Changes in adult literacy skills across European countries:

Are we ready for the "knowledge economy"?

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Abstract

Skills are at the core of improving individuals' employment outcomes and increasing countries productivity and growth, while ensuring social cohesiveness. In this paper, we look into the current levels and distribution of literacy skills in the working-age population of 11 EU Member States, and examine how the population gains, loses or preserves cognitive skills over time. The empirical analysis is based on a representative sample of adult age population, built merging the two main surveys measuring individual cognitive skills, the 1994-1998 International Adult Literacy Survey (IALS) and the 2012 Survey on Adult Skills (PIAAC). Findings reveal that countries not only differ in average values of skills but also in their distribution, i.e. in the share of high and low achievers. Moreover, the paper shows that a process of deterioration of skills over time is at work in almost all European countries. However, while skill deterioration due to ageing is common to almost all European countries, for some of them concerns arise for the occurrence of skill deterioration due to cohort effects, which has important policy implications. Indeed, the loss of skills between generations may potentially lead to some inequalities in the set of opportunities that different generations can enjoy, but also – and more directly linked to the whole aim of this research – has serious implications for the successful integration of individuals in the economic sector.

Keywords: human capital, literacy, cognitive skills, ageing, labour supply, PIAAC

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1. Introduction

In the current socio economic context, increasingly dominated by technological change and global competition and characterized by a higher share of knowledge-based content, human capital plays a crucial role, whose analysis requires a careful scrutiny of the level and distribution of knowledge and skills. In particular, adult skills are fundamental to ensure a successful integration of individuals in society (Sen, 1999). Poor skills prevent citizens from equally participating in the economic, social and political life of their countries, and expose them to worse employment opportunities, lower earnings and a much greater risk of economic disadvantage, health problems and overall social exclusion (Green and Riddell, 2003; Statistics Canada and OECD, 2005). An adequate investment in skills is critical to promote social mobility, tackling poverty, inequality and marginalization, and contributing to the overall stability and well-being of societies.

Empirical evidence from the new Survey of Adult Skills (PIAAC) in twenty-two OECD countries shows that, across and within countries, there is substantial variation in the level of skills among individuals despite similar formal qualifications. Moreover, at country level, significant disparities exist between the proportion of adults whose skills are among the highest and that of those (generally more numerous) whose skills are among the lowest, which ultimately affect the country's skill level and the rankings among its peers (OECD, 2013). Hence, it comes as no surprise that policy makers in most developed economies, besides the decline of cognitive abilities of an increasingly ageing population, are concerned about whether current and future generations will have the necessary skills to keep pace with the changes in this modern "knowledge economy". *Developing* but also *preserving* skills becomes crucial in a context where competition between national economies is based on intangible production factors such as scientific, technical and organizational skills, emphasizing the amount of knowledge and innovation in goods and services produced. Moreover, skill deterioration is also a concern, since it may lead to increasing skill mismatch and job insecurity over the life course, making it difficult to maintain an adequate level of labour market participation of less skilled individuals and jeopardizing country's economic competitiveness and overall wellbeing.

Therefore, it is important to better understand not only the level and distribution of skills, but also how individuals (and the population) gain, lose and preserve their skills over time. Thus, in this paper, we study the level, distribution and evolution of literacy skills across several OECD countries using data from the 1994-1998 International Adult Literacy Survey (IALS) and the 2012 Survey of Adult Skills (PIAAC), so as to provide a comprehensive picture of the skill challenges these countries are facing.

The IALS and PIAAC surveys are unique datasets in providing measures of individual skills for a representative sample of adult age population across a number of OECD countries using methods of educational testing jointly with household survey techniques and individuals' demographic and socio-economic information. Thus, these surveys offer an exceptional opportunity to better understand how skills are likely to evolve. In this paper, we focus on literacy skills, since PIAAC was specifically designed to link to IALS in this specific domain. Literacy, as a key information-processing competence, refers to the ability to understand, evaluate, use and engage with written texts to participate in society, to achieve one's goals, and to develop one's knowledge and potential (OECD, 2013). Thus, there is growing

recognition of its critical role for personal success workwise and beyond. Deeper knowledge on which literacy abilities to foster, at what age, and desirably through which interventions, is likely to have major implications for the design of effective policies aimed at improving labour market integration and overall individual and social wellbeing.

Building on previous research in this field (see Green and Riddell, 2013 for Canada, Norway and the United States), our work investigates the evolution of skills in 11 European countries, with the aim of separating age and cohort effects in the process of skill deterioration and paying particular attention to what extent different parts of the distribution (top or bottom performers) are affected. Knowing whether the process of deterioration of skills in a society occurs through the lifetime of an individual or rather across different generations and whether top (or bottom) performers are particularly affected, does make a difference and raises the flag for targeted interventions at policy level. In details, we take advantage of the fact that we have two different surveys from two points in time to distinctly identify ageing and cohort effects across the distribution of skills and by educational level. This approach allows determining the different patterns of skill loss or gain with age and across successive cohorts. The focus on the distribution of skills additionally allows us to specifically address the issue of low performers, testing whether the process of ageing and cohort impact differently (negative/positive) and with different magnitude on this particularly relevant group. Overall, this distinction is significant in terms of policy implications, since knowing the source of skill deterioration is the fundamental first step for designing specific measures able to effectively contrast the problem.

Our research provides some important results. First, it seems that individuals acquire their skills through formal education years and these begin to deteriorate afterwards. There is a significant and consistent ageing effect across Europe. Second, we find evidence that more recent birth cohorts have lower levels of literacy in the majority of European countries (except for FI, NL, IT and PL). This is particularly true for more highly educated individuals, highlighting the poorer/unsuccessful role played by education institutions in their attempt to better endow younger generations with relevant skills.

The paper is organized as follows. Section 2 describes the datasets used and provides some descriptive statistics both on the level and distribution of literacy skills across the different countries studied, as well as some socio-economics characteristics of the sample used in PIAAC. Section 3 uses the pooled data from both surveys (IALS and PIAAC) to analyse the primary drivers of adult literacy skills and, in particular, disentangle the age and cohort effects using “artificial cohorts”. Further, in Section 4 we run a series of quantile regressions in order to better investigate whether some specific groups along the skill distribution are affected more than others by age and cohort effects. Then, Section 5 provides results taking into consideration the formal qualification attained. Discussion and conclusions are reported in Section 6.

2. Data and descriptive statistics on the distribution of skills

For the purposes of the 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. Three separate data collections spanning a four years period were conducted in 24 countries or regions (see Table 1).

Table 1. Waves and countries participating in IALS

	YEAR		
	1994	**1996**	**1998**
COUNTRIES	Canada (English and French-speaking populations), France, Germany, Ireland, the Netherlands, Poland, Sweden, Switzerland (German and French-speaking regions), United States of America	Australia, Belgium (Flemish community), Great Britain, New Zealand Northern Ireland	Chile, the Czech Republic, Denmark, Finland, Hungary, Italy, Norway, Slovenia Italian-speaking region of Switzerland

The type of skills investigated is literacy skills, defined as the ability of "using 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). Three domains of literacy are investigated:

a) *Prose literacy*: understanding and using information from written text of various nature (newspapers, fiction, poems);
b) *Document literacy*: understanding, locating and using information contained in various formats (job applications, payroll forms, transportation schedules, maps, tables, and graphics, …);
c) *Quantitative literacy*: the ability to apply arithmetic operations to numbers embedded in printed materials, such as balancing a check book, calculating a tip, completing an order form, or determining the amount of interest on a loan from an advertisement.

The Survey of Adult Skills is an international survey conducted as part of the Programme for the International Assessment of Adult Competencies (PIAAC)[1]; run in 2011 and 2012, it measures key cognitive and workplace skills needed for individuals to participate in society and for economies to prosper. The survey assesses three domains of cognitive skills, namely literacy, numeracy and problem solving in technology-rich environments (PSTRE). According to 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"; numeracy is defined as "the ability to access, use, interpret and communicate mathematical information and ideas, in order to engage in and manage the mathematical demands of a range of situations in adult life", while PSTRE is "using digital technology, communication tools and networks to acquire and evaluate information, communicate with

[1] For the sake of simplicity, in this paper we will use the acronym PIAAC to refer to the survey.

others and perform practical tasks". The first wave of PIAAC problem-solving survey focused on the "abilities to solve problems for personal, work and civic purposes by setting up appropriate goals and plans, and accessing and making use of information through computers and computer networks."

PIAAC was specifically designed to link to IALS in the domain of literacy, while the substitution of the assessment of quantitative literacy with numeracy[2] made it impossible to establish the same type of connection for this domain, since numeracy represents a much wider concept than the former. PSTRE constitutes a new domain, so no comparison is possible. In the literacy domain, around 60% of the assessment items in PIAAC were drawn from IALS (OECD 2013, p. 14), so as to ensure the strong link between surveys. However, in IALS, literacy was assessed on two separate scales (prose and document literacy); while in PIAAC there is one single scale. As explained in the updated documentation for IALS, following PIAAC, the prose and document scales have been re-scaled and combined into one literacy scale; this new scale allows for carrying out of trend analysis with PIAAC. Practically speaking, this implies that in the newly released microdata for IALS, new plausible values for literacy are included that are comparable to those provided by PIAAC. Nonetheless, a couple of slight differences remain; first of all, PIAAC expanded the type of texts used in IALS for assessing literacy: in addition to the continuous (prose) and non-continuous (document) texts used in IALS, PIAAC also includes electronic and combined texts; secondly, PIAAC includes a measure of reading component skills which was not included in IALS (OECD, 2013).

Both surveys have been designed to be representative of the civilian, non-institutionalized population aged 16-65 in the different countries. For the purposes of our analysis, we restrict the 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 11: Belgium (FL), Czech Republic, Denmark, Finland, Germany, Ireland, Italy, The Netherlands, Poland, Sweden, and United Kingdom. It should however be pointed out that while for IALS the UK 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. Furthermore, in PIAAC Germany does not include age as a continuous variable, which forced us to exclude it from the analysis that considers IALS and PIAAC jointly.

Table 2 reports summary statistics for our sample drawn from the 2012 PIAAC data.

[2] This took place already in the Adult Literacy and Lifeskills Survey (ALL), carried out between 2003 and 2006, which is the second international adult skills survey implemented by OECD countries, after IALS and before PIAAC.

Table 2. Demographic and socio-economic characteristics of the individuals in the sample – EU average

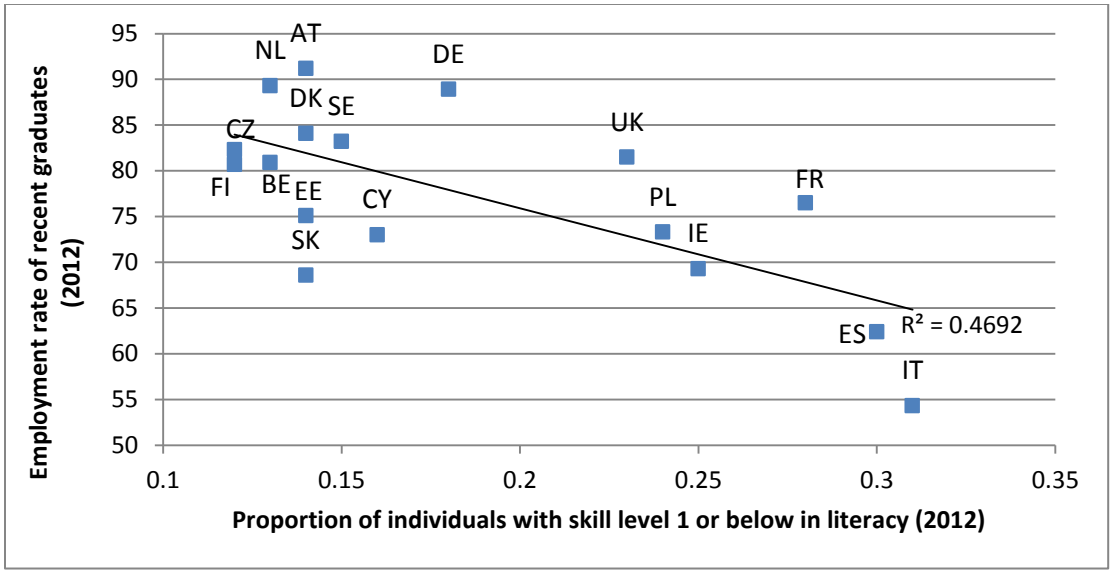
Characteristics	Share
Age group	
16-24	0.196
25-34	0.193
35-44	0.199
45-54	0.197
55 +	0.213
Gender	
Female	0.524
Marital status	
Married	0.588
Family structure	
Presence of children in household	0.613
Parental education	
High level (at least one of the parents having high education)	0.616
Migrants	
Foreign-born	0.102
Educational attainment	
Low Education	0.225
Medium Education	0.473
High Education	0.300
Occupation (for employed individuals only – sample size =67,099)	
Professional occupation	0.438
Semi-professional, white collar occupation	0.274
Semi-professional, blue collar occupation	0.207
Unskilled occupation	0.079
Literacy skills level	
Level 1 or below 1	0.153
Level 2	0.339
Level 3	0.390
Level 4 and 5	0.116
N = 102,895	

Source: Own calculations on our working sample from PIAAC (2012).

2.1. The distribution of skills across and within countries: a look beyond the mean

As previously mentioned, skills have become a critically important "*tool*" of the current century and the recent publication of the PIAAC Survey has generated large debates among academics and the general public on the relationship between skills and economic and social outcomes. Countries like IT and ES, which are lagging behind in terms of economic performance and social cohesion, are also performing among the worst in terms of individual literacy and numeracy skills in current PIAAC survey; on the contrary, countries like FI, the NL and BE (Flanders), with good economic and social indicators, rank among those with the highest individual average skills. However, while most of the analyses are limited to comparing average values among countries, how these skills are distributed is just as important as the average levels of skills, despite having received less attention so far. If we take, for example, the lower end of the skill distribution (i.e. individuals who score at level 1 or below in literacy skills in PIAAC[3]) and relate it to the benchmark of the strategic framework for European cooperation in education and training (ET 2020) concerning the employment rate of recent graduates[4] (as a possible proxy of economic performance), it appears that countries with fewer low-skilled adults tend to enjoy better economic performance (see Figure 1). Similar results are obtained if we compare the upper end of the skill distribution (i.e. individuals who score at level 3 or above in literacy skills in PIAAC) and a social outcome such as individuals' trust (see Figure 2): countries with higher shares of high-skilled individuals rank higher in levels of social trust.

Figure 1. Relationship between the proportion of individuals with skill level 1 or below in literacy and the ET 2020 benchmark on the employment of recent graduates

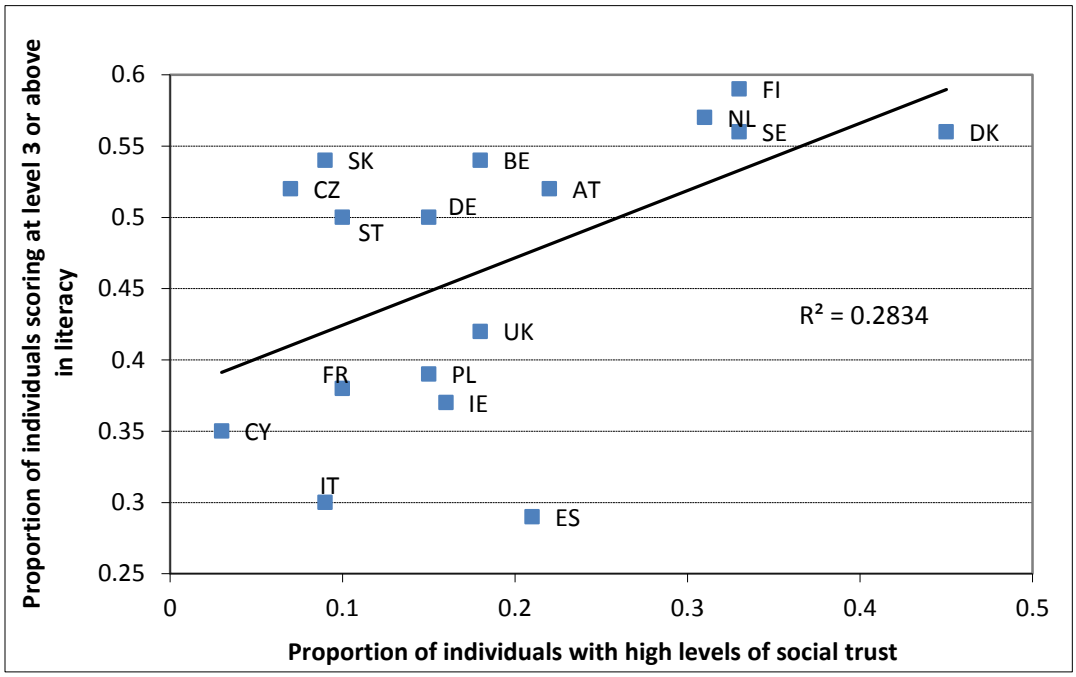


Note: Own elaborations on PIAAC and Eurostat data.

[3] Score points on the proficiency scale in PIAAC are grouped in standard proficiency levels: "Below Level 1" (scores between 1 and 175); "Level 1" (176-225); "Level 2" (226-275); "Level 3" (276-325); "Level 4" (326-375); "Level 5" (376-500).

[4] This benchmark aims to employ 82% of 20-34 year old graduates from upper secondary to tertiary education having left education and training no more than three years before the reference year.

Figure 2. Relationship between the proportion of individuals scoring at level 3 or above in literacy and individuals' social trust



Note: Own elaborations on PIAAC 2012 data. In PIAAC, the item on trust asks the respondents how much they agree – on a scale from 1 to 5, where 1 is "strongly agree" and 5 is "strongly disagree" – with the statement "There are only a few people you can trust completely". Individuals with a high level of social trust are defined as those who answered "disagree" or "strongly disagree" to the question.

These figures suggest that in evaluating the performance in terms of skills of a country, it can be relevant to go beyond the simple average scores, and analyse the distribution of skills. From a policy perspective, this is particularly important, since it can provide useful insight for a more targeted approach, assessing the efficiency of the system in providing the appropriate level of skills to all individuals, but also informing governments on the segment of the population where they should invest in order to achieve greater economic and social results.

As a first step in the analysis, we start by simply looking at the average score in literacy and the standard deviation in the surveyed countries, as a measure of how dispersed the skills distribution is (see Table 3).

Table 3. Mean and standard deviation for literacy skills by country

Country	Literacy	
	Mean	Standard deviation
Austria	269.45	43.96
Belgium	275.48	47.08
Cyprus	268.84	40.27
Czech Republic	274.01	40.79
Denmark	270.79	47.72
Estonia	275.88	44.40
Finland	287.55	50.67
France	262.14	49.02
Germany	269.81	47.40
Ireland	266.54	47.19
Italy	250.48	44.69
Netherlands	284.01	48.39
Poland	266.90	47.98
Slovak Republic	273.85	40.07
Spain	251.79	49.03
Sweden	279.23	50.56
United Kingdom	272.46	48.97

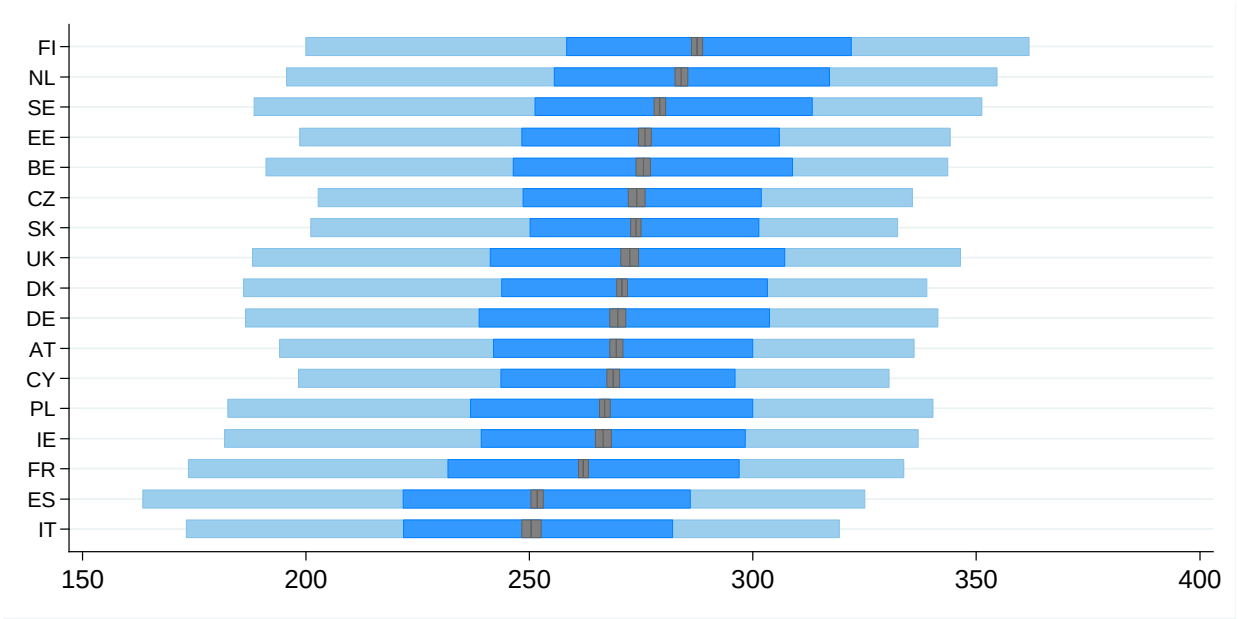
Note: Own elaboration on PIAAC data.

Average scores are useful to rank countries and to acknowledge which countries are – on average – top and worst performers. As widely known, we have IT and ES being the worst performers and FI, SE, NL and BE being the top ones. Nevertheless, looking at the standard deviation can provide some additional information. In particular, we see that for literacy three of the top performers have the higher standard deviation: SE, FI and NL have the most disperse distribution, together with ES and FR, which are, on the other side, two of the worst performers. This result highlights how a consistent heterogeneity within the population can be found both in countries that are outstanding performers and in others that are considered as poor performers. Higher dispersion means that the difference between the top and the bottom part of the distribution of skills is more pronounced. In Figure 3 we report the mean literacy skill level in the population (together with the 0.95 confidence interval, represented by the grey bars), the 25^{th} and 75^{th} percentiles (dark blue bars), and the 5^{th} and 95^{th} percentiles (light blue bars). We see that for example, although the Finnish are on average performing better than all the remaining countries in literacy, the bottom 5% of Finnish some people are performing worse than their Czech or Slovak counterparts. On the other side, while on average CZ and SK perform better than many countries, we notice that the top 75% of the German, English, and Danish population, and even some peers from PL and IE perform better than the corresponding Czech and Slovak population. This suggests that a higher average performance does not necessarily imply a higher score at all points of the skills distribution, and therefore also that higher mean scores do not guarantee a higher proportion of high achievers. As a

matter of fact, while CZ and SK have higher average performances, DE, DK and UK have a higher proportion of high achievers (here considered as those individuals scoring at proficiency level 4 and above), as can be seen in Table 4, where the distribution of the population by literacy skill level is reported. The same is true for FR and CY: the former has a lower average than the latter, but has a higher value of the 95th percentile, resulting in a higher percentage of individuals scoring at level 4 and above in FR than in CY. This percentiles analysis is also helpful for interpreting differences between countries and for having a sense of the magnitude of these differences. So, in Figure 3 we notice for example that on average the Finnish perform better than the Spanish and the Italian, but "how much better" can be seen noticing that the average Italian score is as low as the score of the bottom 25% of the Finnish population, or that the average Finnish score is as high as the score of the top 75% of the Italian population.

Figure 3. Distribution of skills – Literacy

Percentiles in literacy proficiency: mean score and 0.95 confidence interval (grey bars), 25th and 75th (dark blue) and 5th and 95th (light blue)



Note: Own elaborations on PIAAC data.

Table 4. Distribution of the population by PIAAC skills proficiency level

Country	Literacy			
	Level 1 and below	Level 2	Level 3	Level 4 and 5
Austria	14.66	36.64	38.20	8.68
Belgium	13.46	28.83	39.17	13.39
Cyprus	11.69	31.95	33.10	5.58
Czech Republic	11.48	34.66	43.53	9.70
Denmark	15.32	34.14	39.63	10.53
Estonia	12.54	33.92	40.90	12.27
Finland	10.20	25.80	41.08	22.92
France	20.57	36.28	33.96	8.35
Germany	17.13	32.74	37.70	10.95
Ireland	17.03	36.27	37.15	9.08
Italy	25.77	42.63	27.23	3.71
Netherlands	11.44	26.47	40.75	19.08
Poland	18.57	36.04	35.04	10.35
Slovak Republic	11.46	34.89	45.34	8.04
Spain	26.87	39.20	28.08	5.09
Sweden	13.23	28.91	41.27	16.60
United Kingdom	15.15	33.08	37.12	13.24

Note: Own elaboration on PIAAC data. Reported skill levels correspond to PIAAC proficiency levels explained above.

Overall, this exercise suggests that looking at the mean performance may not be enough, especially if policy makers aim at identifying particular groups upon which to intervene. These first descriptive analyses have pointed out some facts that deserve deeper investigation: first, countries differ not only in their average performance, but also in the distribution of skills within the population, and in particular in, the degree of dispersion of the distribution itself. Second, differences in averages are not always reflected in differences at the top or bottom quantiles of the skill distribution: as an example, some countries may have higher averages than others, but lower values at top quantiles, likely resulting in a lower proportion of high achievers. Last, looking at the quantiles can give us insight into the magnitude of country differences in averages, especially comparing top performing and low achieving countries. We devote the rest of the paper to getting a deeper insight into the distribution and evolution of adult skills across Europe.

3. Disentangling ageing and cohort effects in the evolution of skills: a multivariate analysis

As widely discussed in the literature, ageing is one of the key drivers of skill change (Arthur, et al., 1998; Desjardins and Warnke, 2012; or De Grip and Van Loo, 2002), and moreover one of the main social and economic challenges of the current century for many countries. In Europe, for example, the ratio of people aged 65 and over as a percentage of the population aged 18-65 is expected to increase dramatically in the next 50 years (Eurostat, 2013). However, countries are currently facing another threat regarding skill evolution: are the new generations leaving formal education with higher or lower levels of skills? Have the massive education expansion policies implemented in most European countries been effective in raising the skills of the younger part of the population?

Generational differences may exist. Thus, understanding the interplay of ageing and cohort effects, and how they contribute to shape the skill levels of the European countries, is fundamental for policy makers, so as to ensure that their citizens are skilled enough to increase prosperity and growth in the overall society, at the same time reaching individual fulfilment. To better disentangle cohort and ageing effects we need either panel data or at least two cross-sectional datasets built in such a way that allows following "synthetic" cohorts through time. Given the consistent time lag between IALS and PIAAC surveys (between 13 and 17 years) we pool them for this purpose. More specifically, from the IALS sample, we observe a set of 5-year age groups for the individuals (i.e., age groups 25-29, 30-34, 35-39, 40-44, and 45-49). From PIAAC we can construct age groups that correspond to the age people in these initial groups would be 13, 15 and 17 years after IALS (see Table 5 for a correspondence between age groups, that takes into account how many years passed between IALS and PIAAC). We refer to people who were aged 45-49 in IALS as "Cohort 1", that is, the oldest cohort which is also captured in PIAAC later on at ages ranging between 58 and 65 depending on the country. Younger cohorts in IALS are sequentially number 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 the literacy distribution for the cohort at two different points in time and we can follow the progress of a given cohort over time. Our sample therefore includes individuals which are present in cohorts both in IALS and PIAAC[5].

[5] Since for DE the only age information available in PIAAC is about 5-years age groups, we decided to discard this country from the analysis, because the information on age as a continuous variable is strictly fundamental under this setting

Table 5. Correspondence between cohorts in IALS and PIAAC to build synthetic cohorts (depending on time gap between the two surveys)

COHORT	IALS	PIAAC		
		13 years gap	15 years gap	17 years gap
1	45-49	58-62	60-64	62-65
2	40-44	53-57	55-59	57-61
3	35-39	48-52	50-54	52-56
4	30-34	43-47	45-49	47-51
5	25-29	38-42	40-44	42-46

We start by pooling IALS and PIAAC data, and running a simple OLS regression in which the dependent variable is the individual score in literacy skills. Age categories and cohort dummies are included as covariates as explained above. Other variables used as controls are: individual educational level categorised as low (ISCED 0-2), medium (ISCED 3-4) or high (ISCED 5 or higher), gender, and variables related to parental background. In particular, we include mother's and father's education and immigrant background. Parental education follows the same categories as above (low, medium and high), to which we add an extra category for missing responses that is used as baseline group. The regressions are estimated separately by country[6].

When trying to disentangle age, cohort and year effects, an identification issue arises, since the year is basically the sum of birth year and age. Thus, an assumption we have to make before estimating the regression is that there is no year effect, i.e. there is no such a thing that increases or decreases skills in all groups defined by age and cohort in a similar way in a given year.[7] This is an assumption usually made in the literature (see Green and Riddel, 2013). Given this assumption, we can identify age and cohort effects. Unfortunately, since we have only two cohorts per country, it is not possible to interact age and cohort, so to allow for the ageing to have a different effect for the different cohorts.

We present the results in Table 6. In general we notice a true ageing effect. In most of the countries, the negative coefficients increase as age increases, suggesting that the decrease in skills continues over the life span of the individuals. IT and PL are two exceptions, since in PL the ageing effect is negative in all age groups, but coefficient are very similar between themselves, but only significant for the age groups 45-54 and 55-65. In any case, the progressive age effect is less pronounced; in IT instead no significant results have been found.

[6] Given the combination of PIAAC and IALS we could not use the replicated weights, since in IALS there are only 30 replicated weights, while in PIAAC there are 80. Nevertheless we could use the 10 plausible values, since IALS test scores have been adapted in order to match the PIAAC plausible values.

[7] A violation of this assumption would be that in a given year between IALS and PIAAC, e.g. in year 1999, the skills of the overall population increased similarly in all age and cohort groups due to external events (e.g. natural disasters or reforms). In our case, we have no evidence of what event could lead to such an increase/decrease, so we assume no year effect.

If we look at cohort effects an interesting pattern emerges: in most of the countries more recent generations are performing worse than the older ones, indeed the coefficients associated to younger cohorts are negative and significant, meaning that they have lower skills that the reference cohort (individuals aged 45-49 in IALS); in some countries, however, we see either no cohort effect or even a positive one.

Table 6. Age and cohort effect on literacy skills

	BE	CZ	DK	FI	IE	IT	NL	PL	SE	UK
Age: 25-34	-	-	-	-	-	-	-	-	-	-
Age: 35-44	-0.408***	-0.479***	-0.391***	-0.284***	-0.225***	-0.0694	-0.123**	-0.106	-0.531***	-0.241***
	(0.052)	(0.053)	(0.046)	(0.046)	(0.061)	(0.044)	(0.045)	(0.063)	(0.061)	(0.043)
Age: 45-54	-0.624***	-0.814***	-0.813***	-0.457***	-0.466***	0.0168	-0.367***	-0.190***	-0.803***	-0.520***
	(0.053)	(0.062)	(0.046)	(0.051)	(0.054)	(0.054)	(0.040)	(0.057)	(0.054)	(0.041)
Age: 55-65	-1.066***	-1.125***	-1.318***	-0.771***	-0.662***	-0.0795	-0.684***	-0.175*	-1.439***	-0.867***
	(0.070)	(0.077)	(0.068)	(0.064)	(0.071)	(0.067)	(0.055)	(0.080)	(0.073)	(0.061)
Cohort 1: 45-49 in IALS	-	-	-	-	-	-	-	-	-	-
Cohort 2: 40-44 in IALS	-0.133*	-0.168***	-0.194***	-0.0385	-0.0376	0.132**	-0.0933*	0.0505	-0.0594	-0.154***
	(0.060)	(0.049)	(0.037)	(0.047)	(0.060)	(0.051)	(0.044)	(0.062)	(0.058)	(0.041)
Cohort 3: 35-39 in IALS	-0.278***	-0.223***	-0.309***	0.0185	-0.0424	0.120*	-0.0697	0.167**	-0.193***	-0.277***
	(0.058)	(0.056)	(0.040)	(0.055)	(0.056)	(0.057)	(0.046)	(0.061)	(0.058)	(0.048)
Cohort 4: 30-34 in IALS	-0.353***	-0.455***	-0.481***	-0.0537	-0.220***	0.209***	-0.0913	0.120	-0.483***	-0.392***
	(0.071)	(0.062)	(0.050)	(0.059)	(0.065)	(0.059)	(0.047)	(0.069)	(0.061)	(0.046)
Cohort 5: 25-29 in IALS	-0.389***	-0.494***	-0.570***	-0.000028	-0.284***	0.259***	-0.0720	0.105	-0.511***	-0.542***
	(0.078)	(0.063)	(0.057)	(0.062)	(0.062)	(0.064)	(0.048)	(0.072)	(0.064)	(0.053)
Observations	3708	4063	5814	4455	3920	4350	4544	3805	3591	8607

Notes: Own elaborations on IALS and PIAAC data. All figures are weighted. Controls for education, parental education, migrant status and gender not reported.
* p < 0.05, ** p < 0.01, *** p < 0.001. Standard errors in parentheses.

More in detail, we see that in some countries there is a strong negative cohort effect, increasing as cohorts become younger, meaning that more recent cohorts have fewer skills than older cohorts. This is the case in BE, CZ, DK and the UK. In SE and IE, there is a negative cohort effect only from cohorts 3 and 4 onwards, respectively: only younger generations (those who were aged under 35 in IALS) have lower skills than the older ones (aged 45-49), while middle cohorts still perform in line with the previous generations. Interestingly, in FI or NL there is no cohort effect, while in IT and, to a lesser extent in PL we see a positive impact for all more recent generations, implying that they have a higher level of skills than the reference generation.

These patterns lead to some implications: countries where younger cohorts are performing worse than the older cohort ring the bell to the performance of the educational system. Are the new generations less prepared than the older ones? If this is the case it is worrying, since we have seen that skills tend to decrease with age, and the fact that younger cohorts start off with lower level of skills indirectly implies that the overall population will hold lower and lower skills as time goes by. On the other side, fewer concerns are raised by countries where there are no differences between younger and older cohorts, even if the ideal situation would be to increase the skills of the younger cohorts, as it happened in IT. However, this country is not entirely exempt from a critical judgment. Are the new generations more skilled simply because there are more people enrolled in higher level of education? While this would in any case be a positive outcome, proving that education expansion is a successful policy, it would nevertheless be desirable that new generations have higher skills even at the same educational level. This question cannot be answered with the current regressions, since, despite controlling for education, we are not allowing ageing/cohort effect to vary by educational level. Likewise, in light of the evidence provided in the previous section, it is also necessary to consider how literacy skills evolved, and the role of ageing and cohort effects, at different points of the skill distribution, i.e. taking into account low and high achievers. We therefore proceed further in the analysis in two ways: next section provides the results of running the same regressions adopting a quantile approach, studying cohort and ageing effects on the different quantiles of the skill distribution; second we replicate the OLS and the quantile regression by level of education (Section 5), to assess whether skills loss/gain in the new generations is consistent across education groups.

4. Ageing and cohort effects over the skills distribution: a quantile regression

Building on the OLS regressions carried out in the previous section, we run here a series of quantile regressions to investigate whether the cohort and ageing effects affect differently different quantiles of the skill distribution. In particular, we focus on three important quantiles, i.e. 10^{th}, 50^{th} and 90^{th}. The 10^{th} quantile relates to the bottom part of the skill distribution, thus on what we can consider as ***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. On the other side, the 90^{th} quantile focuses on the top part of the distribution, thus on ***high achievers*** within the country.[8] Finally, studying the median is interesting to see effects on the middle part of the

[8] Notice that the concept of high and low achievers used here is not directly connected with skill level. We use high and low achievers to refer to the bottom and top part of the skill distribution within a country.

distribution and how they diverge from the mean (estimated in the OLS) and by the extreme quantiles.

Results are reported for all countries in Table 7. Several facts are noticeable from these regressions. First, while we observe that the declining literacy with age is present in most of the quantiles, the effect is larger at top that at the bottom of the distribution for IE, the UK and SE quantiles, meaning that the high achievers part of the skill distribution loses more skills than the low achievers as age increases. On the other side, in BE, CZ, DK, FI and NL we observe the opposite: the age effect is larger at bottom quantiles, meaning that the decrease in skills due to ageing is larger in the low achievers part of the population, while high achievers manage to better preserve their skills. No significant results are reported for IT or PL.

Second, as far as cohort effects are concerned, again some differences between countries and across quantiles arise. In CZ, SE, DK and the UK we observe a negative cohort effect, with younger generations (especially cohorts 3, 4 and 5 from 25 to 35 when IALS took place) owning lower levels of skills compared to the older ones (aged 45-54). In SE and the UK, the negative cohort effect is in all quantiles increasing as cohort increases, being much larger at top quantiles, suggesting that the younger generations have lower skills than the old ones, especially among the high achievers. In DK and CZ, on the other side, the negative cohort effect is in all quantiles, increasing as cohort increases, but the effect is larger at bottom quantiles, implying that the more recent generations have lower skills than the old ones, and this effect is larger for low achievers. Similar trend, though to a lesser extent is found in BE and NL (the latter significant only for low achievers). Alternatively, no big differences are observed between low and high achievers for NL. Interestingly, in IT we observe a positive cohort effect mainly driven by the bottom part of the distribution (the 10^{th} quantile), implying that younger generations start off with higher skills that the old ones.

Table 7. Age and cohort effect on literacy skills – Quantile regressions by country

	Belgium			Czech Republic			Denmark			The Netherlands		
	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
Age: 35-44	-0.543***	-0.405***	-0.353**	-0.512***	-0.459***	-0.437***	-0.607***	-0.351***	-0.294***	-0.129	-0.121	-0.0799
	(0.130)	(0.079)	(0.111)	(0.135)	(0.080)	(0.093)	(0.092)	(0.054)	(0.079)	(0.093)	(0.067)	(0.081)
Age: 45-54	-0.581***	-0.694***	-0.563***	-0.861***	-0.787***	-0.745***	-1.166***	-0.753***	-0.645***	-0.477***	-0.357***	-0.240***
	(0.143)	(0.072)	(0.101)	(0.130)	(0.090)	(0.120)	(0.094)	(0.058)	(0.085)	(0.078)	(0.062)	(0.071)
Age: 55-65	-1.092***	-1.177***	-0.954***	-1.309***	-1.112***	-0.953***	-1.697***	-1.279***	-1.103***	-0.893***	-0.665***	-0.509***
	(0.185)	(0.094)	(0.138)	(0.158)	(0.113)	(0.155)	(0.130)	(0.074)	(0.120)	(0.114)	(0.081)	(0.091)
Cohort 2: 40-44 in IALS	-0.145	-0.0929	-0.111	-0.183	-0.187*	-0.129	-0.273**	-0.219***	-0.144*	-0.179	-0.0825	-0.0258
	(0.126)	(0.081)	(0.082)	(0.098)	(0.078)	(0.107)	(0.094)	(0.048)	(0.064)	(0.097)	(0.061)	(0.071)
Cohort 3: 35-39 in IALS	-0.306*	-0.304***	-0.235*	-0.284*	-0.254**	-0.120	-0.358***	-0.301***	-0.259***	-0.230*	-0.0197	0.0201
	(0.144)	(0.077)	(0.116)	(0.112)	(0.084)	(0.127)	(0.105)	(0.052)	(0.076)	(0.092)	(0.061)	(0.068)
Cohort 4: 30-34 in IALS	-0.424**	-0.363***	-0.292*	-0.459***	-0.469***	-0.410***	-0.732***	-0.458***	-0.393***	-0.203*	-0.0410	-0.0310
	(0.144)	(0.081)	(0.130)	(0.129)	(0.098)	(0.122)	(0.103)	(0.063)	(0.086)	(0.092)	(0.071)	(0.084)
Cohort 5: 25-29 in IALS	-0.222	-0.481***	-0.359**	-0.578***	-0.506***	-0.365*	-0.738***	-0.555***	-0.484***	-0.185	-0.0417	0.0149
	(0.151)	(0.097)	(0.138)	(0.156)	(0.104)	(0.146)	(0.123)	(0.067)	(0.097)	(0.102)	(0.072)	(0.075)
Observations	3708	3708	3708	4063	4063	4063	5814	5814	5814	4544	4544	4544
	Finland			**Ireland**			**Italy**			**Poland**		
	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
Age: 35-44	-0.424***	-0.249***	-0.132	-0.179	-0.236**	-0.245**	-0.00632	-0.0916	-0.155*	-0.100	-0.135	-0.150
	(0.094)	(0.058)	(0.088)	(0.136)	(0.082)	(0.095)	(0.102)	(0.066)	(0.076)	(0.151)	(0.084)	(0.122)
Age: 45-54	-0.714***	-0.390***	-0.225*	-0.508***	-0.437***	-0.502***	0.196	-0.0401	-0.170	-0.203	-0.227**	-0.188
	(0.112)	(0.074)	(0.097)	(0.114)	(0.078)	(0.097)	(0.137)	(0.078)	(0.098)	(0.131)	(0.083)	(0.096)
Age: 55-65	-1.063***	-0.744***	-0.477***	-0.619***	-0.667***	-0.810***	0.221	-0.225*	-0.291*	-0.165	-0.241*	-0.197
	(0.144)	(0.091)	(0.094)	(0.158)	(0.105)	(0.113)	(0.185)	(0.108)	(0.117)	(0.176)	(0.107)	(0.129)
Cohort 2: 40-44 in IALS	-0.111	-0.0350	0.0114	-0.0707	-0.000363	-0.0841	0.208	0.0722	0.104	0.00767	0.0554	0.0762
	(0.094)	(0.067)	(0.066)	(0.140)	(0.082)	(0.114)	(0.124)	(0.079)	(0.105)	(0.115)	(0.085)	(0.104)
Cohort 3: 35-39 in IALS	-0.0200	0.0216	0.105	0.0102	-0.0356	-0.185	0.250	0.0351	0.0777	0.172	0.192**	0.0941
	(0.096)	(0.082)	(0.084)	(0.114)	(0.079)	(0.102)	(0.141)	(0.087)	(0.096)	(0.127)	(0.071)	(0.091)
Cohort 4: 30-34 in IALS	-0.230*	-0.0373	0.106	-0.173	-0.229*	-0.346***	0.474***	0.0834	0.0762	0.129	0.109	0.0511
	(0.109)	(0.086)	(0.083)	(0.147)	(0.095)	(0.102)	(0.139)	(0.099)	(0.100)	(0.163)	(0.098)	(0.111)
Cohort 5: 25-29 in IALS	-0.221	0.0308	0.171	-0.290	-0.284**	-0.380***	0.575***	0.109	0.0798	0.0781	0.107	0.124
	(0.125)	(0.106)	(0.095)	(0.152)	(0.090)	(0.109)	(0.151)	(0.109)	(0.122)	(0.186)	(0.094)	(0.105)
Observations	4455	4455	4455	3920	3920	3920	4350	4350	4350	3805	3805	3805

	Sweden			UK		
	10th	50th	90th	10th	50th	90th
Age: 35-44	-0.547***	-0.543***	-0.619***	-0.119	-0.301***	-0.267**
	(0.111)	(0.079)	(0.124)	(0.124)	(0.066)	(0.090)
Age: 45-54	-0.834***	-0.771***	-0.852***	-0.397**	-0.608***	-0.602***
	(0.097)	(0.075)	(0.096)	(0.124)	(0.071)	(0.088)
Age: 55-65	-1.321***	-1.453***	-1.593***	-0.775***	-1.013***	-0.963***
	(0.129)	(0.089)	(0.130)	(0.170)	(0.085)	(0.109)
Cohort 2: 40-44 in IALS	0.0112	-0.0365	-0.0102	-0.192	-0.184**	-0.178
	(0.097)	(0.062)	(0.092)	(0.119)	(0.065)	(0.102)
Cohort 3: 35-39 in IALS	-0.0655	-0.167**	-0.129	-0.292*	-0.335***	-0.332***
	(0.114)	(0.063)	(0.094)	(0.137)	(0.072)	(0.090)
Cohort 4: 30-34 in IALS	-0.292**	-0.479***	-0.555***	-0.391**	-0.463***	-0.438***
	(0.112)	(0.076)	(0.110)	(0.140)	(0.069)	(0.087)
Cohort 5: 25-29 in IALS	-0.353**	-0.496***	-0.563***	-0.465**	-0.648***	-0.654***
	(0.116)	(0.078)	(0.107)	(0.143)	(0.080)	(0.115)
Observations	3591	3591	3591	8607	8607	8607

Notes: Own elaborations on IALS and PIAAC data. All figures are weighted. Reference categories are age group 25-34 and Cohort 1. Controls for education, parental education, migrant status and gender not reported.
* p < 0.05, ** p < 0.01, *** p < 0.001. Standard errors in parentheses.

These results, especially those related to the cohort effects, raise the concern about whether they are the consequence of a significant decline in effectiveness of the different education systems in Europe, particularly at the university level. We are currently witnessing an upward trend in terms of the proportion of the overall population that is in possession of a tertiary education qualification, with the European Union getting closer to the 40% attainment rate amongst 30-34 year olds that represents one of the EU 2020 headline targets. In the next section, we present a set of regressions for those with low-medium education and those with high education (university graduates) so as to

take a closer look at education-related effects and shed further light into the effectiveness of education systems.

5. Drivers of skills change over the skills distribution: the effect of education.

In order to assess whether different patterns emerge across different educational groups, in this section we carry out the same type of analysis presented in Section 4, i.e. the quantile regression for the estimation of ageing and cohort effect, by level of education. For sample size issues, we consider here two possible levels, high versus medium-low. We focus on this division since we are mainly interested in seeing differences in skills' preservation/deterioration distinguishing between university graduates and individuals with at most upper secondary education. For this reason we group together all individuals who do not have a tertiary degree, independently of whether they reached upper secondary education. Results are presented in Table 8.

In general, for the low-medium educated group in BE, CZ, FI, IE, NL, SE and UK, the ageing effects are evident from the age group 45-54 (for CZ the ageing for this group is noticeable from 55 onwards). These results suggest that there is less loss with age at the very basic level of literacy than among more literacy demanding levels. The fact that the ageing patterns are similar across all countries suggests that the impact of post-school education is similar in all of them. Further, there is no systematic evidence that the lowest quantiles for this education group have decreased across cohorts (weak significance on the deterioration of skills by cohort is found in BE). At the top end of the distribution (90^{th} percentile of highly educated individuals), results are overall similar to those presented in Table 6 and Table 7. We witness a strong decline with age combined with declines across recent cohorts (except for FI and NL). These results may indicate that while it seems possible that changes in the different educational systems have been balancing across cohorts, with better literacy levels for those individuals at the bottom, the outcome has not been so successful for those at the top end, with decline in literacy among younger cohorts. This has not been the case for FI or NL, where despite the larger ageing decline in skills among university graduates (compared to the low-medium educated peers), there is no cohort effects across all the literacy skills distribution, suggesting that the educational systems managed to preserve skill levels across cohorts. For the university educated group, the decline with age are evident across the whole distribution but tend to be more noticeable at the bottom of the distribution (10^{th} percentile). There is also some greater evidence of decline across cohorts for these individuals.

Particularly unexpected are the results for DK, where we find recurrent ageing and cohort effects across all the literacy/education distribution. Numbers tend to be larger for the lowest quantiles. If differences in cohort patterns are possible signs of the efficiency of institutions in providing the proper literacy levels, then one needs to conclude that despite being a reference country in generating high levels of literacy skills, it appears that lately the country has not been able to maintain high levels of literacy over consecutive cohorts.

In PL instead we observe a positive cohort effect, which is driven mostly by bottom and medium quantiles, meaning that younger generation with high education start off with higher skills than the

older generation (compared to the low-medium educated counterparts), especially among the individuals located in lower part of the skill distribution.

Table 8. Age and cohort effect on literacy skills- Quantile regressions

	Low Medium Education			High Education			Low Medium Education			High Education		
	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
	Belgium						**Czech Republic**					
Age: 35-44	-0.359	-0.284*	-0.304	-0.646***	-0.461***	-0.376**	-0.383	-0.372***	-0.294	-0.562***	-0.478***	-0.471***
	(0.200)	(0.141)	(0.226)	(0.165)	(0.078)	(0.120)	(0.269)	(0.109)	(0.197)	(0.136)	(0.082)	(0.094)
Age: 45-54	-0.494*	-0.469**	-0.438	-0.663***	-0.769***	-0.597***	-0.369	-0.444***	-0.413*	-0.985***	-0.860***	-0.824***
	(0.235)	(0.161)	(0.260)	(0.167)	(0.073)	(0.101)	(0.264)	(0.134)	(0.203)	(0.149)	(0.093)	(0.115)
Age: 55-65	-1.295***	-0.897***	-0.946***	-1.063***	-1.259***	-0.965***	-0.744**	-0.800***	-0.655*	-1.467***	-1.206***	-1.028***
	(0.307)	(0.177)	(0.273)	(0.216)	(0.095)	(0.143)	(0.281)	(0.146)	(0.272)	(0.175)	(0.126)	(0.162)
Cohort 2	-0.166	0.0271	0.0222	-0.0927	-0.123	-0.149	0.0920	-0.0619	-0.0432	-0.262*	-0.204*	-0.146
	(0.172)	(0.116)	(0.133)	(0.149)	(0.080)	(0.089)	(0.197)	(0.153)	(0.192)	(0.132)	(0.091)	(0.115)
Cohort 3	-0.516*	-0.236	-0.266	-0.190	-0.309***	-0.239	0.00850	0.0374	0.207	-0.374**	-0.331***	-0.193
	(0.202)	(0.131)	(0.218)	(0.181)	(0.082)	(0.124)	(0.206)	(0.149)	(0.297)	(0.131)	(0.096)	(0.110)
Cohort 4	-0.433*	-0.158	-0.224	-0.463**	-0.447***	-0.326**	-0.109	-0.219	-0.220	-0.568***	-0.530***	-0.453***
	(0.211)	(0.147)	(0.201)	(0.177)	(0.080)	(0.125)	(0.260)	(0.161)	(0.220)	(0.128)	(0.098)	(0.126)
Cohort 5	-0.500*	-0.279	-0.311	-0.133	-0.526***	-0.380*	-0.0196	-0.0685	-0.0874	-0.720***	-0.602***	-0.437**
	(0.225)	(0.159)	(0.258)	(0.203)	(0.095)	(0.151)	(0.262)	(0.176)	(0.241)	(0.176)	(0.112)	(0.143)
Observations	1134	1134	1134	2574	2574	2574	754	754	754	3309	3309	3309
	Denmark						**Finland**					
Age: 35-44	-0.504**	-0.347***	-0.263	-0.635***	-0.346***	-0.300**	-0.326	-0.134	-0.0174	-0.451***	-0.268***	-0.139
	(0.195)	(0.101)	(0.153)	(0.096)	(0.066)	(0.095)	(0.187)	(0.126)	(0.182)	(0.107)	(0.073)	(0.096)
Age: 45-54	-0.961***	-0.696***	-0.630***	-1.218***	-0.753***	-0.627***	-0.477*	-0.200	-0.0348	-0.785***	-0.434***	-0.242*
	(0.244)	(0.120)	(0.179)	(0.106)	(0.074)	(0.086)	(0.218)	(0.158)	(0.205)	(0.122)	(0.088)	(0.103)
Age: 55-65	-1.740***	-1.252***	-1.078***	-1.620***	-1.264***	-1.094***	-0.941***	-0.591**	-0.234	-1.107***	-0.769***	-0.502***
	(0.229)	(0.134)	(0.210)	(0.130)	(0.096)	(0.129)	(0.247)	(0.205)	(0.255)	(0.149)	(0.101)	(0.111)
Cohort 2	-0.442***	-0.325***	-0.177	-0.188	-0.161**	-0.116	-0.168	-0.0784	0.00692	-0.132	-0.0263	-0.000845
	(0.117)	(0.069)	(0.098)	(0.099)	(0.063)	(0.082)	(0.217)	(0.136)	(0.193)	(0.109)	(0.070)	(0.071)
Cohort 3	-0.539***	-0.359***	-0.301**	-0.289*	-0.269***	-0.234**	-0.166	-0.0328	0.0951	-0.00828	0.0314	0.0967
	(0.125)	(0.089)	(0.116)	(0.118)	(0.077)	(0.090)	(0.222)	(0.127)	(0.239)	(0.108)	(0.088)	(0.081)
Cohort 4	-0.777***	-0.501***	-0.451***	-0.693***	-0.422***	-0.359***	-0.332	-0.0584	0.139	-0.232*	-0.0398	0.0855
	(0.152)	(0.100)	(0.130)	(0.116)	(0.081)	(0.091)	(0.256)	(0.162)	(0.217)	(0.118)	(0.098)	(0.096)
Cohort 5	-0.781***	-0.578***	-0.490**	-0.685***	-0.518***	-0.469***	-0.232	0.0571	0.227	-0.264	0.0214	0.162
	(0.147)	(0.099)	(0.169)	(0.135)	(0.096)	(0.107)	(0.245)	(0.179)	(0.286)	(0.137)	(0.119)	(0.116)
Observations	2149	2149	2149	3665	3665	3665	908	908	908	3547	3547	3547
	Ireland						**Italy**					
Age: 35-44	-0.339	-0.174	-0.0619	-0.130	-0.249**	-0.289**	-0.290	-0.303*	-0.245	0.0261	-0.0638	-0.145
	(0.258)	(0.179)	(0.227)	(0.155)	(0.094)	(0.110)	(0.271)	(0.139)	(0.198)	(0.108)	(0.068)	(0.084)
Age: 45-54	-0.690**	-0.502**	-0.430*	-0.451**	-0.411***	-0.510***	-0.321	-0.317*	-0.343	0.258	-0.00115	-0.153
	(0.251)	(0.162)	(0.203)	(0.143)	(0.086)	(0.110)	(0.330)	(0.160)	(0.277)	(0.145)	(0.081)	(0.099)
Age: 55-65	-1.058**	-0.818***	-0.839**	-0.519**	-0.623***	-0.797***	-1.092**	-0.706**	-0.487	0.373	-0.154	-0.270*
	(0.323)	(0.208)	(0.297)	(0.190)	(0.116)	(0.132)	(0.399)	(0.230)	(0.311)	(0.193)	(0.115)	(0.133)
Cohort 2	-0.204	-0.0575	-0.0296	-0.0519	0.0184	-0.0782	0.145	0.0292	0.161	0.208	0.0816	0.102
	(0.231)	(0.170)	(0.235)	(0.157)	(0.091)	(0.128)	(0.313)	(0.155)	(0.283)	(0.129)	(0.092)	(0.109)
Cohort 3	-0.348	-0.00547	-0.173	0.0639	-0.0365	-0.187	-0.204	0.0278	0.124	0.331*	0.0449	0.0676
	(0.262)	(0.166)	(0.228)	(0.139)	(0.090)	(0.113)	(0.331)	(0.147)	(0.246)	(0.145)	(0.097)	(0.101)
Cohort 4	-0.550*	-0.307	-0.291	-0.103	-0.208*	-0.349**	-0.180	-0.0475	0.151	0.557***	0.109	0.0786
	(0.270)	(0.176)	(0.287)	(0.164)	(0.103)	(0.120)	(0.300)	(0.169)	(0.253)	(0.146)	(0.109)	(0.102)
Cohort 5	-0.659*	-0.472**	-0.413	-0.220	-0.240*	-0.368**	-0.0192	-0.130	0.0782	0.657***	0.149	0.0882
	(0.285)	(0.179)	(0.258)	(0.181)	(0.110)	(0.129)	(0.362)	(0.166)	(0.293)	(0.158)	(0.120)	(0.129)
Observations	985	985	985	2935	2935	2935	705	705	705	3645	3645	3645

	Low Medium Education			High Education			Low Medium Education			High Education		
	10th	50th	90th	10th	50th	90th	10th	50th	90th	10th	50th	90th
	The Netherlands						**Poland**					
Age: 35-44	0.0267	-0.110	-0.0938	-0.215	-0.140	-0.0938	0.296	-0.0341	-0.111	-0.106	-0.180	-0.188
	(0.145)	(0.120)	(0.131)	(0.115)	(0.074)	(0.101)	(0.471)	(0.283)	(0.287)	(0.169)	(0.097)	(0.142)
Age: 45-54	-0.326*	-0.245**	-0.162	-0.565***	-0.413***	-0.278***	0.384	0.00409	-0.0882	-0.278*	-0.298**	-0.226
	(0.131)	(0.091)	(0.129)	(0.103)	(0.065)	(0.073)	(0.393)	(0.217)	(0.242)	(0.140)	(0.092)	(0.119)
Age: 55-65	-0.743***	-0.471***	-0.441**	-0.976***	-0.756***	-0.538***	0.432	-0.0442	-0.242	-0.235	-0.297*	-0.216
	(0.175)	(0.126)	(0.155)	(0.136)	(0.096)	(0.109)	(0.486)	(0.295)	(0.330)	(0.209)	(0.117)	(0.147)
Cohort 2	-0.286	-0.0392	-0.0778	-0.142	-0.0973	-0.0105	-0.416	0.0831	0.202	0.0500	0.0414	0.0510
	(0.157)	(0.093)	(0.165)	(0.121)	(0.076)	(0.080)	(0.323)	(0.192)	(0.278)	(0.116)	(0.094)	(0.113)
Cohort 3	-0.268*	-0.0212	-0.0501	-0.218	-0.0291	0.0418	0.190	0.260	0.187	0.143	0.174*	0.0886
	(0.131)	(0.092)	(0.142)	(0.121)	(0.074)	(0.082)	(0.311)	(0.179)	(0.231)	(0.132)	(0.082)	(0.109)
Cohort 4	-0.115	0.0592	-0.0674	-0.244*	-0.0975	-0.0194	0.342	0.331	0.227	0.104	0.0376	0.0100
	(0.161)	(0.104)	(0.155)	(0.116)	(0.084)	(0.103)	(0.373)	(0.233)	(0.281)	(0.181)	(0.109)	(0.110)
Cohort 5	-0.138	0.0803	0.0935	-0.223	-0.0943	-0.0132	0.0289	0.345	0.364	0.0739	0.0488	0.0727
	(0.163)	(0.112)	(0.153)	(0.137)	(0.088)	(0.097)	(0.364)	(0.212)	(0.342)	(0.188)	(0.108)	(0.121)
Observations	1397	1397	1397	3147	3147	3147	561	561	561	3244	3244	3244
	Sweden						**UK**					
Age: 35-44	-0.390	-0.501**	-0.525*	-0.577***	-0.562***	-0.642***	0.0153	-0.169	-0.165	-0.150	-0.356***	-0.266*
	(0.275)	(0.170)	(0.213)	(0.136)	(0.086)	(0.148)	(0.224)	(0.121)	(0.157)	(0.141)	(0.076)	(0.107)
Age: 45-54	-0.641**	-0.695***	-0.767***	-0.871***	-0.796***	-0.896***	-0.784***	-0.561***	-0.413**	-0.310*	-0.631***	-0.666***
	(0.245)	(0.174)	(0.174)	(0.112)	(0.080)	(0.118)	(0.223)	(0.127)	(0.156)	(0.133)	(0.082)	(0.081)
Age: 55-65	-1.367***	-1.320***	-1.462***	-1.325***	-1.492***	-1.632***	-0.999***	-1.071***	-0.930***	-0.664***	-1.008***	-0.974***
	(0.320)	(0.238)	(0.232)	(0.144)	(0.101)	(0.152)	(0.288)	(0.149)	(0.217)	(0.173)	(0.094)	(0.122)
Cohort 2	0.156	0.140	0.142	-0.0511	-0.0762	-0.0420	-0.0789	-0.133	-0.0480	-0.203	-0.195*	-0.233*
	(0.186)	(0.105)	(0.163)	(0.115)	(0.073)	(0.095)	(0.204)	(0.109)	(0.139)	(0.130)	(0.078)	(0.114)
Cohort 3	-0.276	-0.0646	-0.0120	-0.0821	-0.197**	-0.159	-0.184	-0.447***	-0.356*	-0.263	-0.303***	-0.364***
	(0.207)	(0.121)	(0.186)	(0.129)	(0.075)	(0.099)	(0.280)	(0.127)	(0.159)	(0.163)	(0.080)	(0.100)
Cohort 4	-0.313	-0.199	-0.295	-0.329**	-0.564***	-0.621***	-0.100	-0.456***	-0.385*	-0.411**	-0.477***	-0.480***
	(0.241)	(0.161)	(0.218)	(0.123)	(0.092)	(0.123)	(0.234)	(0.125)	(0.166)	(0.156)	(0.081)	(0.091)
Cohort 5	-0.406	-0.307	-0.326	-0.390**	-0.548***	-0.616***	-0.681*	-0.765***	-0.677***	-0.370*	-0.629***	-0.669***
	(0.234)	(0.160)	(0.224)	(0.131)	(0.092)	(0.122)	(0.279)	(0.134)	(0.187)	(0.185)	(0.095)	(0.119)
Observations	965	965	965	2626	2626	2626	2307	2307	2307	6300	6300	6300

Notes**:** Own elaborations on IALS and PIAAC data. All figures are weighted. Reference categories are age group 25-34 and Cohort 1. Controls for parental education, migrant status and gender not reported.

* p < 0.05, ** p < 0.01, *** p < 0.001. Standard errors in parentheses.

6. Discussion and conclusions

In this paper we use the IALS and PIAAC surveys to investigate the relationship between ageing and cohort effects in the distribution and evolution of literacy skills across a number of European countries.

Most of the debate among academics, but also the general public, occurring at each release of the PISA or PIAAC surveys is about differences in country performances, expressed in average values. However, the comparison of average values leaves most of the story behind the scene: looking at the whole distribution of skills among the population, with particular attention to the two tails of the distribution (the share of high and low achievers) is more informative and policy relevant. Indeed, results presented in our paper indicate that countries not only differ in average values of skills but also in their distribution. Some countries may have higher averages than others, but lower values at top quantiles, meaning a lower proportion of high achievers and vice versa. As an example, CZ and SK have better average values than other countries, but have lower proportions of high achievers compared to DE or UK, which on average, perform worse than CZ and SK. The contrary can be said for FI, which on average is the top performing country, whose bottom 5% however, performs worse than the bottom 5% of CZ, SK, CY.

Second, this paper shows that literacy skills tend to decline with age, but with some important differences according to the distribution of skills. In CZ, DK, DK, NL, FI and BE to a lesser extent, there is stronger evidence of a decline with age occurring at the bottom of the literacy skill distribution, while this trend is stronger for the top end of the distribution in SE and UK (for IE the results are pretty similar for bottom and top quantiles). This result suggests the need of policies oriented to prevent skill loss after the end of formal education and specifically targeted to particular segments of the distribution.

Third, the empirical analysis carried out in the paper also shows a deterioration of skills across age cohorts for many of the European countries considered.

Although the analysis performed cannot clearly define which factors determined the deterioration of skills in younger cohorts, it points to the fact that a worsening in the overall performance of the educational system across birth cohorts took place. 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 implications, 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 automatized processes and the increasing technological complexity which involves all occupational sectors, even low skilled occupations. Thus, the cohort effect has to be carefully taken into consideration, first in light of the positive social outcomes associated to education and higher skills, potentially leading to some inequalities in the set of opportunities that different generations can enjoy, but also- and more directly linked to the whole aim of this research- for a successful integration of individuals in the economic sector, in light of the increasing complexity of the labour market.

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