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Cohort patterns in adult literacy skills: How are new generations doing?

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Abstract

Skills are core elements of the socio-economic prospects of individuals, while they also improve national productivity, growth and social cohesion. Understanding how skills evolve over time and what drives their evolution has become a policy priority of many European countries. Using the 1994–1998 International Adult Literacy Survey (IALS) and the 2012 Survey on Adult Skills (PIAAC) we build synthetic cohorts and examine how the population gains, loses or preserves cognitive skills (literacy) over time. While, as expected, deterioration in the level of skills due to ageing is common to almost all the European countries studied, for some of them concerns arise for the occurrence of skill deterioration across generations, especially among less well-educated and medium-educated individuals. Certain countries appear to be doing a poorer job in providing the necessary literacy skills over successive generations.

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Keywords: Human capital; Literacy; Cognitive skills; Ageing; Cohort effects; IALS; PIAAC; New Skills Agenda for Europe

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1. Introduction

In the current socio-economic context, increasingly dominated by technological change and global competition; and characterised by a higher proportion of knowledge-based content, human capital plays a crucial role. Thus, a lack of relevant skills prevents citizens from full participation in the economic, social and political life of their countries since they suffer from more limited employment opportunities, lower earnings and are at much greater risk of economic disadvantage, health problems and general social exclusion (Agasisti and Cordero, 2017; Green and Riddell, 2003; Mateos Romero, Murillo Huertas, & Salinas Jiménez, 2017; Statistics Canada and OECD, 2005).

An adequate investment in skills is critical for social mobility, insofar it contributes to tackling poverty, inequality and marginalization, improving the employability of individuals, social cohesion and global competitiveness through the development of human capital. These challenges have pressed the adoption of a set of policy initiatives within the European Union including the New Skills Agenda for Europe (adopted by the Commission on 10th June 2016), which embraces 10 actions to provide the right guidance and mentoring services to support learners' progression through all steps of the upskilling process.¹

In this paper we study the level, distribution and evolution of literacy skills across several EU countries using data from the 1994–1998 International Adult Literacy Survey (IALS) and the 2012 Survey of Adult Skills (PIAAC), so as to better understand how skills are preserved and developed over time while providing a comprehensive picture of the skill challenges countries are facing, particularly in relation to how well new generations are doing vis-à-vis their older counterparts.

Until recently, the availability of relevant data has restricted opportunities to perform this type of study; surveys measuring skills are traditionally cross-sectional, and thus lack the longitudinal component that would enable pure age and cohort effects to be disentangled. However, since IALS 1994–1998 and PIAAC 2012 were designed to be comparable regarding literacy skills, their joint use offers an exceptional opportunity to perform, a synthetic cohort analysis that aims at arriving to an approximation of individual skills trajectories over time, separating ageing and cohort effects, after other socio-economic factors have been controlled for. Knowing whether the process of deterioration of skills in a society occurs during the lifetime of an individual or rather over several generations, and whether top or bottom performers are particularly affected, does make a difference and flags a potential need for targeted policy interventions.

Our research offers some interesting results. Individuals appear to acquire their skills in the course of their years of formal education, but these skills subsequently appear to deteriorate, with a significant and consistent age effect in most of the European countries we studied (similar results have been found by Green and Riddell, 2013 and Barrett and Riddell, 2016). However, more importantly, we find evidence that more recent birth cohorts start off their professional careers with lower levels of literacy than previous generations in a number of European countries (Belgium, Czech Republic, Denmark, Ireland and Sweden), and this is particularly true for low/medium educated individuals. This latter result suggests that the effectiveness of education institutions merits closer examination, particularly those that provide primary- and secondary-level education in their efforts to better endow younger generations with relevant skills.

¹ <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52016DC0381>.

The paper is structured as follows. Section 2 is a short review of the main drivers of skill change. Section 3 describes the data and provides some statistics on the level and distribution of literacy skills. Section 4 uses the pooled data from the two surveys to analyse the primary drivers of adult literacy skills and, in particular, to disaggregate age and cohort effects by means of synthetic cohorts. In Section 5 we run a series of quantile regressions by level of formal qualification attained in order to determine whether specific groups along the skill distribution spectrum are affected more than others by age and cohort effects. Section 6 describes and discusses our conclusions. In particular, the focus of the recommendations is on policy options that may add value to what has been or is already commonly implemented in the different countries taking into account recent policy and socio-economic developments.

2. The dynamics of skills formation: A short review of the main drivers of skill deterioration and skill gain

Ageing has traditionally been identified in the literature as one of the key driver of skill change (Arthur, Bennett, Stanush, & McNelly, 1998; De Grip and Van Loo, 2002; Desjardins and Warnke, 2012), and as one of the main social and economic challenges facing many countries in this century.²

Research has shown that the ageing trend is not uniform across all individuals or all types of cognitive skills, with several factors influencing the speed and extent of the process of skill deterioration, including both neurological and behavioural maturation. Social and economic characteristics of the environment in which the individual lives can also play significant roles in preserving or even raising skill levels. The *family* and *social relationships* also make up a “nurturing environment” that provides a range of quantities and qualities of intellectual stimuli, reinforcing or compensating for the impact of *schooling* (Desjardins and Warnke, p.14). Further, the *working environment* is also crucial in avoiding skill loss and preserving skills through time.

Nevertheless, all such contexts (family, school, community, workplace, etc.) are also subject to change over time, and this may affect the skill development trajectories of individuals born or living at different points in time. Such changes bring about the potential for “cohort effects” on skill development. The effect of these events on the pattern of skill development may be *indirect*, affecting the set of opportunities available to individuals (as in the case of wars, famines or cultural changes as the mass diffusion of news), but less radically. They may also *directly* influence the quantity and quality of skills transmitted by formal education, as in the case of national educational reforms that regulate access to compulsory education or changes in teaching practices or curricula (Desjardins and Warnke 2012); or other policy initiatives geared towards making better use of the skills that are available or equip people with the new skills needed (e.g. European Commission proposals on: (1) the review of key competences for lifelong learning; (2) the establishment of a Skills guarantee; or (3) the support for VET modernization). Understanding how the ageing and cohort effects interact and how they help to shape the skill levels of the European countries is fundamental for policy makers, in order to ensure that their citizens are endowed with the combination and level of skills required to reach their individual wellbeing, and to increase prosperity and growth in society as a whole.

² In Europe, the ratio of people aged 65 or more to those aged 18–65 is expected to increase dramatically in the next 50 years (Eurostat, 2013).

3. Data and descriptive statistics on the distribution of skills

For the purpose of this paper, we rely on data from the 1994–1998 International Adult Literacy Survey (IALS) and the 2012 Survey on Adult Skills (PIAAC).

IALS provided the world's first comparable estimates of the levels and distributions of cognitive foundation skills in the adult population (for further details see <https://nces.ed.gov/statprog/handbook/pdf/ials.pdf>). The type of individual skills investigated is literacy skills, defined as the ability to use “printed and written information to function in society, to achieve one’s goals, and to develop one’s knowledge and potential” (Statistics Canada, 2003, p.15).

Similarly, the Survey of Adult Skills is an international survey that forms part of the OECD Programme for the International Assessment of Adult Competencies (PIAAC). PIAAC measures key cognitive and workplace skills needed by individuals in order to participate in society and by economies if they are to prosper. The survey assesses three domains of cognitive skills, namely literacy, numeracy and problem-solving in technology-rich environments (PSTRE).³ In this paper, we focus on literacy skills, since PIAAC was specifically designed to link to IALS in the domain of literacy.

Both surveys have been designed to be representative of the civilian, non-institutionalized population aged 16–65 in each country. For the purposes of our analysis, we restricted our sample to individuals aged 25 or more, so as to focus on the group that has already completed schooling.

The EU countries that participated in both surveys and for which it is possible to study the evolution of literacy skills over time are 10: Belgium — Flanders (BE), Czech Republic (CZ), Denmark (DK), Finland (FI), Ireland (IE), Italy (IT), The Netherlands (NL), Poland (PL), Sweden (SE), and the United Kingdom (UK).⁴

It is worth noticing that there are distinct features associated with these countries that make their joint analysis and systematic comparison extremely interesting for policy purposes. On the one hand, some countries – in particular the Nordic ones – tend to perform well internationally in literacy assessments and rank among the top ones for some economic and social indicators; on the other hand, some other countries – e.g. Italy, Poland and Ireland – are generally characterised by lower average skills and greater variability in terms of economic performance and social cohesion. Moreover, this group of countries embodies the traditional divide among educational systems made by the sociological literature, which distinguishes them according to their level of standardisation and stratification (Allmendinger 1989). Typically, countries as Germany, the Netherlands, Switzerland, Austria, and the Scandinavian countries are characterized by a high level of stratification, with a well-established track of vocational education both at secondary and tertiary level. High levels of stratification provide better opportunities to match supply and demand on the labour market (Allmendinger 1989; Müller and Shavit 1998). In contrast, Southern European countries and Ireland are characterized by a low level of educational tracking and a high level of general training, which generally lead to a higher incidence of occupational mismatch and underperformance on the labour market.

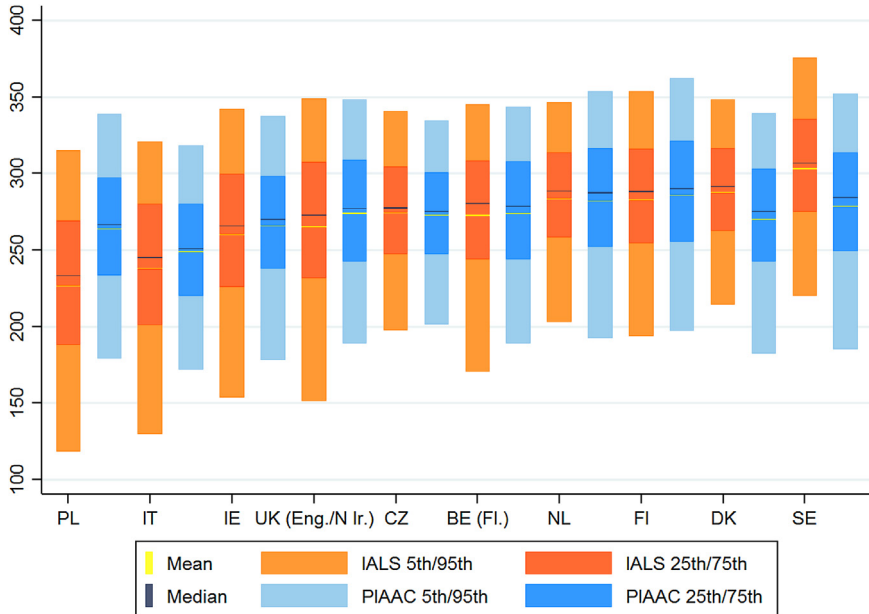


Fig. 1. Distribution of literacy proficiency scores among individuals (25–65): IALS and PIAAC Surveys.
 Notes: Percentiles in literacy proficiency: mean (yellow), median (black), 25th and 75th (dark blue/dark orange) and 5th and 95th (light blue/light orange). Own elaborations on IALS and PIAAC data. Countries are presented in order of increasing average literacy score in IALS. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

In order to obtain a first glimpse of the evolution of literacy skills across these countries, Fig. 1 illustrates the distribution of literacy scores in the two surveys, showing mean and median literacy skill scores, as well as scores at the top and at the bottom of the distribution (95th and 75th, and 25th and 5th percentiles, respectively, to capture the performance of what could be defined as high- and low-achievers in each country⁵). This comparison between average literacy scores over time immediately shows a certain degree of stability over time in countries like Finland, the Netherlands, Belgium and the Czech Republic, while a clear decrease over time affects Sweden and Denmark. For these countries, this decrease in the average (as well as median) scores was accompanied by an overall shift downwards of the levels throughout the entire distribution, although this was more pronounced at the bottom, resulting in an increasingly unequal distribution. A similar situation in terms of higher inequality in the distribution of skills was found for the Netherlands. In Italy, Ireland and the United Kingdom, small increases were registered in both mean and median skill levels, although opposite trends affected the opposite ends of the distribution: while

³ According to the OECD (2012), literacy is defined in PIAAC as “understanding, evaluating, using and engaging with written texts to participate in society, to achieve one’s goals, and to develop one’s knowledge and potential”.

⁴ It should however be pointed out that while for IALS the United Kingdom includes the whole country (Great Britain + Northern Ireland), only England and Northern Ireland participated in PIAAC, so there is a discrepancy in the representation of the country in the two surveys that is taken into consideration in the interpretation of the results.

⁵ Notice that the concept of high and low achievers used here is not directly connected with an absolute skill level. We use high and low achievers to refer to the bottom and top part of the skill distribution within a country, and can therefore vary significantly from one country to the other.

an improvement could be observed in the lowest percentiles, the scores of the best performers appear to have either fallen or remained stable, resulting in a narrowing of the distribution of literacy scores over time. Finally, Poland is the country with the largest increase in average and median adult literacy skills between the two surveys. This is accompanied by an improvement at both the bottom and top ends of the distribution, but which is more pronounced at the bottom.

While this Figure offers a preliminary idea of the overall changes in the level of skills in the countries concerned, they do not enable us to identify the drivers of skills change underlying the observed trends, particularly how ageing and cohort effects interact in different countries. The next sections are devoted to investigating this issue.

4. Disentangling cohort patterns in adult skills: a multivariate analysis

The empirical analysis starts with a first specification in which we pooled IALS and PIAAC data. IALS was carried out between 1994 and 1998, therefore, depending on the year the survey took place, the time lag between IALS and PIAAC 2012 may be 13, 15 or 17 years. Thus, from the IALS sample, we considered all individuals aged 25–49, dividing them into five-year age groups: 25–29, 30–34, 35–39, 40–44, and 45–49, each of which was treated as a cohort of individuals. We refer to people who were aged 45–49 in IALS as “Cohort 1”, that is, the oldest cohort, which was subsequently captured in PIAAC at ages ranging between 58 and 65 depending on the country. Younger cohorts in IALS are sequentially numbered in ascending order from there, so that “Cohort 5” is the youngest cohort in IALS. Since both surveys provide representative samples of the adult population, it follows that each provides an unbiased estimate of each cohort’s literacy distribution at two different points in time, and we can follow the progress of a given cohort over time.

We ran a simple OLS regression in which the dependent variable was the log form of the individual score in literacy skills. Our estimated coefficients thus display impacts in terms of percentage changes in average literacy skills. Age categories and cohort dummies are included as covariates. Other variables used as controls were: individual educational level categorised as low (ISCED 0-2), medium (ISCED 3-4) or high (ISCED 5 or higher); gender; variables related to parental background (in particular, mother’s and father’s level of education and immigrant background); and working status (employed or unemployed). Parental educational level follows the same categories as above (low, medium and high). [Table 1](#) provides the working samples for IALS and PIAAC used for the analysis and some descriptive statistics of our sample (averaging all countries).

The regressions were estimated separately by country. In view of the limitations of the data, the relationship between the dependent variable and the covariates will be discussed in the form of correlations rather than of causal impact.

As expected, formal education variables have a significant impact on the level of individual literacy skills, with highly educated individuals having between 16% (Sweden) and 27% (Poland) higher average literacy than their less well-educated peers (results from these covariates are available from the authors upon request). We also find that higher parental education has a small but significant impact on average literacy skills for Denmark, Sweden and the United Kingdom for both father’s and mother’s education; and Finland and the Netherlands only for father’s education; no clear patterns were observed for the remaining countries. Having an immigrant background is associated with a lower level of literacy skills, the negative difference ranging from 2.4% in Ireland to 23% in Finland. Finally, we also found a positive association between being in employment and level of skills: employed individuals have significantly higher literacy skills than people not

Table 1

Demographic and socio-economic characteristics of the individuals in the sample — EU average (standard errors in brackets).

Variables	IALS	PIAAC
Age group		
25–34	0.412 (0.006)	–
35–44	0.417 (0.006)	0.227 (0.002)
45–54	0.169 (0.004)	0.421 (0.002)
55–65	–	0.351 (0.002)
Gender		
Female	0.496 (0.006)	0.510 (0.002)
Parental education		
Mother (no education reported)	0.026 (0.001)	0.045 (0.001)
Mother (low)	0.830 (0.004)	0.713 (0.002)
Mother (medium)	0.121 (0.003)	0.193 (0.002)
Mother (high)	0.021 (0.001)	0.047 (0.001)
Father (no education reported)	0.026 (0.001)	0.049 (0.001)
Father (low)	0.769 (0.005)	0.593 (0.002)
Father (medium)	0.147 (0.004)	0.271 (0.002)
Father (high)	0.056 (0.002)	0.085 (0.001)
Migrants		
Mother foreign-born	0.038 (0.002)	0.107 (0.001)
Father foreign-born	0.037 (0.002)	0.105 (0.001)
Foreign-born	0.028 (0.002)	0.083 (0.001)
Educational attainment		
Low education	0.498 (0.006)	0.335 (0.002)
Medium education	0.382 (0.005)	0.434 (0.002)
High education	0.119 (0.003)	0.230 (0.002)
Labour market status		
Working	0.730 (0.005)	0.684 (0.002)

Notes: Own elaborations on IALS and PIAAC data. Country sample sizes (pooling IALS and PIAAC) = Belgium — Flanders (3702); Czech Republic (4061); Denmark (5813); Finland (4454); Ireland (3917); Italy (4349); The Netherlands (4543); Poland (3803); Sweden (3583); United Kingdom (8598).

in employment, although here the differences are relatively small (between 2.3% for the Czech Republic and 9.4% for the United Kingdom).

More importantly, after controlling for the above mentioned socio-economic characteristics, in line with previous empirical findings, we identified a true ageing effect (see Table 2).

In most of the countries involved, the negative coefficients increase as age increases, suggesting that the decrease in skills continues throughout the life-span of the individual. Thus, for example, 55–65 year-olds in Belgium have an 18% lower average literacy rate than the younger group of 25–34 year-olds. However, Italy and Poland are two countries worth commenting on. On the one hand, there was no significant effect on the relationship between age and literacy for Italy, which ranks among the lowest nations in average literacy scores, for both IALS and PIAAC. The fact that skills are not subject to deterioration due to age in Italy may be due to the initial very low level of literacy skills in the sample. On the other hand, in Poland the ageing effect is negative in all age groups, but only significant for the age groups 45–54. Since Poland is the only country

Table 2
Age and cohort effects on literacy skills.

Countries	Age: 35–44	Age: 45–54	Age: 55–65	Cohort 2: 40–44 in IALS	Cohort 3: 35–39 in IALS	Cohort 4: 30–34 in IALS	Cohort 5: 25–29 in IALS	N
BE-FI	-0.072***	-0.11***	-0.18***	-0.038**	-0.061***	-0.076***	-0.082***	3702
CZ	-0.090***	-0.15***	-0.20***	-0.035***	-0.044***	-0.084***	-0.094***	4061
DK	-0.076***	-0.16***	-0.24***	-0.039***	-0.061***	-0.093***	-0.11***	5813
FI	-0.064***	-0.098***	-0.15***	-0.015	-0.0047	-0.023*	-0.012	4454
IE	-0.038**	-0.089***	-0.11***	-0.015	-0.012	-0.045**	-0.061***	3917
IT	-0.012	0.013	0.013	0.029*	0.034*	0.056***	0.072***	4349
NL	-0.023*	-0.073***	-0.13***	-0.028**	-0.026**	-0.030**	-0.029**	4543
PL	-0.022	-0.040**	-0.02	0.011	0.040**	0.031	0.027	3803
SE	-0.096***	-0.15***	-0.25***	-0.026*	-0.046***	-0.094***	-0.098***	3583
UK	-0.039***	-0.091***	-0.12***	-0.038***	-0.048***	-0.069***	-0.093***	8598

Notes: Own elaborations on IALS and PIAAC data. All figures are weighted. Omitted categories: age 25–34 and Cohort 1 45–49 in IALS. Other control variables include: educational level; gender; parental background; and working status (available from the authors upon request). Table 1 provides the working samples for IALS and PIAAC used for the analysis and some descriptive statistics of our sample (averaging all countries).

- * p < 0.05.
- ** p < 0.01.
- *** p < 0.001.

in this study which has improved its average literacy score from IALS to PIAAC, this may be the result of a significant national effort to shift the distribution of skills through more education (which appears as strong and significant in the regression) and may explain the explanatory power of ageing.⁶ In fact, as argued in Educational Research Institute (2013), the increase in literacy in Poland is probably related to changes in labour force participation patterns and a falling proportion of pensioners, persons on disability pensions or those employed in industrial sectors requiring lower qualifications, i.e. the groups that on average achieve lower scores. This improvement is also influenced by social changes in Poland, including better adaptation to the market economy.

If we now look at cohort (generational) effects, an interesting general pattern emerges: in most of the countries (BE, CZ, DK, NL, SE and UK) more recent generations are performing worse than the older ones. Indeed the coefficients associated with younger cohorts are significantly negative, meaning that they have lower skills than the older reference cohort. Thus, once socio-economic characteristics have been controlled for, newer cohorts seem to be endowed with poorer literacy skills. However, no significant difference in average literacy skills between cohorts was found for Finland (with the exception of Cohort 4), and in Ireland the effect is found only on the two youngest cohorts. In contrast, younger generations in Italy are significantly more likely to report higher average literacy scores than their older counterparts. Given the poor average skill performance of this country, this significant improvement among younger cohorts, after controlling for educational attainment, provides some hope for the accumulation and preservation of human capital among

⁶ This has also been demonstrated by the PISA results, which show that between 2003 and 2012, Italy and Poland increased their shares of top performers and simultaneously reduced their shares of low performers in mathematics in PISA (OECD, 2014). PISA stands for Programme for International Student Assessment and it is a triennial OECD international survey which evaluates educational systems worldwide by testing the skills and knowledge of 15-year-old students (more details at: <http://www.oecd.org/pisa/>).

Italians. In Poland, the coefficients are positive, but not significant, with the exception of that one associated with Cohort 3.⁷

The observed patterns have some relevant implications. First, countries in which younger cohorts are performing worse than their elders raising the alarm regarding the performance of their educational systems. Are the new generations less well prepared than the older ones? Secondly, what about the results for Finland or Poland where younger and older cohort groups seem to report similar average literacy scores? Thirdly, even if the ideal solution would be to raise skills levels among younger cohorts, should we pay particular attention to the results reported by Italy? In fact, this country is not entirely exempt from criticism in this respect. Are the younger generations more skilled simply because more of them have been enrolled in higher education? While this would in any case be a positive outcome, proving that the expansion of education is a successful policy, it would nevertheless be desirable that new generations possess higher levels of skills even at the same educational level. Likewise, in the light of the evidence mentioned in the previous section, it is also necessary to consider the role played by ageing and cohort effects, at different points on the skills distribution. These questions cannot be answered with the current regressions since, although we controlled for education, we did not allow ageing/cohort effects to vary with level of education or across the distribution of skills. We now do so in the following section, by running a quantile regression by level of education.

5. Ageing and cohort effects over the skills distribution by level of education: a quantile regression

We run here a series of quantile regressions to investigate whether the cohort and ageing effects affect differently different quantiles of the skill distribution by level of education. In particular, we focus on three important quantiles; the 10th, 50th and 90th. The 10th quantile relates to the lowest range of the skill distribution, on those whom may be considered to be *low achievers* within a country, and estimates resulting from this regression will provide some insight into the ageing and cohort effect in this particular group of individuals. At the other end of the distribution, the 90th quantile focuses on *high achievers* within the country. Finally, studying the median is interesting for the insights it provides into effects on the middle part of the distribution and how they diverge from the mean (estimated in the OLS) and the extreme quantiles. Regarding the classification by level of education, due to our limited sample size issues, we consider only two possible levels: high versus medium-low educational attainment. We focus on this division since we are primarily interested in differences in skills' preservation/deterioration, distinguishing between university graduates and individuals with, at best, upper secondary education.

The ageing effect results are presented in Table 3, where non-significant values have been shaded. For each country we report the effects on the 10th, 50th and 90th quantile for each age group.

For the low/medium educated group, we observe that ageing is a more serious problem than it is for the more highly educated group. For all countries (except Poland and Italy, for which few significant effects were found), ageing effects among those without a tertiary-level qualification

⁷ Some studies (e.g. Paccagnella, 2016a) that present an overview of ageing effects do not consider Poland in the analysis due to concerns about the reliability of IALS data, arising from coding inconsistencies in the survey. Paccagnella (2016b), however, shows that the possible inconsistencies affecting the country would result in an upward bias of IALS scores. Considering the direction of our results, this issue could only be underestimating the potential positive cohort effect and the negative ageing effect we find, but it could not change the direction of the effects.

Table 3

Ageing effects on literacy skills — quantile regressions by level of education.

	Low/Medium Education			High Education			Low/Medium Education			High Education		
	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
Belgium - Flanders												
Age: 35-44	-0.127***	-0.08***	-0.054**	-0.062	-0.044	-0.039	-0.124***	-0.086***	-0.07***	-0.0660	-0.058**	-0.0510
Age: 45-54	-0.153***	-0.14***	-0.09***	-0.09*	-0.077**	-0.062	-0.216***	-0.157***	-0.13***	-0.0624	-0.072**	-0.0710*
Age: 55-65	-0.234***	-0.22***	-0.14***	-0.231***	-0.13***	-0.125**	-0.319***	-0.212***	-0.16***	-0.137**	-0.130***	-0.100*
N =	2569	2569	2569	1133	1133	1133	3307	3307	3307	754	754	754
Denmark												
Age: 35-44	-0.126***	-0.059***	-0.050**	-0.0848*	-0.06***	-0.0430	-0.099***	-0.056***	-0.0267	-0.0544	-0.0209	-0.0038
Age: 45-54	-0.258***	-0.134***	-0.100***	-0.177***	-0.12***	-0.096***	-0.157***	-0.083***	-0.045**	-0.0900*	-0.0331	-0.0068
Age: 55-65	-0.351***	-0.225***	-0.174***	-0.314***	-0.21***	-0.163***	-0.224***	-0.140***	-0.08***	-0.169***	-0.096**	-0.0347
N =	3664	3664	3664	2149	2149	2149	3546	3546	3546	908	908	908
Ireland												
Age: 35-44	-0.0292	-0.0408*	-0.0448*	-0.0601	-0.0302	-0.0068	0.00403	-0.0145	-0.0235	-0.0601	-0.0565*	-0.0381
Age: 45-54	-0.113**	-0.079***	-0.081***	-0.134*	-0.085**	-0.0626*	0.0654	0.00091	-0.0238	-0.0762	-0.0581	0.0560
Age: 55-65	-0.128**	-0.115***	-0.126***	-0.204**	-0.13***	-0.121**	0.114*	-0.0213	-0.0358	-0.253**	-0.128**	0.0780
N =	2932	2932	2932	985	985	985	3644	3644	3644	705	705	705
The Netherlands												
Age: 35-44	-0.0410	-0.022	-0.0133	0.00462	-0.0192	-0.0116	-0.0377	-0.0375	-0.0321	0.0590	-0.0074	-0.007
Age: 45-54	-0.122***	-0.07***	-0.046***	-0.064**	-0.041**	-0.0250	-0.0847*	-0.06***	-0.0380	0.0827	-0.0002	-0.011
Age: 55-65	-0.213***	-0.13***	-0.082***	-0.14***	-0.08***	-0.061**	-0.0479	-0.049*	-0.0298	0.0953	-0.0044	-0.023
N =	3146	3146	3146	1397	1397	1397	3243	3243	3243	560	560	560
Sweden												
Age: 35-44	-0.117***	-0.10***	-0.098***	-0.0786	-0.082**	-0.0772*	-0.0342	-0.06***	-0.0395*	0.00081	-0.0275	-0.022
Age: 45-54	-0.187***	-0.15***	-0.143***	-0.139**	-0.115***	-0.12***	-0.0823*	-0.12***	-0.10***	-0.149***	-0.09***	-0.06**
Age: 55-65	-0.270***	-0.26***	-0.251***	-0.26***	-0.204***	-0.20***	-0.126*	-0.16***	-0.13***	-0.192**	-0.17***	-0.13***
N =	2618	2618	2618	965	965	965	6292	6292	6292	2306	2306	2306
United Kingdom												
Age: 35-44	-0.117***	-0.10***	-0.098***	-0.0786	-0.082**	-0.0772*	-0.0342	-0.06***	-0.0395*	0.00081	-0.0275	-0.022
Age: 45-54	-0.187***	-0.15***	-0.143***	-0.139**	-0.115***	-0.12***	-0.0823*	-0.12***	-0.10***	-0.149***	-0.09***	-0.06**
Age: 55-65	-0.270***	-0.26***	-0.251***	-0.26***	-0.204***	-0.20***	-0.126*	-0.16***	-0.13***	-0.192**	-0.17***	-0.13***
N =	2618	2618	2618	965	965	965	6292	6292	6292	2306	2306	2306

Notes: Own elaborations on IALS and PIAAC data. Values refer to the percentage change in literacy with respect to the base category (i.e. younger age group 25–34). All figures are weighted. Controls for parental education, migrant status, gender and employment status not reported but available from the authors upon request. Shaded cells are not significant.

* p < 0.05.

** p < 0.01.

*** p < 0.001.

are significant for all age groups, with a stronger decline with age at the lower end of the skills distribution; in Denmark, for example, the negative gap between individuals aged 55–65 and the base category of 25–34 year-olds is 35.1% for the 10th percentile, compared to 17.4% for the 90th percentile. For university graduates of all the countries (except for Poland, where no effect was found), ageing effects are most significant for the older group (aged 45–65 compared to those aged 25–34) and this problem is evident throughout the skill distribution (10th, 50th and 90th percentile). Overall, our research suggests that ageing patterns are fairly similar in all the countries studied (except for Italy and Poland), with a stronger decline with age at the lower end of the skill distribution at any education level (in line with the results in Table 2). This is consistent with the findings of Green and Riddell (2013).

Table 4 presents more detailed results for the cohort effect. For the low/medium education level, there is a clear decline across cohorts for Belgium, the Czech Republic, Denmark, Sweden and the United Kingdom; for the Czech Republic and Denmark, this negative effect is more pronounced at

Table 4
 Cohort effect on literacy skills – Quantile regressions by level of education.

	Low/Medium Education			High Education			Low/Medium Education			High Education		
	Belgium -Flanders						Czech Republic					
	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
Coh2	-0.0387	-0.039*	-0.031*	-0.039	-0.0036	-0.0039	-0.0640*	-0.0399*	-0.0277	0.0216	-0.0115	-0.0085
Coh3	-0.0698	-0.07***	-0.042*	-0.095*	-0.040	-0.041	-0.0806*	-0.061***	-0.0342*	0.00452	0.00650	0.0263
Coh4	-0.137***	-0.10***	-0.06**	-0.079	-0.025	-0.033	-0.128***	-0.098***	-0.07***	-0.0163	-0.0354	-0.0323
Coh5	-0.0704	-0.11***	-0.07**	-0.093*	-0.048	-0.050	-0.161***	-0.110***	-0.068**	-0.00447	-0.0112	-0.0122
N =	2569	2569	2569	1133	1133	1133	3307	3307	3307	754	754	754
	Denmark						Finland					
Coh2	-0.0595*	-0.036**	-0.0195	-0.09***	-0.1***	-0.028*	-0.0249	-0.0073	-0.0009	-0.0371	-0.0154	0.00235
Coh3	-0.081**	-0.053***	-0.036*	-0.10***	-0.06***	-0.046**	0.00043	0.00109	0.0144	-0.0288	-0.0070	0.0126
Coh4	-0.172***	-0.079***	-0.06***	-0.15***	-0.09***	-0.07***	-0.0550*	-0.0146	0.0104	-0.0610	-0.0121	0.0191
Coh5	-0.172***	-0.093***	-0.07***	-0.15***	-0.10***	-0.071**	-0.0487	-0.0009	0.0217	-0.0519	0.00540	0.0301
N=	3664	3664	3664	2149	2149	2149	3546	3546	3546	908	908	908
	Ireland						Italy					
Coh2	-0.0245	-0.00200	-0.0146	-0.0434	-0.0094	-0.0058	0.0538	0.0130	0.0169	0.0200	0.0048	0.0240
Coh3	0.00021	-0.0104	-0.0339	-0.0727	-0.0041	-0.0304	0.0852*	0.0092	0.0111	-0.0420	0.0052	0.0203
Coh4	-0.0406	-0.0423*	-0.06***	-0.111*	-0.0548	-0.0420	0.14***	0.0203	0.0153	-0.0506	-0.009	0.0250
Coh5	-0.0804	-0.0510*	-0.06**	-0.135*	-0.081**	-0.0621	0.17***	0.0321	0.0190	-0.0120	-0.021	0.0146
N=	2932	2932	2932	985	985	985	3644	3644	3644	705	705	705
	The Netherlands						Poland					
Coh2	-0.0415	-0.027*	-0.0075	-0.061*	-0.0091	-0.0138	0.0135	0.0084	0.0060	-0.0921	0.0121	0.0239
Coh3	-0.0612*	-0.015	-0.0001	-0.054*	-0.0056	-0.0107	0.0456	0.035*	0.0139	0.0359	0.0408	0.0203
Coh4	-0.069**	-0.023	-0.0081	-0.0315	0.00629	-0.0095	0.0358	0.0094	0.0009	0.0686	0.0539	0.0301
Coh5	-0.0607*	-0.027	-0.0093	-0.0377	0.00998	0.0116	0.0298	0.0106	0.0116	0.00668	0.0557	0.0485
N=	3146	3146	3146	1397	1397	1397	3243	3243	3243	560	560	560
	Sweden						United Kingdom					
Coh2	-0.0254	-0.025	-0.0154	0.0128	0.00756	0.0133	-0.0657	-0.1***	-0.04*	-0.0179	-0.025	-0.011
Coh3	-0.0276	-0.1***	-0.034*	-0.0650	-0.0200	-0.0061	-0.0597	-0.1***	-0.1***	-0.0383	-0.1***	-0.05**
Coh4	-0.081**	-0.1***	-0.1***	-0.0707	-0.0334	-0.0391	-0.094*	-0.1***	-0.1***	-0.0200	-0.1***	-0.05*
Coh5	-0.088***	-0.1***	-0.1***	-0.091*	-0.0556*	-0.0440	-0.09*	-0.1***	-0.1***	-0.131*	-0.1***	-0.1***
N=	2618	2618	2618	965	965	965	6292	6292	6292	2306	2306	2306

Notes: Own elaborations on IALS and PIAAC data. Values refer to the percentage change in literacy with respect to the base category (Cohort 1: 45–49 in IALS) All figures are weighted. Controls for parental education, migrant status, gender and employment status not reported but available from the authors upon request. Shaded cells are not significant.

* p < 0.05.

** p < 0.01.

*** p < 0.001.

the lower end of the distribution (10th percentile). Among highly educated individuals, the cohort effects are practically absent in all countries except Denmark and the United Kingdom, and there is therefore no evidence that for this education group, literacy skills have diminished across cohorts. A few remarks are worth making. First, small effects are found for Finland, Ireland and the Netherlands, where despite the larger ageing effects among the low- and medium-educated, a small cohort effect emerges. This suggests that the educational systems of these countries may have managed to preserve skill levels across cohorts. Secondly, for Poland, no cross-cohort patterns are found at any level of education. As mentioned above, Poland is the only country in this analysis where average literacy skills improved between IALS and PIAAC. The fact that this improvement does not appear in the regression analysis – either from age or cohort effects – suggests that it may be due to the fact that we controlled for schooling and parental education, and the benefits of this stronger investment in education has affected several generations. A similar explanation can be offered in the case of Italy, though the improvement in skills between IALS and PIAAC is more pronounced at the lower end of the distribution of skills among less well-educated individuals. Lastly, the cases of Denmark and Sweden (the latter for less well- and medium-well educated only) are also worth commenting on; while these are top-performing countries on average literacy skills,

the results here show that they have not been able to maintain the same high level of literacy skills over several generations.

All in all, these results further raise the question of whether they are the consequence of a significant decline in the efficacy of certain European education systems. As mentioned earlier, differences in cohort patterns are the reflection of institutions that have significant and relatively permanent effects on individuals; schools (and education systems) emerge best candidates to explain the differences in average literacy skills.

6. Discussion and conclusions

In this paper, we used IALS 1994–1998 and PIAAC 2012 to investigate how cognitive skills (more specifically, literacy skills) have evolved over time, trying to disentangle ageing and cohort (generational) effects, throughout the distribution of skills and for different levels of educational attainment. Our analysis offers new insight into future scenarios of the evolution of skills in European countries, which are highly relevant in terms of policy implications.

As expected, results show that literacy skills significantly decline with age among the countries investigated, except in Italy and Poland. The negative ageing effect is stronger in older individuals; it is more pronounced at the lower end of the skill distribution, and systematically stronger and more significant for less- and medium-educated individuals. Furthermore, once we controlled for educational attainment and ageing, we also found that the prevalent trend in some countries is that younger cohorts have poorer literacy skills than previous generations. For less- and medium-educated individuals, we identified a negative cohort effect in Belgium, the Czech Republic, Denmark, Sweden and the United Kingdom, while among individuals with high education it was found only in Denmark and the United Kingdom.

More specifically, results show that the negative cohort effect was clearest among the less well-educated in Sweden, and widespread among both levels of education in Denmark. This represents a weakness that has the potential to undermine the position of these countries as benchmarks for the rest of Europe. Indeed, as has also been pointed out by other studies (Ichino and Tabellini, 2014; OECD 2014, 2015), the consequences of recent educational reforms seem to suggest that we are on a negative path of declining skills. In contrast, negative cohort effects are only found in the lower quantiles for Finland and the Netherlands, suggesting that their educational systems may have managed to preserve skill levels across cohorts, as also shown in PISA reading performance, which has been stable between 2000 and 2009 (PISA 2010). Lastly, Poland was among the worst average performers in IALS and PIAAC; however, the country has managed to preserve its levels of skills, and even improve them between the two surveys. In particular, as shown by the OECD's Education at a Glance,⁸ the picture for Poland's 15–29 year-olds without upper secondary education looks slightly brighter than in other OECD countries, since the vast majority were in education in 2011 (80% against the 68% OECD average). Moreover, Poland's annual rate of attainment at tertiary level is growing faster than any other OECD country, and displays the most significant decrease (83%) in the proportion of less-educated individuals in the adult population between IALS and PIAAC. Thus, despite the lack of significant results for ageing and cohort effects, Poland appears to be catching up significantly due to the increased participation in education.

⁸ See https://www.oecd.org/edu/Poland_EAG2013%20Country%20Note.pdf.

All in all, the results of our analysis suggest that declining literacy with age and even more importantly, over consecutive generations, are serious or critical problems in a considerable number of European countries. Our results seem to make clear that deterioration in the overall performance of the educational system across birth cohorts has taken place, especially at the lower and medium levels of education. This raises some concerns for possible structural changes which may have negatively influenced the process of skill acquisition by younger cohorts. In terms of policy, the loss of skills between generations is a big concern: it may result in a loss of competitiveness and well-being in broader terms for the whole society, but it is also particularly relevant if we consider that younger cohorts have to face a more competitive labour market, requiring higher level of skills in information and communication technology due to the higher proportion of automated processes and the increasing technological complexity which involves all occupational sectors, even low-skill occupations. Further, it may lead to inequalities in the set of opportunities that different generations can enjoy, given the positive social outcomes that are associated with education and higher skills. Accordingly, these results confirm the suitability of the EU New Skills Agenda and its different actions in place geared towards building stronger bridges between education and training providers and the labour market.

References

- Agasisti, T., & Cordero, J. M. (2017). The determinants of repetition rates in Europe: Early skills or subsequent parents' help? *Journal of Policy Modeling*, 39(1), 129–146.
- Allmendinger, J. (1989). Educational systems and labor market outcomes. *European Sociological Review*, 5(3), 231–250.
- Arthur, W., Jr., Bennett, W., Jr., Stanush, P. L., & McNelly, T. L. (1998). Factors that influence skill decay and retention: A quantitative review and analysis. *Human Performance*, 11, 57–101.
- Barrett, G., & Craig Riddell, W. Craig. (2016). *Ageing and Literacy Skills: Evidence from IALS, ALL and PIAAC*, OECD Education Working Papers 145. OECD Publishing.
- De Grip, A., & Van Loo, J. (2002). The economics of skills obsolescence: A review in A. de Grip, J. van Loo & K. Mayhew (eds.). *The economics of skills obsolescence: Theoretical innovations and empirical applications*. *Research in Labor Economics*, 21, 1–26.
- Desjardins, R., Warnke, A. J. (2012). Ageing and skills: A review and analysis of skill gain and skill loss over the lifespan and over time. OECD Education Working Papers. Paris: OECD Publishing.
- Educational Research Institute. (2013). *Adult skills in Poland — results of the Programme for the International Assessment of Adult Competencies (PIAAC)*. Warsaw: Educational Research Institute. <http://eduentuzjasci.pl/images/stories/publikacje/ibe-PIAAC-adult-skills-in-Poland-brochure.pdf>
- Eurostat. (2013). Internet at: https://ec.europa.eu/eurostat/statistics-explained/index.php/Population_structure_and_ageing.
- Green, D. A., & Riddell, W. C. (2003). Literacy and earnings: An investigation of the interaction of cognitive and unobserved skills in earnings generation. *Labour Economics*, 10, 165–184.
- Green, D. A., & Riddell, W. C. (2013). Ageing and literacy skills: Evidence from Canada, Norway and the United States. *Labour Economics*, 22, 16–29.
- Ichino, A., & Tabellini, G. (2014). Freeing the Italian school system. *Labour Economics*, 30, 113–128.
- Mateos Romero, L., Murillo Huertas, I. P., & Salinas Jiménez, M. M. (2017). Wage effects of cognitive skills and educational mismatch in Europe. *Journal of Policy Modeling*, 39(5), 909–927.
- Müller, W., & Shavit, Y. (1998). The institutional embeddedness of the stratification process: A comparative study of qualifications and occupations in thirteen countries. In Yossi Shavit, & Walter Müller (Eds.), *From school to work: A comparative study of educational qualifications and occupational destinations* (pp. 1–48). Oxford: Oxford University Press.
- OECD (2010). PISA 2009 results: Executive summary. <https://www.oecd.org/pisa/pisaproducts/46619703.pdf>.
- OECD. (2018). *Literacy, numeracy and problem solving in technology-rich environments: Framework for the OECD survey of adult skills*. OECD Publishing. <http://dx.doi.org/10.1787/9789264128859-en>
- OECD. (2014). *PISA 2012 results in focus what 15-year-olds know and what they can do with what they know*. <http://www.oecd.org/pisa/keyfindings/pisa-2012-results-overview.pdf>

- OECD. (2015). *Improving schools in Sweden: An OECD perspective*. OECD Publishing. Available at <http://www.oecd.org/edu/school/Improving-Schools-in-Sweden.pdf>
- Paccagnella, M. (2016a). *Age, ageing and skills: Results from the survey of adult skills*. *OECD Education Working Papers, No. 132*. Paris: OECD Publishing. <http://dx.doi.org/10.1787/5jm0q1n381vc-en>
- Paccagnella, M. (2016b). *Literacy and numeracy proficiency in IALS, ALL and PIAAC*. *OECD Education Working Papers, No. 142*. Paris: OECD Publishing. <http://dx.doi.org/10.1787/5jlpq7qglx5g-en>
- Statistics Canada. (2003). *International adult literacy survey. Microdata user's guide*.
- Statistics Canada, & OECD. (2005). *Learning a living: First results of the adult literacy and life skills survey*. Ottawa and Paris: Statistics Canada and OECD.