushek *et al.* (2015) who find substantial earnings returns to numeracy skills using the PIAAC data. Our study complements their paper by explicitly studying how variations in labor market conditions in teenage years across countries affect these skills as measured in PIAAC. By combining our results with the

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findings in Hanushek *et al.*, we can illustrate the potential earnings effect in adulthood from differences in labor market conditions in teenage years. To illustrate the economic impact of our findings in terms of earnings, assume for a moment that skills measured by the PIACC tests fully capture human capital differences between individuals. Using the estimated earnings return to numeracy as found in Hanushek *et al.* (2015), our findings then suggest that an increase in unemployment rate in teenage years by 5 percentage points represents an earnings difference of approximately 1.3% in adulthood. These numbers illustrate that labor market conditions at the time individuals make crucial educational decisions have economically and statistically long-lasting effect on their skills and earnings potential in adulthood.

Supplementary material

Supplementary material is available on the OUP website. This comprises the Supplementary Appendix and data and replication files for the empirical work.

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Conflicts of Interest

There are no conflicts of interest that we are aware of.

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