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How age at entry at school affects future educational and socio-emotional outcomes: evidence from PISA.

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How age at entry at school affects future educational and socio-emotional outcomes: evidence from PISA.

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Abstract

This study provides new empirical evidences of birthday effects over a range of educational and socio-emotional outcomes. It relies on data from the recent cycles of the Program for International School Assessment (PISA), for 6 European countries. The age at entry has a significant and sizeable impact on cognitive outcomes as measured in PISA for 15-year-old students. The magnitude of the birthday effects on no cognitive dimensions varies, but overall the results suggest that those students who enter school relatively young have a more negative relationships at school with their teachers and peers. These students have also lower intrinsic motivation and self-esteem, and have less more ambitious educational expectation than their peers who entered school older.

Key words: Birthday effects, PISA, Instrumental Variables, socio-emotional outcomes.

1 Introduction

This study provides new empirical evidences of the magnitude of birthday effects on educational outcomes, based on comparative evidence from 6 European countries (England and Wales, Finland, France, Germany, Italy and Spain) using data of the Program for International School Assessment (PISA). The PISA survey makes it possible to estimate how the age at entry at primary school have consequences on 15-year-old students not only on their school performance, but also on no cognitive dimensions related notably to the quality of their relations at school, their attitudes towards learning and their level of self-confidence.

Investigating these dimensions provide new avenues for understanding why birthday effects may have long lasting consequences on future outcomes. Indeed, while birthday effects on educational outcomes have been largely documented (Bedard and Dhuey, 2006; Grenet, 2010; Ponzo and Scoppa, 2014; Crawford et al., 2010), suggesting that the month of birth appears related with performance at school, but also with educational attainment and labour market outcomes, the interpretation of these correlations facts is still widely debated. Such differences between months arise because in all school systems, the school year begins at roughly the same time for all students, while children's birthdays are spread across the calendar. The definition of a school cohort is usually defined by a "cut-off" date. Within a school cohort, children who are born just after the cut-off are likely to be older by almost one year than those born just before this cut-off.

Differences in cognitive maturity may explain that students who sit exams at the same date perform differently. As eldest students in a school cohort are more mature when they sit tests or exams, they are more likely to perform well than the youngest students in the school cohort (those born just after the cut-off). This "age at the test effect" on school performance are expected to fade with age (Bedard and Dhuey, 2006). For instance, in school systems where children are supposed to enter primary school at 6, in relative terms the eldest students in the first grade are 15% elder than their youngest classmates - while they are only 6% elder when they are aged 15. However, these age effects may have long term consequences, as they may affect the children emotional development. If the youngest children are not "ready" enough when they start formal schooling,

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their future perception of school and their motivation to learn may be durably undermined by these negative experiences. If age is related to performance, then students of different ages are likely to be ranked differently within their class, and to learn alongside classmates who are more or less competent than they are. Older and more competent children may inspire their younger and less-advanced peers: for instance, it has been shown that peer effects partly explain birthday effects on school achievements (Cascio and Schanzenbach, 2016; Peña, 2017). On the other hand, when teachers adapt the pace of learning to the "average student" in the class, the youngest students may be discouraged if catching up turns out to be too difficult. The relative lack of maturity of the youngest students may be mistakenly taken as indicating learning difficulties. Evidences show that students entered early at school are more likely to be diagnosed with learning disabilities, such as attention deficit hyperactivity disorder (ADHD) (Dhuey and Lipscomb, 2010; Elder and Lubotsky, 2009; Furzer et al., 2020), and this may affect their educational paths and emotional development. Furthermore, being held back may undermine the self-esteem and thus motivation to learn of the relative young children in a class (Thompson et al., 2004; Dee and Sievertsen, 2018; Suziedelyte and Zhu, 2015). For instance, Crawford et al. (2010) observe that the youngest students in a school cohort report lower view on their own scholastic competence than their elder peers, that is not fully explained by the actual differences due to their lower age at the time of test. Using longitudinal data for students in England, Murphy and Weinhardt (2018) show that students' ordinal academic rank within a class during primary school had lasting consequences on their future schooling that were not related to underlying ability. Students who had a high rank in a subject (such as English, mathematics or science) amongst the students in their class in primary school usually attained higher test scores in that same subject throughout secondary school than a student with a similar absolute level of performance but who ranked lower in his or her primary school class. These results suggest that birthday effects may not only be due to maturity effects. They may affect the self-confidence and motivation of children, and this may explain the lasting impact of age at entry at school observed in several countries. Students who are more mature when they start school may achieve early successes, prompting a virtuous cycle of reinforcement, support and more success. They may develop higher self-esteem (Thompson et al., 2004), and learn early the skills that are required for leadership (Dhuey and Lipscomb, 2008). Recent evidences suggest that those who were the oldest in their school-entry cohort are over-represented in leadership positions in the political (Muller and Page, 2016; Tukiainen et al., 2019) and economic fields (Du et al., 2012).

However, as already largely discussed in the literature (see for instance Dhuey et al., 2019), the reasons why the month of birth has an impact on educational outcomes are difficult to identify. As the age at which students sit the test, the age at which they started school, and the grade where a student is enrolled are linearly related, it is not possible to identify the impact of one of them in isolation from the others. Students born just after the school entry cut-off date are usually the eldest in their school cohort, and are thus expected to be the eldest amongst students who sit the test. When measures are provided at a grade level, students may be selected depending on their previous educational path, that may depend on their relative age. For instance, if the youngest students in a cohort is more likely to be held back in their first years of schooling, those at the normal age in later grades are more likely to be the brightest in their cohort.

Using PISA data may provide some useful elements in this context. As the PISA sample is age-based, it is representative within a country of students aged around 15 years old (between 15 years and 4 months to 16 years and 3 months), whatever the type of schools and the grade they are enrolled in. In addition, PISA data provides measures of cognitive and no cognitive dimensions that are comparable over a set of countries. One may thus compare the magnitude of the estimates depending on the characteristics (such as gender or socio-economic status) and across countries. Alternative specifications will thus provide estimations of the impact on educational outcomes of the relative age at entry interacted with respectively gender and socio-economic status (defined by the quarters of the national distribution of the PISA index of socio-economic and cultural status). One may plausibly assume that the age-at-the-test effects on cognitive and no-cognitive outcomes would be similar from one country to another, and from children of different socio-economic status within the same countries, as it would depend on biological

maturity. The observed differences in birthday effects between countries may thus depend on the conditions of schooling: for instance, whether students receive sufficient attention in their first grades to overcome the initial disadvantage of being the youngest in a cohort. The analyses focus on 6 European countries that have quite distinct organisation of schooling notably regarding school starting age and the use of ability-grouping practices in primary schools. These features may explain that the relative age effect may have more or less pervasive impact on children development. The impact of the relative age at school entry are more likely to have pervasive consequences on educational outcomes in school systems that use stratification by ability at an early age. Stratification by ability may occur through tracking into different types of schools, such as in Germany, by ability grouping within a class or a school, such as in England and Wales, or by grade repetition, such as notably in France, Germany, Italy and Spain. By contrast, Finland has a comprehensive schooling. As children who are relatively young are often less mature than their peers, they are more likely to be identified as "low ability" students in their first years of school. In countries where ability grouping is used in early grades, they are thus more likely to be held back. The rationale of these practices is that students could be taught at the academic level that corresponds to their needs. However, it may also have a negative effect on the motivation and self-esteem of slow learning students.

In all school systems, the age at entry has a significant and sizeable impact on cognitive outcomes at 15, as measured in PISA. The magnitude of the birthday effects on no cognitive dimensions depends on countries, but overall the results suggest that those students who enter school relatively young compared to their peers perceive more often poor student-teacher relationships attitudes and are more frequently exposed to bullying at school. The relative age at entry affects positively intrinsic motivation and self-esteem. One key issue is whether the lower performance of students who were the younger in their school entry cohort, may have long-turn consequences. According to the results, in almost all countries analysed here, those who were the eldest in their school entry cohort also tend to have more ambitious educational expectation at least for one group of students. This means that the month of birth may have consequences on educational attainment, and thus on future outcomes.

2 Data and identification strategy

2.1 PISA data and school system regulations

The analysis is conducted using data from the 2015 and 2018 rounds of the PISA. The PISA is a survey conducted every three years by the Organisation for Economic Co-operation and Development (OECD) in a large set of countries. The PISA provides comparable measures of 15-year-old students school performance in three domains (reading, mathematics and science).

In the following, the analysis focuses on six European countries, England and Wales,[1] Finland, France, Germany, Italy and Spain. Comparing a set of distinct school systems is a way of questioning whether birthday effects are a constant, or whether they may have distinct impacts on some outcomes depending on the context. The set of Europeans countries analysed here are indeed quite similar in terms of economic development and school enrolment,[2] but their school systems have distinctive features. For instance, compulsory age for primary school is 7 in Finland, while it is 5 in the UK, and 6 in the others. School systems also differ in the age of the first selection into differentiated systems. The age of first selection is 12 or below in Germany, while it is 16 in Finland, England and Spain (see Table 1).

Even though it would not be possible with the data at hand to identify the causal effect of one or other of these features on the magnitude of birthday effects on educational outcomes, these distinctive features of school systems may be useful to contextualise the magnitude of these effects.

[1] PISA data include data for the United-Kingdom, but the school regulations appear to be distinct in Scotland than in England and Wales.

[2] In all these countries, the upper age limit of compulsory education is above 16 and as a consequences the coverage of the PISA survey is high: the survey respondents represent 85% of the 15-year-old population in the United-Kingdom and Italy, ans more than 90% in other countries.

Table 1: Characteristics of the school system

	DEU	FIN	FRA	GBR	ITA	SPA
Start. age prim educ	6	7	6	5	6	6
Age 1st selection	10	16	15	16	14	16
Cut-off (dd/mm)	30/09	31/12	31/12	31/08	31/12	31/12
1st day school (dd/mm)	01/09	01/08	01/09	01/09	01/09	01/09
Range Birth Months (PISA sample)	Jan 02-Dec 02	Feb 02-Jan 03	Jan 02-Dec 02	Aug 02-Jul 03	Jan 02-Dec 02	Jan 02-Dec 02

Source: PISA 2018, System level data

In PISA information are also collected from national education authorities using a dedicated questionnaire on system-level variables, such as compulsory school starting age and age of first selection in education. PISA 2018 also provides information about the regulations regarding school entry: first day (dd/mm) of the school year at each level of education and the cut-off date (dd/mm) for eligibility to enrol in school. The cut-off date was defined as the date at which a child should have reached the theoretical starting age for primary school, i.e. the age for being eligible to enrol in school (see Table 1).[3] In Germany, England and Wales, this cut-off date coincides or almost coincides with the first day of schooling, meaning that all children are expected to have attained the compulsory age of entry into primary school the day, or by the end of that month, that they begin school. However, in Finland, France, Italy and Spain, the cut-off date for eligibility to school enrolment corresponds to the end of the calendar year while the school year begins in August or September, meaning that some children may be younger than the theoretical age at entry at school even when they comply with school entry regulation. In addition, in some countries flexibility is given to parents to delay or advance their child's entry into school, depending on their readiness. Some children may thus enter school at a different age than the compulsory age.

In all countries, 15-year-old students may be enrolled in distinct grades when they sit the PISA test. This could be the case if students had started primary school later or earlier than the applicable regulations stipulate, or if they have repeated or skipped a grade since their entry to school.[4] In addition, one of the specific features of the PISA test is that the sample is age-based, while most of existing tests are usually grade-based. The average age is around 15 years and 10 months in most countries (see Givord, 2020 for details). Depending on the date of the test, the PISA 2018 sample includes students born in 2002 and, in some school systems, in 2003 (see Table 1).[5]

The PISA sample may be considered as based on the theoretical school cohorts at entry at school, as defined by a strict application of the school entry regulations. However, in some cases, the PISA sample encompass two grade cohorts, as determined by the school start date and the cut-off date for determining age eligibility. It has been chosen to select only students who belong to one theoretical grade (see the Appendix). This corresponds to a restriction of the sample based on the month of birth that are expected to be random and thus is not expected to alter the identification of the impact of the relative age on educational outcomes.

[3]This information was not available for all countries that participated in PISA 2018, as the school entry and cut-off dates may vary by jurisdiction and thus could not be provided by federal authorities (as it is the case for instance in the United-States or Australia).

[4]Variations may also be observed between students enrolled "at the normal age", but in distinct countries, as the modal grade for 15-year students in a school system depends on the age at entry into primary school, and as that school starting age varies from one country to another. Amongst the set of countries analysed here students who sit the PISA test are mostly enrolled in 9th grade in Finland, 11th grade in England and in 10th grade in other countries.

[5]According to its technical standards, PISA is expected to cover in students who are aged between 15 years 3 months and 16 years 2 months at the time of the assessment (and who are enrolled in an educational institution at grade 7 or higher). This age definition arises from operational considerations for the first PISA survey that took place in April 2000, as for ease of implementation the population to be surveyed was students born in 1984. See details on the sampling in `https://www.oecd.org/pisa/pisaproducts/SAMPLING-IN-PISA.pdf`. Variation of up to one month in this age definition is permitted so long as the birth date range is maintained as a 12 month period.

2.2 Contextual variables and educational outcomes

PISA measures of literacy are completed by contextual questionnaires, notably providing information about students background (for instance gender, date of birth, occupations and education of parents, etc.), their educational path (age at entry at primary school, grade repetition). These variables make it possible to control for individual characteristics (such as the socio-economic background, measured relying on the PISA index of economic, social and cultural status, ESCS, see Avvisati, 2020), but also to identify those students who have repeated a grade, and whether it occurred in primary school or in middle school.

In the student questionnaire, students who sit the PISA test are also asked how old they were when they started primary school. The possible answers ranged from "4 years" to "9 years or older" (and included "I do not remember"). This information is reported in years, but a more accurate measure of the actual age of students at their entry in primary school may be calculated using the information on both the child birthday and the date of the first day of school year.

In PISA, students are also asked about their attitudes, beliefs, motivation and aspirations (see for details OCDE, 2019).[6]

For this study, several dimensions are explored. The first group is related to the quality of the student/teacher relationships, as reported by the students, and specifically how they perceived the disciplinary climate within the class, whether their teacher appears interested by what s/he teaches and whether the students perceive to be treated unfairly by the teachers.

A second group of indices captures the social connections of the students with their peers at school: whether they report to have been bullied by other students, whether they report to belong at school and whether they enjoy cooperation (see OECD, 2017, 2019 for details).

A third group of outcomes may be related to motivation: an index measures the motivation to master tasks, whether they have a positive attitude towards learning activities and whether they set ambitious learning goals. Finally, some variables are more related to self-confidence, and notably a measure of self-efficacy, whether they enjoy competition and whether they expect to complete tertiary education.[7]

2.3 Identification issues and econometric models

The actual age entry of one child may differ from the theoretical starting age of primary education. For instance, in Germany, it is quite common for parents to delay the entry at school of their child by one year, if they think he or she is not ready for school (Mühlenweg and Puhani, 2010). In the United-Kingdom, if most children are expected to start formal schooling quite early (in September after they turn 4), "summer children" (those born between 1 April and 31 August) may delay entry at school by one year (Cirin and Lubwama, 2018). On the contrary, in Italy for instance, it is quite common that some families may favour early entry in primary school, which is perceived as more stimulating than kindergarten (Ponzo and Scoppa, 2014). In any cases, it is likely that the decisions to postpone or advance entry at school are endogenous, as they usually depend on the child maturity at the time of school entry.[8] For this reason, even though the proportions of late and early entry widely differ from one country to another, at the individual level it usually depends on the relative position in the theoretical school cohort (Givord, 2020): those who start school earlier are more often the children just after the cut-off (those are the eldest in their theoretical

[6]The answers to these questions are summarised by indices relying on Item response theory (IRT) modelling, notably to confirm the theoretically expected behaviour of the indices and to validate their comparability across countries. For details see for instance (OECD, 2019) or the PISA 2018 Technical Report.

[7]Variables related to these no cognitive dimensions vary depending on the PISA cycle. Indices related to whether students enjoy cooperation and the measures of the perception of teachers' unfair attitudes are available in PISA 2015 only. For these variables, the underlying assumption is that the cut-off date used for school entry were the same for the cohorts who sit the PISA test in 2015 than for those who sit the PISA test in 2018.

[8]In Germany, children may start primary school in the autumn term the year a child turns six years old even if they are born after the cut-off, but they may be required to pass a test to prove their ability to attend school. Even if this is passed, administrators may not offer entering secondary school as an option if the child is not also socially or physically ready (Jurges and Schneider, 2006).

school cohort) and those who start school later are those born just before the cut-off (the youngest in their theoretically school cohort).

As the actual age at school entry is endogenous, one should be cautious in measuring the birthday effects on educational outcomes. The OLS estimates of the impact of the age at entry on most educational outcomes are expected to be downward biased. In addition, measurement error in the age at entry variable would also result in an attenuation bias. Such error may occur because the variable measuring age at entry in primary school is self-reported. Some of the students who had been enrolled in pre-primary school may have no clear memory of the age at which they entered pre-primary, as opposed to primary, school.

Even though it is likely that the measurement error is uncorrelated with the true age at entry, the misreport of age at entry may attenuate the magnitude of the estimates of the "true" effect of age on educational outcomes. In order to deal with these two empirical issues, the impact of the school starting age on various educational outcomes are measured using a 2-stage-least-square estimations, where the self-reported age at entry at entry is instrumented by the theoretical age at entry, as defined by the strict application of regulations for school enrolment.

More specifically, the main estimates are given by:

$$Y_i = SSA_i\beta + X_i\gamma + u_i \tag{1a}$$

$$SSA_i = SSA_i^{th}\alpha + X_i\gamma_2 + v_i \tag{1b}$$

with

$$v_i \perp Y_i|X_i \tag{2}$$

The equation 1a is the main equation relating the educational outcomes Y_i (for instance, score performance in PISA, grade repetition, expectation to complete tertiary education, self-efficacy, etc.) to the actual school starting age SSA_i as calculated from the report in PISA (in years and months, defined from the reported age and first day of schooling) and controlling for the individual characteristics of students X_i (gender, socio-economic status as measured by the quartile of the distribution of the PISA ESCS index and immigrant background). The equation 1b corresponds to the first stage that relates the actual school starting age with the theoretical age at entry SSA_i^{th}, as defined by the strict application of the school entry regulation and calculated using the birthday and the cut-off dates, and controlling for the same characteristics. In practice the theoretical age at entry SSA_i^{th} is set to one month for students born the month just before the cut-off date, and 12 months for those born just after the cut-off date. Defined this way, the variable measures the theoretical relative age of students within their cohort as defined by the school regulation. This corresponds to the theoretical age at which the student should have started school had the regulations been enforced without exception. It is the greatest for the students assumed to be the eldest in their school-entry cohort, and the lowest for the students assumed to be the youngest in their school-entry cohort.

The estimates are performed separately by countries, meaning that the estimates correspond, within a country, on how the educational outcomes vary with the age at entry in primary school, relatively to the average. In order to take into account the complex PISA survey design, standard errors are computed using the Balanced-Repeated-Replication (BRR) weights .[9].

The theoretical relative age at entry SSA_i^{th} is a valid instrument if it is related with the actual age at entry (meaning that $\alpha \neq 0$ in equation 1b) and it is unrelated with the unobserved characteristics v_i of the outcome, conditionally on observable X_i. The first assumption may be directly measured, as shown in the Table 2. In all the six countries analysed here, the actual age at entry is strongly related with the theoretical age at entry. In Finland, France and Spain, the coefficient is close to one, which is consistent with the fact that in these countries most students enter schools at the expected age (see Givord, 2020 for details). However, in Germany, Italy and England, the coefficients are markedly lower than one. This can be explained by the fact that some children may enter school later (in Germany and England) or earlier (in Italy) than scheduled, and the decision usually depends on the maturity of the children: the students who are the eldest

[9] All estimates are computed using the Stata Package Repest (Avvisati and Keslair, 2014).

in their school cohort are more likely to enter school earlier while the youngest students in their cohort are more likely to enter school later.

Table 2: First Stage Estimate (coefficient and F-Statistics)

countries	Nb Obs.	Coef	F-Stat
DEU	7,689	0.62^{***} (0.03)	85.4
FIN	10,305	0.89^{***} (0.02)	376.2
FRA	11,290	0.90^{***} (0.03)	157.7
GBR	18,319	0.53^{***} (0.02)	143.5
ITA	22,379	0.66^{***} (0.02)	489.9
ESP	39,016	0.90^{***} (0.02)	705.4

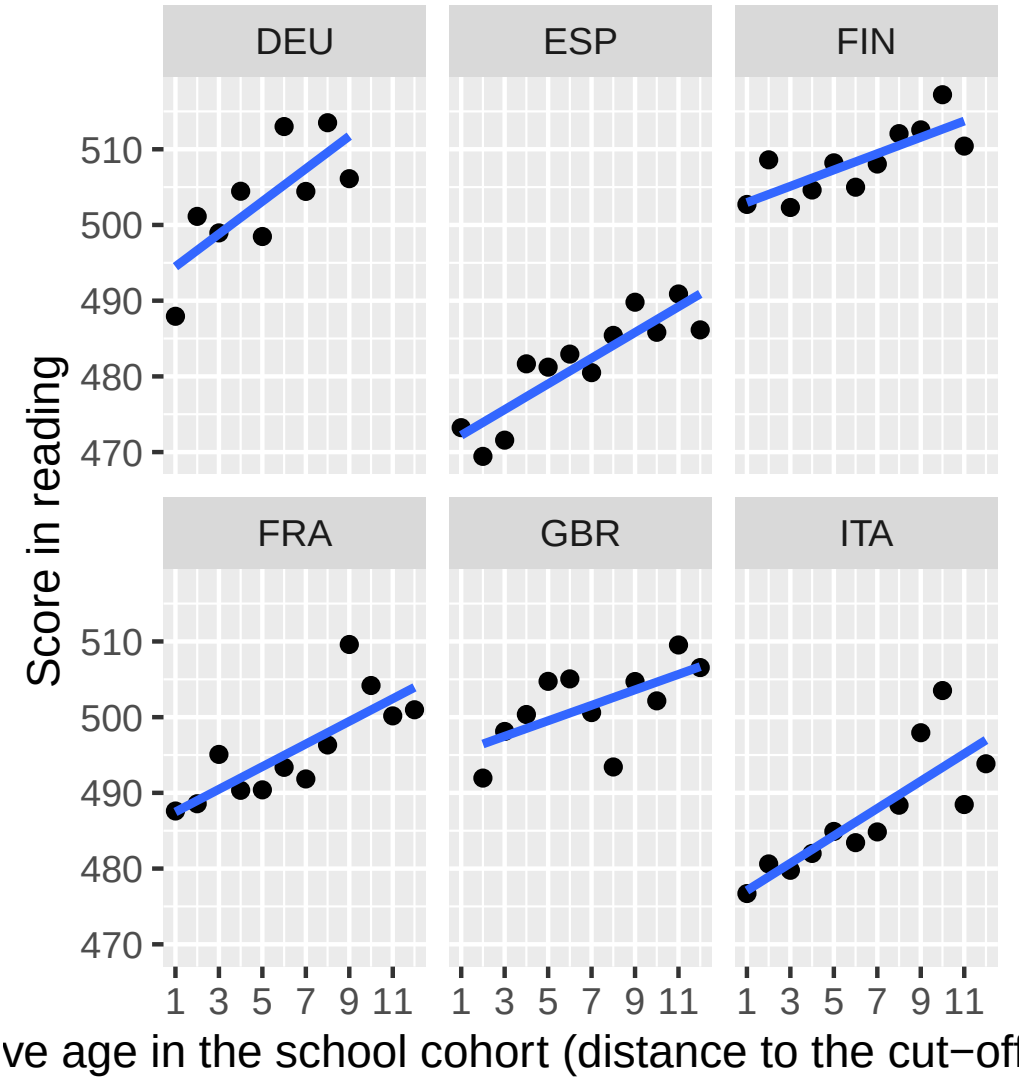
Source: PISA 2018, Author's calculations. Note: Only the coefficient of the age at entry on the theoretical age at entry and the F-Statistics are reported. Models include as additional controls variables: gender, socio-economic status (4 dummies) and immigrant background. Standard Errors in parenthesis.

The identification assumption 2 means that conditionally on observable characteristics, the theoretical starting age has no direct effect on educational outcomes except through the effect on actual school starting age. This cannot be formally tested, but as the theoretical age at entry is only related to the month of birth, one may plausibly assume that it is unrelated with other unobserved determinant of the outcomes.

3 Results

3.1 Relative age and performance at cognitive tests

According to the estimates, the month of birth has significant and sizeable effects on the cognitive results as measured in PISA for 15-year-old students (Table 4). Reduced form estimates are all statistically significant, meaning that the theoretical relative age at entry, as would be observed from the strict application of the regulations regarding school entry, is significant in all countries, has sizeable impact on the performance in PISA in the three main domains. Note that these estimates are informative by themselves. They can be interpreted as the difference in outcomes between two children, one born the month just after the cut-off date (thus the eldest in his or her school-entry cohort) and one born almost one year later, but the month just before the cut-off date and thus amongst the youngest in his or her school-entry cohort. Such relations is also observed in the Figure 1, that represents the average PISA score in maths depending on the theoretical age at entry SSA^{th}, measured in month.



The relative age is defined by the strict application of the school entry regulation and calculated using the birthday (in months) and the cut-off date. This variable is set to one month for students born the month just before the cut-off date, and 12 months for those born just after the cut-off date.

Figure 1: Average performance in mathematics in PISA, by relative theoretical age in the school cohort

Regarding the actual age at entry of students, the OLS estimates are much smaller, usually not significant and even negative in Germany, France and Italy. This is consistent with the fact that some children may be enrolled earlier or later than scheduled, and these decisions are usually based on the observed maturity of children. Those students who are entry school earlier for instance are more likely to have higher cognitive performance, while they are the youngest students in their class - and, conversely, children who entered school later than scheduled, are more likely to have lower cognitive performance while the eldest in their cohort.

Table 3: Impact of relative age on mathematic performance (OLS, Reduced form and IV estimates)

countries	OLS	RF	IV
DEU	-18.74^{***}	30.56^{***}	50.42^{***}
	(2.15)	(5.32)	(9.18)
FIN	1.45	12.82^{***}	14.34^{***}
	(2.05)	(3.32)	(3.74)
FRA	-3.43^{***}	15.27^{***}	16.41^{***}
	(1.31)	(3.53)	(4.05)
GBR	6.17^{***}	8.89^{**}	11.11
	(1.42)	(4.03)	(7.80)
ITA	-8.60^{***}	20.88^{***}	31.85^{***}
	(1.73)	(3.36)	(5.24)
ESP	2.48^{**}	16.54^{***}	18.86^{***}
	(1.15)	(2.51)	(2.89)

Source: PISA 2018, Author's calculations.

Note: Only the 2SLS estimates of the impact of the relative age at school entry (instrument: theoretical age at entry) is reported. Models include as additional controls variables: gender, socio-economic status (4 dummies) and immigrant background. Standard Errors in parenthesis.

The 2SLS estimates, using the theoretical age at entry as an instrument for the measured relative age at entry, provide a very different picture. They show that the relative age at entry has a significant impact on performance in the three main domains measured in PISA. Being the eldest in a class at entry at school is positively related with performance in PISA. One year of difference in entry age at school is associated with more than 30 score points in maths in Italy and Germany, at least 15 score points in Finland, France and Spain.

2SLS estimates are not significant for the UK, that may be due to the fact that the instrument is weaker for this countries. Estimates related to performance in reading and science are of similar magnitude (Table 4). For the sake of comparison, in most countries the difference between the eldest and the youngest students in a school cohort corresponds to the difference in average PISA score between students in the first quartile of ESCS and the second quartile of ESCS (see Table B.3)

Table 4: Impact of relative age at entry on PISA performance

	DEU	FIN	FRA	GBR	ITA	ESP
Mathematics						
	50.42***	14.34***	16.41***	11.11	31.85***	18.86***
	(9.18)	(3.74)	(4.05)	(7.80)	(5.24)	(2.89)
Interaction with Gender						
Girl	45.89***	12.57**	16.44***	5.19	28.10***	16.74***
	(13.57)	(4.88)	(5.86)	(10.68)	(6.75)	(3.33)
Boy	54.60***	16.05***	16.38***	17.45*	35.52***	21.24***
	(12.30)	(5.37)	(5.01)	(9.85)	(7.30)	(4.35)
Interaction with ESCS Quartile						
ESCS Q1	50.96**	14.33**	18.82**	8.49	22.86***	19.06***
	(23.49)	(7.31)	(8.13)	(14.12)	(8.60)	(5.83)
ESCS Q4	38.83***	11.06	9.88	20.69	29.16**	12.50***
	(12.56)	(7.99)	(7.16)	(13.71)	(13.60)	(4.30)
Reading						
	41.78***	21.17***	22.60***	19.49***	30.46***	na
	(9.78)	(4.38)	(3.83)	(6.33)	(5.22)	
Interaction with Gender						
Girl	35.16***	18.62***	20.17***	7.34	26.24***	na
	(12.89)	(5.38)	(5.74)	(9.38)	(8.19)	
Boy	47.89***	23.64***	24.94***	32.48***	34.59***	na
	(13.26)	(5.99)	(5.43)	(9.01)	(6.14)	
Interaction with ESCS Quartile						
ESCS Q1	32.43	18.45**	26.52***	18.28	16.96*	na
	(20.77)	(8.01)	(8.57)	(13.49)	(9.70)	
ESCS Q4	37.71***	21.65**	16.55**	27.46**	35.00***	na
	(12.87)	(8.42)	(7.55)	(13.51)	(12.66)	
Sciences						
	45.65***	21.34***	17.88***	8.99	28.57***	16.15***
	(9.35)	(4.18)	(3.34)	(6.19)	(5.80)	(2.94)
Interaction with Gender						
Girl	36.92***	17.89***	15.87***	−0.14	26.78***	15.56***
	(12.33)	(4.92)	(4.70)	(8.42)	(7.82)	(3.31)
Boy	53.71***	24.68***	19.80***	18.76*	30.32***	16.80***
	(13.10)	(6.37)	(5.38)	(9.62)	(7.08)	(4.56)
Interaction with ESCS Quartile						
ESCS Q1	40.13*	21.04***	16.14**	7.41	21.52**	17.13***
	(21.02)	(7.97)	(7.26)	(13.76)	(8.90)	(5.90)
ESCS Q4	31.52**	17.93**	11.15	18.09	30.27**	9.69**
	(13.19)	(8.41)	(6.91)	(13.27)	(12.69)	(4.67)

Source: PISA 2018, Author's calculation. Note: Only the 2SLS estimates of the impact of the relative age at school entry (instrument: theoretical age at entry) is reported. Models include as additional controls variables: gender, socio-economic status (4 dummies), immigrant background, dummies for PISA cycle. Standard Errors in parenthesis.

In several cases, the impact of the relative age at entry varies with individual characteristics of the students, but in a way that is not identical depending on the school systems. Regarding gender, the point estimates related to the impact of the relative age at entry on performance in PISA appear higher for boys than for girls, even though the differences are not statistically different. In England and Wales, the impact of the relative age at entry is significant only for boys. Regarding socio-economic status, in Germany, Italy and England, the impact of relative age in reading is significant only for socio-economically advantaged students (those located in the top quarter of this distribution), while in Germany, Finland and France, the estimates appear higher for socio-economically disadvantaged students (those located in the bottom quartile of the national distribution of the socio-economic index).

3.2 Relative age and grade repetition

As discussed earlier, one should be cautious when interpreting these differences. Birthday effects may be due to school starting age, but also on age at the time of the test. One may expect that the impact of the difference in maturity within a birth-cohort is expected to decrease with age (Bedard and Dhuey, 2006; Crawford et al., 2010), even though Black et al. (2011) observe still significant impact of age at the test at 18 on IQ test in Norway. However, using retrospective variables, such as the likelihood to have repeated a grade in primary school, may provide some distinct elements, as it cannot be linked to the age at the test.

It is possible to analyse whether the month of birth has an impact on the probability to repeat a grade, using PISA data. Students who sit the test were asked whether they had ever repeated a grade, and whether this happened in primary school or later. It is thus possible to measure the impact of relative age, in countries where grade repetition is commonly used as a remediation tool in primary school.

France, Germany, Italy and Spain are school systems where grade repetition is frequently used as a remediation tool, as a large proportion of students reported in PISA 2018 than they have repeated a grade in primary school (see Table B.1 in the Appendix). In all of these countries except Germany, the relative age at entry is a strong predictor of grade repetition. This impact is especially high in France and Spain. The estimates suggest that being elder by one year at school entry reduce the probability to repeat a grade by at least 10 percentage points on average (see Table 5). The point estimates appear greater for disadvantaged students than for advantaged students : in France, one year of difference in age at entry increases the likelihood of grade repetition by 20 percentage points for disadvantaged students (those in the lower quarter of the distribution of the PISA index of economic, social and cultural status), and only 4 percentage points for advantaged students (those in the higher quarter of the distribution of this index). The magnitude is not significant in Germany. In this country, delayed entry in primary school are more common, especially for students who are born just before the cut-off (Givord, 2020). These students are also the youngest in their school cohort at entry, and probably the less mature amongst them and thus those who would have been more likely to repeat a grade, if enrolled at normal age. The impact of the age at entry is much lower when measuring the grade repetition in middle schools rather than primary school, consistently with the fact that this is mediated by a lack of maturity in the early years of schooling that fade with age (see Table B.4 in the Appendix).

Table 5: Impact of relative age at entry on grade repetition

	DEU	FIN	FRA	GBR	ITA	ESP
	0.03	-0.02^{***}	-0.10^{***}	0.03^{***}	-0.01^{*}	-0.08^{***}
	(0.03)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Interaction with Gender						
Girl	-0.02	-0.02^{***}	-0.09^{***}	0.04^{**}	-0.01	-0.06^{***}
	(0.03)	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)
Boy	0.09^{*}	-0.02^{**}	-0.12^{***}	0.02^{*}	-0.02	-0.10^{***}
	(0.05)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)
Interaction with ESCS Quartile						
ESCS Q1	0.09	-0.01	-0.19^{***}	0.08^{***}	-0.02	-0.14^{***}
	(0.07)	(0.02)	(0.04)	(0.03)	(0.02)	(0.03)
ESCS Q4	0.00	-0.02^{*}	-0.04^{***}	-0.02	-0.01	-0.03^{***}
	(0.03)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)

Source: PISA 2018, Author's calculations.

Note: Only the 2SLS estimates of the impact of the relative age at school entry (instrument: theoretical age at entry) is reported. Models include as additional controls variables: gender, socio-economic status (4 dummies), immigrant background. Standard Errors in parenthesis.

3.3 Relative age, social connections and motivation

Previous works have questioned whether school starting age may affect the quality of the first experience of children with formal schooling. Negative experience may alter the perception and attitude towards school of children, as well as their self-confidence, and this may have long-term consequences. The PISA survey makes it possible to investigate this issue through several dimensions: how 15-year-old students in PISA qualify their relationships with their teachers and peers, and what are their motivation and self-confidence.

3.3.1 Relations with teachers and peers

First, one may question the quality of the relation of students with teachers.

The youngest students in a school cohort may be confronted with difficulties in learning, as they are intellectually less mature, they may have difficulties with some tasks and thus may receive less often positive feedback from their teachers. In consequences, they may have the feeling that their efforts are not rewarded enough. In PISA 2018, students are asked several questions aiming at measuring whether they perceive that their teacher show interest in teaching ("enthusiasm") and inspiring them, and whether they suffer from a negative disciplinary climate in the class. PISA 2015 provides an index of the perception of "teachers' unfairness". All these dimensions are subjective and cannot be analysed as a "true" measure of the teachers' behaviour or disciplinary climate within a class, nevertheless it informs on the perception that students have about school.

In almost all countries analysed here, the age at entry at primary school negatively affects one or another measures of the quality of their relation with teachers. In Germany, Finland and Italy, it is positively related with the index measuring the disciplinary climate.[10] A higher value of this index is related with better disciplinary climate, meaning that younger students report lower disciplinary climate than their peers. This may be explained by the fact that the youngest students in a cohort are more likely to be tracked to low-ability groups. Even in school systems without formal tracking into distinct schools or grade repetition, ability grouping may occur within the school. Youngest students may be thus more often in classes with low ability learning, that experiment more often disciplinary issues.

However, in some countries the age at entry appears to affect more directly the quality of the relations with teachers. For instance, in France, the age at entry is negatively related with the perception of the "unfairness" of the teacher. This is especially the case of boys, but in very impressive manner, for disadvantaged students: being the youngest in a cohort for disadvantaged students in France increases by one standard error the index of perceived unfairness of students. Similar magnitude is observed for disadvantaged students in Spain.

In almost all countries except Germany, the relative age at entry is related with their perception of whether their teacher is inspiring for girls - and this is the case for boys in England and Spain. Again, ability grouping may explain part of this effect: if the best teachers are allocated to the high-achieving classes, and as youngest students are less likely to be affected to these classes, they have lower chances to be exposed to the best teaching practices. Another explanation would that if these youngest students have negative first experiences with school (for instance, if they have felt that they have to work hard in their first classes with insufficient rewards from their teachers), they may keep an uneasy feelings when they interact with their teachers. Taken together, these results suggest that the age at entry in primary school has an impact to the quality of teaching students may experience when they are 15-year-old.

Such negative perceptions are also observed regarding their relations with their peers. In France and Italy, the students who were the youngest at entry at primary school are more exposed to

[10] This index is measured using questions on how frequently ("never or hardly ever", "some lessons", "most lessons", "every lesson") the following things happen in the students' language-of-instruction lessons: "Students don't listen to what the teacher says"; "There is noise and disorder"; "The teacher has to wait a long time for students to quiet down"; "Students cannot work well"; and "Students don't start working for a long time after the lesson begins". These statements were combined to create the index of disciplinary climate whose average is 0 and standard deviation is 1 across OECD countries.

bullying when they are 15.[11] The impact appears higher for boys (see Table B.6 in the Appendix). In Finland and France, the elder peers report more often to value relationships with their peers and to be engaged in collaborative activities not for their own benefit (they report more often that they “are good listeners”; “enjoy seeing their classmates be successful”; “take into account what others are interested in”; and "enjoy considering different perspectives”).

3.3.2 Motivation and self-confidence

Age at entry has a positive impact on motivation and self-confidence of students. In England and Wales, Italy and Spain, being the eldest at entry at school positively affect the motivation to master tasks, and also the propensity to set ambitious learning goals in Italy and Spain. In these three countries, it also positively impacts the index of self-efficacy, that is estimated from the answers to questions such as "My belief in myself gets me through hard times" and "When I’m in a difficult situation, I can usually find my way out of it". These results are not driven by the fact that students who were relatively the eldest at entry at school perform better at school, as the estimates are still significant when controlling for performance (see Table B.9 in the Appendix). An in all countries except Italy, the eldest students express stronger feeling of perceived competence in reading. Again, the differences may be gender related, but in a difference way. For instance, in Germany birthday effects on self-perceived competence in reading is observed only for girls, while it is the case only for boys in England and Wales. The fact that depending on school systems, the impact is either significant for boys or for girls, supports the idea that these differences are not driven only by difference in maturity (that may vary by gender, but is expected to vary in the same way in all countries), but differences in socialisation (that may differ across countries).

The fact that relative age may affect self-esteem of students and self-confidence also explains that it also affects their attitudes of teenagers towards competition. While competition may be valued because it is seen as a way to improve own performance, one major motivation for competition is also the desire to win (Franken and Brown, 1995). The students who were the eldest in their classes at entry at school have been more often in position to achieve better results than their peers. This also help them to reinforce their self-confidence and to see the benefit of effort, as a way of improving their performance levels. The lack of self-confidence may have long-term consequences for these students who entered school earlier than their peers.

[11] Such effect has been observed for Italy (Ballatore et al., 2020).

Table 6: Impact of relative age on no cognitive outcomes

	DEU	FIN	FRA	GBR	ITA	ESP
Quality of Teacher/Students relationships						
Perception of disciplinary climate	0.33**	0.11**	−0.02	0.18	0.19**	0.04
	(0.13)	(0.05)	(0.06)	(0.13)	(0.08)	(0.03)
Perception of teacher enthusiasm	0.04	0.18***	0.04	0.35***	0.10	0.13***
	(0.12)	(0.05)	(0.06)	(0.13)	(0.08)	(0.03)
Perception of teacher unfairness	−0.37	0.37	−0.45**	−0.27	na	−0.14
	(0.43)	(0.24)	(0.19)	(0.33)		(0.17)
Exposure to bullying	−0.05	−0.02	−0.20***	0.02	−0.18**	−0.04
	(0.16)	(0.06)	(0.06)	(0.11)	(0.08)	(0.03)
Enjoy cooperation	0.13	0.25***	0.10**	−0.04	0.07	−0.04
	(0.14)	(0.06)	(0.05)	(0.09)	(0.08)	(0.05)
Motivations and self-confidence						
Motivation to master tasks	0.01	0.06	−0.02	0.21*	0.13*	0.10***
	(0.12)	(0.06)	(0.05)	(0.11)	(0.07)	(0.03)
Ambitious learning goals	−0.17	0.05	−0.02	0.30**	0.02	0.12***
	(0.11)	(0.05)	(0.06)	(0.12)	(0.07)	(0.04)
Enjoy competition	−0.04	−0.03	0.07	0.40***	0.04	0.09***
	(0.14)	(0.05)	(0.06)	(0.13)	(0.08)	(0.03)
Self-efficacy	−0.09	0.04	0.05	0.34***	0.13**	0.14***
	(0.11)	(0.06)	(0.05)	(0.11)	(0.06)	(0.03)
Self perception of competence in reading	0.18	0.17***	0.17***	0.25**	0.08	0.08***
	(0.12)	(0.05)	(0.06)	(0.11)	(0.07)	(0.03)

Source: PISA 2015 and 2018, Author's calculations.

Note: Only the 2SLS estimates of the impact of the relative age at school entry (instrument: theoretical age at entry) is reported. Models include as additional controls variables: gender, socio-economic status (4 dummies), immigrant background. Standard Errors in parenthesis.

3.4 Expectation to complete tertiary education

In almost all countries except Finland, the relative age at entry is positively related with expecting to complete higher education diploma for at least one group of students (Table 7). Larger effects are observed in England and Wales and in Germany, where being one year older at entrance at school results in an increase in the likelihood of expecting to complete tertiary education by more than 10 percentage points. In Finland, France and England and Wales, the effect is significant only for boys, while in Germany and in Italy, it is significant only for girls. In England and Wales, Germany and Italy, the impact is significant only for the most advantaged students. Only in Spain, a significant effect is observed for disadvantaged students. As educational expectations is a measure of how young individuals see their future prospects, and what they are willing to achieve, it is likely that lower expectation may result in lower achievements. This means that the month of birth may have a long term impact on future outcome.

Table 7: Impact of expectation to complete tertiary education

	DEU	FIN	FRA	GBR	ITA	ESP
	0.12***	0.03	0.02	0.11***	0.07***	0.05***
	(0.04)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)
Interaction with Gender						
Girl	0.19***	0.01	−0.02	0.09*	0.10***	0.04**
	(0.05)	(0.03)	(0.02)	(0.05)	(0.04)	(0.02)
Boy	0.06	0.06*	0.05**	0.13***	0.04	0.07***
	(0.06)	(0.03)	(0.02)	(0.05)	(0.03)	(0.02)
Interaction with ESCS Quartile						
ESCS Q1	0.08	0.08	0.01	0.06	0.01	0.08**
	(0.06)	(0.05)	(0.04)	(0.06)	(0.05)	(0.04)
ESCS Q4	0.17**	0.01	0.04	0.12**	0.10*	0.04*
	(0.08)	(0.03)	(0.03)	(0.06)	(0.05)	(0.02)

Source: PISA 2015 and 2018, Author's calculations.

Note: Only the 2SLS estimates of the impact of the relative age at school entry (instrument: theoretical age at entry) is reported. Models include as additional controls variables: gender, socio-economic status (4 dummies), immigrant background. Standard Errors in parenthesis.

The fact that the magnitude of the birthday effects varies depending across school systems, and within countries across different types of students, suggest that they do not measure only difference differences in maturity. It is most likely that they correspond to the different type of experience children may experience at school, depending of the schooling. While the PISA data does not make it possible to isolate the specific features that explain these differences, one may note that the largest birthday effect on educational expectation in Germany, where children are tracked to different school tracks at a very young age (as early as at the age of 10). Only one of those tracks, the Gymnasium (the most academic curriculum), provides direct access to tertiary education (Mühlenweg and Puhani, 2010). The youngest students in a school cohort are more likely to be tracked into the less academic school tracks, and thus correctly expect that they have low probability of enter higher education. However, early tracking may not be the sole explanation for birthday effects on educational expectation. Birthday effects on educational outcome are also observed in England and Spain, where students are tracked late, at the age of 16. The consequences of low self-esteem, developed in early age, may be another potential reason that explain that the students who are the youngest in their school cohort develop lower expectation for their future than their peers.

3.5 Alternative specification

One of the potential reasons why relative age may have an impact on performance is related to the fact that the month of birth may also affect the grade at which students sit the PISA test. Students enrolled in a higher grade are expected to have learnt more complex notions, and thus to achieve greater score at the PISA test than those enrolled in a lower grade. The duration of schooling may have also consequences on the no cognitive outcomes, as for instance to have been exposed to more information about higher education. As the youngest students in a school cohort (as defined by a strict application of the school regulation) are more likely to be enrolled in lower grade than the eldest ones, part of the differences measured between the eldest and the youngest may be due to the fact that they are enrolled in distinct grades.

Using school systems where two school cohorts are sampled by design makes it possible to determine the magnitude of this effect. Amongst the set of countries analysed here, this concerns Finland and Germany.[12] Using this subset of countries, it is in principle possible to estimate

[12]In England and Wales, only 300 students born in the August 2002 sit the PISA test, while the sample size by month of birth is around three times higher for other months. The performance of these students appear much higher on average than those observed for students born just after the cut-off. As these students may not be fully representative of the students born in the same month, it has been decided to exclude them.

simultaneously the impact of the age at entry in primary school, as well as the fact of being enrolled in a higher grade. As the grade a student is actually enrolled when he or she sits the PISA test is also likely to be endogenous, this variable is instrumented by the theoretical grade student should be enrolled, depending on his or her birthday and if he or she had been "on time". In countries where the PISA sample encompasses two theoretical school cohorts, this is simply related to the fact that the month of birth is above or below the cut-off date. The alternative specification is now:

$$Y_i = SSA_i\beta + Grad_i\delta + X_i\gamma + u_i \tag{3}$$

$$SSA_i = SSA_i^{th}\alpha_1 + X_i\gamma_1 + \mathbb{1}_{m\_birth_i<cutoff}\delta_1 + v_i \tag{4}$$

$$Grad_i = SSA_i\alpha_2 + X_i\gamma_2 + \mathbb{1}_{m\_birth_i<cutoff}\delta_2 + w_i \tag{5}$$

With $Grad_i$ standing for the grade a student is actually enrolled in, $month\_birth_i$ his or he month of birth, and $cutoff$ the cut-off defining a school cohort. The coefficient δ measures the effect of being in a grade $n+1$ instead of the grade n on the outcome Y_i, while as before the coefficient α_1 measures the impact of being older by one year. The former is identified through the fuzzy discontinuity created by the cut-off date on the probability to be enrolled in one or another grade, while the latter is identified through an assumption that the impact of age at entry on outcome is linear. This assumption states, for instance, that compared to students who were born in the fifth month of the 12-month period defining a school cohort, the advantage of being born in the first month (i.e., being four months older) is of the same magnitude as the disadvantage of being born in the ninth month (i.e., being four months younger). If the relative-age effect is non linear (for instance, if only the youngest students in a class are affected by their relative age), then the grade-coefficient δ in this specification may not correspond to a grade effect, but may capture some aspects of the non-linear shape of relative-age effects.

Regarding academic outcomes, in the three countries where the estimates can be made separately, the estimates of both grade and the age at entry are significant when estimated and instrumented simultaneously (Table 8). According to the estimates, the "grade-equivalent", meaning the effect of having attended an additional year of schooling, is around 20 score points in Germany and Finland. Regarding the impact of the age at entry, the point estimates are very close of those obtained without controlling for grade for Finland. However, the estimates obtained for Germany are much lower than without controlling for grade: for instance, the point estimate in reading of the impact of the age at entry is now 18 score points in reading, instead of 44 score points when the estimates do not control for grade. With this correction, the estimate are thus of similar magnitude of those observed in other countries.

A possible explanation for the differences observed in the point estimates in Germany could be that in this country the school regulation regarding school entry is rather flexible. In Germany, it is quite common to postpone entry for some children, and this decision is more likely for the youngest students in a cohort. For this reason, a large proportion of students in the theoretical cohort are enrolled in a lower grade than the modal one, especially for the youngest ones.[13]

[13]Another reason of the differences observed for Germany could be that the sample restriction to one single school cohort is much severe for Germany than Korea and Finland. Note that the sample selection is much severe in Germany, as one quarter of the initial sample is excluded for the main estimates. In order to check the sensitivity of the results to this exclusion, estimates are also conducted using data from Estonia, the only OECD country for which the sample restriction is similar to the one observed in Germany. Both the main specification (in the restricted sample to one single school cohort) and the alternative one (using the entire sample composed for three quarters by a school cohort, and one quarter of a younger school cohort) provide similar point estimates for the impact of age at entry on educational outcomes in Estonia.

Table 8: Impact of relative age at entry and detailed grade on cognitive and no cognitive outcomes

	DEU	FIN
Reading		
Age at entry	10.13	18.91***
	(6.22)	(4.12)
Grade	19.02***	17.81***
	(3.53)	(3.87)
Mathematics		
Age at entry	11.49**	12.30***
	(5.35)	(3.50)
Grade	23.32***	15.96***
	(3.33)	(3.75)
Sciences		
Age at entry	9.06	18.73***
	(6.26)	(3.90)
Grade	21.95***	20.32***
	(3.39)	(4.34)
Disciplinary Climate		
Age at entry	0.04	0.12**
	(0.09)	(0.05)
Grade	0.19***	−0.03
	(0.06)	(0.06)
Teacher enthusiasm		
Age at entry	0.04	0.18***
	(0.08)	(0.05)
Grade	0.02	0.02
	(0.06)	(0.05)
Perception of teacher unfairness		
Age at entry	−0.33	0.27
	(0.29)	(0.22)
Grade	−0.03	0.71***
	(0.15)	(0.22)
Exposure of bullying		
Age at entry	0.03	−0.03
	(0.13)	(0.06)
Grade	−0.08	0.03
	(0.07)	(0.06)
Enjoy cooperation		
Age at entry	0.19*	0.23***
	(0.10)	(0.06)
Grade	−0.01	0.15**
	(0.04)	(0.06)
Self-efficacy		
Age at entry	0.03	0.04
	(0.09)	(0.06)
Grade	−0.07	0.05
	(0.05)	(0.06)
Self perception of competence in reading		
Age at entry	0.05	0.16***
	(0.10)	(0.05)
Grade	0.07	0.10**
	(0.04)	(0.05)
Expectation to complete tertiary education		
Age at entry	0.11***	0.03
	(0.04)	(0.03)
Grade	0.04*	0.03
	(0.02)	(0.03)

Source: PISA 2015 and 2018, Author's calculations.

Note: Only the 2SLS estimates of the impact of the relative age at school entry (instrument: theoretical age at entry) is reported. Models include as additional controls variables: gender, socio-economic status (4 dummies), immigrant background. Standard Errors in parenthesis.

Regarding the socio-emotional variables, the estimates for these three countries of the impact of the age at entry are very similar when controlling for the grade or not. Notably, the estimates of the impact of the relative age on the expectation to complete tertiary education is still high and significant in Germany and Korea. This means that at least in these two countries, the impact of being younger in a cohort may have long lasting effects on future outcomes of students.

4 Conclusion

This study on several countries confirms previous results observed on the literature that birthday effects may have sizeable consequences on several outcomes. In this set of countries the birthday effects on cognitive outcomes of 15-year-old students appear of similar magnitude. The consequences of the month of birth on no cognitive dimensions, that may be related to their self-esteem or ability to cooperate with others, are more contrasted depending on school systems. However, in several countries, birthday effects may have long-term consequences, notably on students' self-esteem. Students who were the youngest at entry not only have lower performance in PISA at 15, but expressed more often negative feeling against school and in their own capacities. In several countries, significant effects are observed on the likelihood to expect to complete tertiary education.

It is worth to emphasise that these results cannot identify separately the main reasons behind these birthday effects, specifically whether these effects may be solely explained by maturity effects ("age at the test effects") or relative age effects. Note that these can be two mutually reinforcing effects. While absolute age effects are expected to be quite important in the first years of schooling - and may still explain the differences observed in academic outcomes measured in PISA, the emotional development (such as self-esteem or competitiveness) may be also plausibly more sensitive to social comparisons and thus to relative age effects. Because they may be compared to their elder peers in a unfavourable way in their first years of schooling, the youngest children may develop lower self-confidence and this may undermine their expectations for the future. However, the features of the school systems may help to mitigate, or on the contrary contribute to amplify, these initial differences.

This may call for policies aiming to inform adequately teachers and parents of the penalty suffered by the youngest students in order to avoid unfair comparisons, and to implement practices that are adapted to the needs of the youngest children. Using age-adjustment for assessments in the first years of schooling may help to avoid unfair comparisons between the less mature students and their peers (Crawford et al., 2014). Such adjustments could be made for instance for standardised tests (such age-based standardisation has been introduced in the late decade in Ireland, see Shiel et al., 2020). Adjustment for age should be specifically recommended for tests that are used for allocation mechanisms, notably in school systems where academic achievement may have consequences on the type of education students may pursue, such as grade repetition or tracking to distinct type of schooling. In addition, the age adjustment may be advocated to reduce the over-classification of the youngest children as having learning difficulties or psychiatric conditions, observed, for instance, by Layton et al. (2018).

Some school practices have been shown to be less suitable for the youngest students, and thus increase those children's initial penalty in the first years of schooling. For instance, in Florida primary schools, Dhuey et al. (2019) observed that longer sequences of teaching (a practice referred to as block scheduling, consisting in fewer but longer classes) are associated with a stronger impact of relative age on achievement. This may be because the youngest students may lack the maturity to concentrate over a long period of time. Similarly, summer-school requirements for grade advancement is also related to greater relative age effect, as it may require an investment that the youngest students are not mature enough to make. Larger classes are also related to greater relative age effect, probably as they reduce the capacity of teachers to devote specific attention to all students, depending to their needs.

At the individual level, it would be difficult to infer from the results here that providing more flexibility to parents to when to enrol their children to school depending on their maturity. While

the results raise caution against the tendency to enrol children students earlier than planned in some countries (as in Italy, see Ponzo and Scoppa, 2014), they do not support either the possibility to postpone entry to school for the less mature children. Indeed, estimates in this paper suggest that in Germany where this practice is very common, the observed estimated effects on cognitive and no cognitive impact appears at the same level than in countries that provide less flexibility to the parents. In the related literature, these practices are highly debated and the evidence are mixed. Dhuey et al. (2019) observe only marginal evidence of a positive impact of red-shirting in Florida's primary schools. In Hungary, Altwicker-Hámori and Köllő (2012) observe a positive impact of delaying school entry for disadvantaged students; but the opposite is observed in Australia, where Suziedelyte and Zhu (2015) report that early entry into school improves cognitive score, especially for disadvantaged students. A possible explanation for these apparently contradictory findings could be that differences in the impact of delayed entry on future outcomes may depend on whether or not the child had attended preschool, and on the quality of that experience. However, the PISA data cannot provide sufficient and relevant information on these issues, and this calls for future investigations.

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A Age, school cohort and relative school starting age in PISA

As discussed extensively in the literature, several reasons may explain the observed birthday effects on educational outcomes.

PISA covers students who are aged between 15 years 3 months and 16 years 2 months at the time of the assessment (see Givord, 2020 for a description of the sample). Depending on their month of birth, some students may be older than others when they sit the PISA test and this "age-at-the-test" effect may make a difference in performance as age may be related to greater maturity.

The age at the test is linearly related with the school starting age, and the duration of schooling. In several countries, the 12-month spread of PISA-sampled students coincide with one and unique school cohort, as defined by the cut-off. If they had started school at the normal age, students who are the eldest when they sit the PISA test were those who are the eldest in their school cohort in primary school. If they have not skipped nor repeated a grade, they are expected to be enrolled in the same grade than their school cohort.

However, in some PISA participating countries the 12-month spread of PISA-sampled students (which is defined by the choice of a particular testing date for PISA) does not completely overlap with a 12-month school-entry window. Amongst the countries analysed here, this is the case in Finland, where 8% of the sample (1 month over 12) is expected to be in a lower grade than the modal one (according to their month of birth, had the regulations regarding school entry strictly applied) and Germany, where 25% (3 months over 12) are in this case. In England and Wales, only 2% of the sample (300 students over 10,817) are born in August 2002 and are thus included in a previous school cohort than main one (the cut-off date for school entry is August 31st).[14]

In case where the PISA sample encompasses two countries, the link between the age at the test and the school starting age is not expected to be continuous. This is illustrated in Figure A.1 for a fictitious case. In this example, Student A is almost one year older than the Student B, they are expected to be enrolled in two subsequent grades when they sat the PISA test, but they should have the same school starting age in primary school.

[14] In this last case, it appears that the number of students born in August is surprisingly much lower than those born in other months, and that the performance of these students are much higher on average than those of their younger peers. One may thus suspect that they are not fully representative of students of their age.

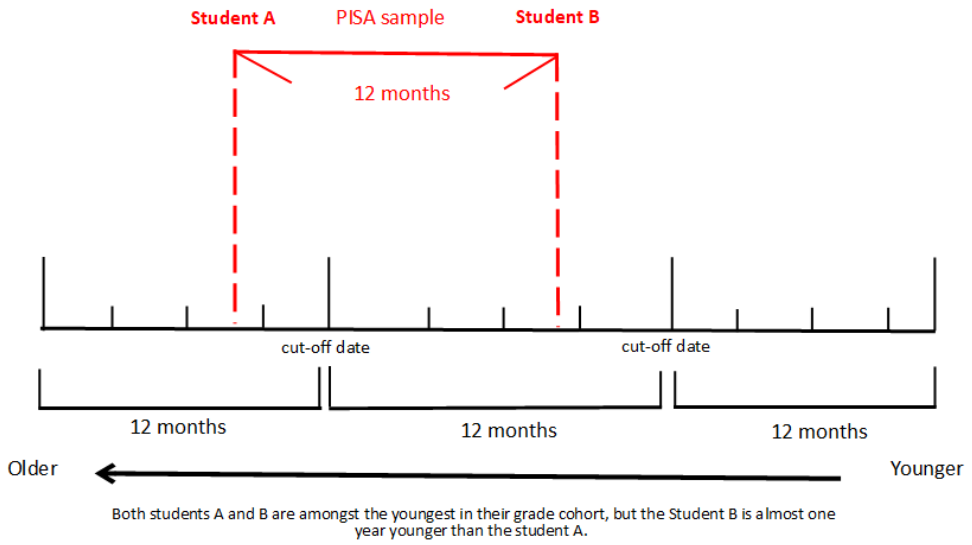

Figure A.1: Structure of the PISA Sample with two theoretical school cohorts

This discontinuous relationship between the age at the time of the PISA test and the relative age within a grade cohort is indeed observed in real data, as shown in Figure A.2. In Finland and Germany, the sampled students born before the cut-off date are expected to be enrolled in a higher grade. These students are amongst the oldest of the PISA sample, while they are the youngest within their grade cohort, defined by the age at entry into school. This configuration makes it possible to identify separately the age at the test and relative age effect. However, for the sake of comparability with countries with only one school cohort, it has been chosen to restrict the sample to students in the largest school cohort, as defined by the birthday date. This corresponds to a restriction of the sample based on the month of birth that are expected to be random.

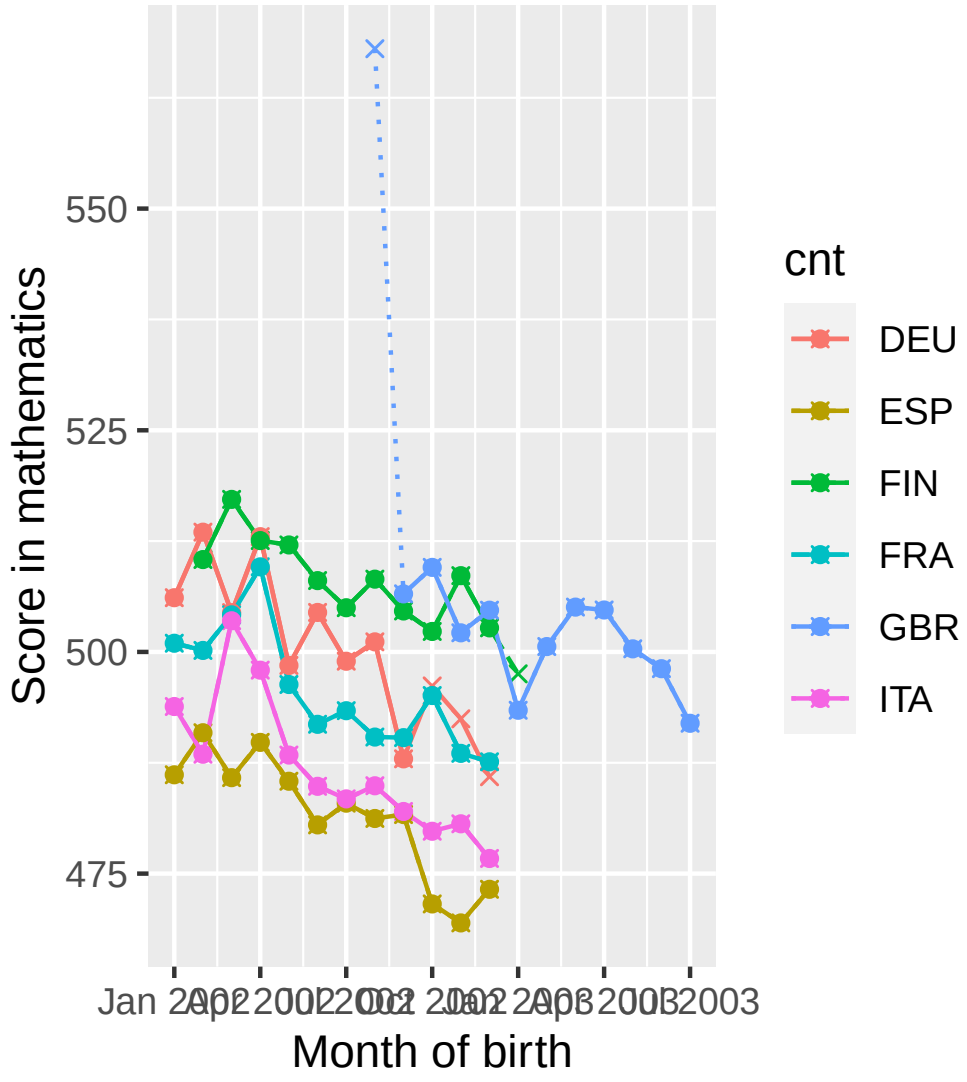

Figure A.2: Age at the test and age at school entry depending on the month of birth

B Additional Tables and Figures

Table B.1: Description of the sample

	DEU	FIN	FRA	GBR	ITA	ESP
N. Obs	5,451	5,649	6,308	10,817	11,785	35,943
Modal grade	9	9	10	11	10	10
Prop. in the main school cohort (%)	75.5	91.1	100.0	2.0	100.0	100.0
Prop. below modal grade (actual) (%)	8.5	14.2	17.4	1.1	14.5	30.0
Prop. of repeaters (%)	19.6	3.3	16.6	2.5	13.2	28.7
Prop. of repeaters in primary school (%)	9.9	2.9	11.3	1.8	1.4	11.4
Average age at entry (year)	6.5	7.0	6.1	5.4	6.2	6.1

Source: PISA 2018, Author's calculations.

Note: Only the 2SLS estimates of the impact of the relative age at school entry (instrument: theoretical age at entry) is reported. Models include as additional controls variables: gender, socio-economic status (4 dummies), immigrant background. Standard Errors in parenthesis.

Table B.2: Descriptive statistics

	DEU	FIN	FRA	GBR	ITA	ESP
Average perf. in maths	505.72^{***} (2.11)	509.96^{***} (1.61)	494.18^{***} (1.47)	496.89^{***} (1.98)	488.12^{***} (2.12)	483.57^{***} (1.21)
Average perf. in reading	505.77^{***} (2.17)	524.03^{***} (1.71)	495.91^{***} (1.59)	500.53^{***} (2.02)	480.41^{***} (1.84)	na
Average perf. in science	508.66^{***} (2.05)	527.22^{***} (1.79)	493.96^{***} (1.37)	507.63^{***} (1.88)	474.12^{***} (1.91)	487.92^{***} (1.27)
Disciplinary climate	0.06^{**} (0.03)	-0.12^{***} (0.02)	-0.34^{***} (0.03)	0.09^{***} (0.03)	-0.02 (0.02)	-0.22^{***} (0.01)
Teacher interest	-0.12^{***} (0.02)	-0.15^{***} (0.02)	0.03 (0.02)	0.24^{***} (0.02)	-0.07^{***} (0.02)	0.03^{**} (0.02)
Perception of teacher unfairness	9.88^{***} (0.06)	9.44^{***} (0.07)	10.00^{***} (0.05)	10.47^{***} (0.07)	na	9.33^{***} (0.06)
Enjoy cooperation	0.14^{***} (0.02)	-0.08^{***} (0.02)	-0.07^{***} (0.01)	-0.04^{**} (0.02)	-0.14^{***} (0.01)	0.19^{***} (0.02)
Motivation to master tasks	-0.06^{***} (0.02)	-0.31^{***} (0.02)	-0.24^{***} (0.01)	-0.17^{***} (0.01)	0.49^{***} (0.02)	0.17^{***} (0.01)
Ambitious learning goals	-0.00 (0.02)	-0.13^{***} (0.01)	-0.20^{***} (0.01)	-0.09^{***} (0.02)	-0.18^{***} (0.01)	-0.10^{***} (0.01)
Enjoy competition	0.14^{***} (0.02)	-0.08^{***} (0.02)	-0.07^{***} (0.02)	-0.04^{**} (0.02)	-0.14^{***} (0.01)	0.19^{***} (0.01)
Self-efficacy	-0.03 (-0.03)	-0.03 (-0.03)	-0.10 (-0.10)	-0.18 (-0.18)	-0.03 (-0.03)	0.17 (0.17)
Self-perceived comp. in reading	0.17^{***} (0.02)	0.09^{***} (0.02)	-0.21^{***} (0.02)	0.21^{***} (0.02)	-0.36^{***} (0.01)	-0.12^{***} (0.01)
Exp. to complete tertiary education	0.26^{***} (0.01)	0.52^{***} (0.01)	0.61^{***} (0.01)	0.57^{***} (0.01)	0.59^{***} (0.01)	0.70^{***} (0.01)

Source: PISA 2015 and 2018, Author's calculations.

Note: Only the 2SLS estimates of the impact of the relative age at school entry (instrument: theoretical age at entry) is reported. Models include as additional controls variables: gender, socio-economic status (4 dummies), immigrant background. Standard Errors in parenthesis.

Table B.3: Performance in PISA (2SLS estimates) - details

	DEU	FIN	FRA	GBR	ITA	ESP
Mathematics						
Age at entry	50.42***	14.34***	16.41***	11.11	31.85***	18.86***
	(9.18)	(3.74)	(4.05)	(7.80)	(5.24)	(2.89)
Girl	−12.74***	4.94**	−8.74***	−14.67***	−15.37***	−14.63***
	(2.57)	(1.95)	(2.07)	(2.53)	(2.70)	(1.81)
Immigrant status	−38.83***	−49.26***	−32.32***	−8.30**	−27.75***	−30.30***
	(5.11)	(5.90)	(4.76)	(4.08)	(3.74)	(3.01)
ESCS Q2	35.80***	22.13***	31.70***	16.20***	34.39***	22.58***
	(3.76)	(2.63)	(2.98)	(2.50)	(3.31)	(2.32)
ESCS Q3	55.54***	43.25***	62.53***	44.87***	48.67***	43.74***
	(3.82)	(2.41)	(3.46)	(2.95)	(3.55)	(2.63)
ESCS Q4	97.16***	70.47***	103.16***	77.36***	79.22***	75.96***
	(4.70)	(2.97)	(3.91)	(3.47)	(4.43)	(2.38)
Intercept	156.80***	378.15***	357.48***	414.34***	265.15***	351.16***
	(60.32)	(26.60)	(24.70)	(39.92)	(32.94)	(17.36)
Reading						
Age at entry	41.78***	21.17***	22.60***	19.49***	30.46***	na
	(9.78)	(4.38)	(3.83)	(6.33)	(5.22)	
Girl	24.48***	46.88***	24.31***	19.12***	23.30***	na
	(2.78)	(2.04)	(2.38)	(2.81)	(2.61)	
Immigrant status	−40.03***	−71.31***	−33.50***	−15.56***	−38.48***	na
	(5.81)	(6.33)	(5.23)	(3.84)	(4.15)	
ESCS Q2	36.62***	20.25***	30.65***	15.44***	38.35***	na
	(3.69)	(2.67)	(2.89)	(2.87)	(2.81)	
ESCS Q3	57.55***	42.85***	65.52***	42.61***	52.41***	na
	(3.29)	(2.92)	(3.55)	(3.27)	(3.16)	
ESCS Q4	100.45***	70.78***	107.52***	75.27***	79.02***	na
	(4.32)	(3.43)	(3.89)	(3.58)	(3.96)	
Intercept	198.21***	327.07***	309.91***	361.86***	248.33***	na
	(64.40)	(31.11)	(24.15)	(32.25)	(32.47)	
Sciences						
Age at entry	45.65***	21.34***	17.88***	8.99	28.57***	16.15***
	(9.35)	(4.18)	(3.34)	(6.19)	(5.80)	(2.94)
Girl	−5.90**	19.49***	−3.36*	−3.42	−7.56***	−7.69***
	(2.53)	(1.89)	(1.94)	(2.81)	(2.43)	(1.61)
Immigrant status	−50.66***	−66.58***	−38.15***	−17.51***	−31.37***	−26.97***
	(5.38)	(5.63)	(4.83)	(3.50)	(4.34)	(2.81)
ESCS Q2	39.29***	22.04***	31.79***	17.12***	33.12***	22.82***
	(3.21)	(2.82)	(2.68)	(2.65)	(2.78)	(2.11)
ESCS Q3	60.91***	46.22***	64.17***	47.96***	46.15***	42.58***
	(3.48)	(2.64)	(3.02)	(2.94)	(2.93)	(2.23)
ESCS Q4	103.94***	74.94***	106.72***	80.39***	71.18***	72.46***
	(4.22)	(3.34)	(3.69)	(3.27)	(3.71)	(2.62)
Intercept	187.20***	340.72***	348.28***	437.65***	275.36***	371.71***
	(61.06)	(29.71)	(20.63)	(31.51)	(36.27)	(17.88)

Source: PISA 2018, Author's calculations.

Note: The instrument is the theoretical age at school entry. Standard Errors in parenthesis.

Table B.4: Impact of relative age at entry on grade repetition

	DEU	FIN	FRA	GBR	ITA	ESP
Primary school						
	0.03	−0.02***	−0.10***	0.03 ***	−0.01*	−0.08***
	(0.03)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Interaction with Gender						
Girl	−0.02	−0.02***	−0.09***	0.04 **	−0.01	−0.06***
	(0.03)	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)
Boy	0.09 *	−0.02**	−0.12***	0.02 *	−0.02	−0.10***
	(0.05)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)
Interaction with ESCS Quartile						
ESCS Q1	0.09	−0.01	−0.19***	0.08 ***	−0.02	−0.14***
	(0.07)	(0.02)	(0.04)	(0.03)	(0.02)	(0.03)
ESCS Q4	0.00	−0.02*	−0.04***	−0.02	−0.01	−0.03***
	(0.03)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)
Middle school						
	0.06 **	−0.00	−0.03***	0.01	−0.03**	−0.07***
	(0.03)	(0.00)	(0.01)	(0.00)	(0.02)	(0.01)
Interaction with Gender						
Girl	0.07 **	0.00	−0.03**	0.01 **	−0.01	−0.04**
	(0.03)	(0.00)	(0.02)	(0.00)	(0.01)	(0.02)
Boy	0.06	−0.00	−0.04**	0.00	−0.06**	−0.11***
	(0.05)	(0.01)	(0.02)	(0.01)	(0.03)	(0.02)
Interaction with ESCS Quartile						
ESCS Q1	0.11	0.01	−0.03	0.01	−0.04	−0.10***
	(0.08)	(0.01)	(0.03)	(0.01)	(0.04)	(0.03)
ESCS Q4	−0.01	−0.00	0.00	0.00	−0.03	−0.04***
	(0.04)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)

Source: PISA 2018, Author's calculations.

Note: Only the 2SLS estimates of the impact of the relative age at school entry (instrument: theoretical age at entry) is reported. Models include as additional controls variables: gender, socio-economic status (4 dummies), immigrant background. Standard Errors in parenthesis.

Table B.5: Impact of relative age on the quality of teacher/students relationships

	DEU	FIN	FRA	GBR	ITA	ESP
Disciplinary climate						
	0.33**	0.11**	−0.02	0.18	0.19**	0.04
	(0.13)	(0.05)	(0.06)	(0.13)	(0.08)	(0.03)
Interaction with Gender						
Girl	0.45**	0.10	0.10	0.17	0.29**	0.05
	(0.19)	(0.08)	(0.09)	(0.17)	(0.13)	(0.04)
Boy	0.21	0.12	−0.13*	0.20	0.10	0.03
	(0.20)	(0.08)	(0.07)	(0.24)	(0.11)	(0.05)
Interaction with ESCS Quartile						
ESCS Q1	0.12	0.01	−0.01	0.11	0.11	0.00
	(0.23)	(0.12)	(0.08)	(0.29)	(0.17)	(0.08)
ESCS Q4	0.14	−0.01	0.20*	0.59**	0.21	0.05
	(0.20)	(0.09)	(0.11)	(0.26)	(0.19)	(0.05)
Teacher Enthusiasm						
	0.04	0.18***	0.04	0.35***	0.10	0.13***
	(0.12)	(0.05)	(0.06)	(0.13)	(0.08)	(0.03)
Interaction with Gender						
Girl	0.10	0.25***	0.14*	0.34*	0.25**	0.10**
	(0.15)	(0.08)	(0.08)	(0.18)	(0.12)	(0.04)
Boy	−0.02	0.12	−0.06	0.36**	−0.02	0.16***
	(0.20)	(0.07)	(0.08)	(0.17)	(0.09)	(0.05)
Interaction with ESCS Quartile						
ESCS Q1	−0.08	0.07	−0.02	0.45	0.06	0.09
	(0.21)	(0.11)	(0.09)	(0.28)	(0.14)	(0.08)
ESCS Q4	0.06	0.16*	−0.02	0.15	−0.11	0.12**
	(0.21)	(0.08)	(0.12)	(0.33)	(0.17)	(0.06)
Perception of teacher unfairness						
	−0.37	0.37	−0.45**	−0.27	na	−0.14
	(0.43)	(0.24)	(0.19)	(0.33)		(0.17)
Interaction with Gender						
Girl	−0.08	0.45	−0.44	−0.53	na	0.08
	(0.53)	(0.30)	(0.28)	(0.45)		(0.24)
Boy	−0.67	0.30	−0.47*	−0.02	na	−0.38
	(0.66)	(0.39)	(0.28)	(0.55)		(0.28)
Interaction with ESCS Quartile						
ESCS Q1	0.80	0.61	−1.17**	0.06	na	−0.84***
	(1.02)	(0.48)	(0.50)	(0.62)		(0.30)
ESCS Q4	0.01	0.13	0.06	−0.89	na	0.10
	(0.70)	(0.48)	(0.36)	(0.75)		(0.27)

Source: PISA 2015, Author's calculations.

Note: Only the 2SLS estimates of the impact of the relative age at school entry (instrument: theoretical age at entry) is reported. Models include as additional controls variables: gender, socio-economic status (4 dummies), immigrant background. Standard Errors in parenthesis.

Table B.6: Impact of relative age on social relations at school

	DEU	FIN	FRA	GBR	ITA	ESP
Exposure to bullying						
	−0.05	−0.02	−0.20***	0.02	−0.18**	−0.04
	(0.16)	(0.06)	(0.06)	(0.11)	(0.08)	(0.03)
Interaction with Gender						
Girl	−0.14	−0.06	−0.13	0.20	0.05	−0.02
	(0.23)	(0.08)	(0.08)	(0.16)	(0.11)	(0.04)
Boy	0.04	0.02	−0.27***	−0.20	−0.36***	−0.06
	(0.21)	(0.10)	(0.08)	(0.19)	(0.13)	(0.05)
Interaction with ESCS Quartile						
ESCS Q1	−0.18	0.03	0.06	−0.09	−0.39**	−0.08
	(0.36)	(0.14)	(0.17)	(0.28)	(0.18)	(0.07)
ESCS Q4	−0.22	−0.11	−0.25**	0.05	−0.14	−0.05
	(0.26)	(0.10)	(0.11)	(0.26)	(0.17)	(0.06)
Sense of belonging at school						
	0.00	−0.04	−0.02	0.12**	0.03	−0.01
	(0.11)	(0.05)	(0.03)	(0.06)	(0.05)	(0.04)
Interaction with Gender						
Girl	0.03	0.02	−0.09**	0.07	0.03	−0.03
	(0.14)	(0.06)	(0.04)	(0.09)	(0.06)	(0.04)
Boy	−0.03	−0.10	0.05	0.19**	0.03	0.01
	(0.15)	(0.06)	(0.04)	(0.09)	(0.07)	(0.05)
Interaction with ESCS Quartile						
ESCS Q1	0.01	0.07	−0.01	0.09	0.09	0.00
	(0.21)	(0.09)	(0.06)	(0.13)	(0.09)	(0.08)
ESCS Q4	0.18	−0.10	−0.04	0.13	−0.10	0.06
	(0.17)	(0.08)	(0.06)	(0.13)	(0.14)	(0.07)
Enjoy cooperation						
	0.13	0.25***	0.10**	−0.04	0.07	−0.04
	(0.14)	(0.06)	(0.05)	(0.09)	(0.08)	(0.05)
Interaction with Gender						
Girl	0.02	0.22***	0.04	0.02	−0.01	−0.03
	(0.18)	(0.08)	(0.07)	(0.12)	(0.10)	(0.07)
Boy	0.24	0.29***	0.16**	−0.09	0.16	−0.04
	(0.20)	(0.07)	(0.07)	(0.12)	(0.11)	(0.07)
Interaction with ESCS Quartile						
ESCS Q1	0.42	0.19	0.17	−0.02	0.15	−0.07
	(0.38)	(0.12)	(0.11)	(0.16)	(0.12)	(0.10)
ESCS Q4	0.14	0.20*	0.07	−0.02	−0.02	−0.01
	(0.18)	(0.12)	(0.11)	(0.16)	(0.20)	(0.09)

Source: PISA 2015 and 2018, Author's calculations.

Note: Only the 2SLS estimates of the impact of the relative age at school entry (instrument: theoretical age at entry) is reported. Models include as additional controls variables: gender, socio-economic status (4 dummies), immigrant background. Standard Errors in parenthesis.

Table B.7: Impact of relative age on motivation

	DEU	FIN	FRA	GBR	ITA	ESP
Motivation to master tasks						
	0.01	0.06	−0.02	0.21*	0.13*	0.10***
	(0.12)	(0.06)	(0.05)	(0.11)	(0.07)	(0.03)
Interaction with Gender						
Girl	−0.05	0.03	−0.03	0.25	0.19*	0.12***
	(0.15)	(0.07)	(0.07)	(0.17)	(0.11)	(0.03)
Boy	0.08	0.08	−0.01	0.15	0.07	0.07*
	(0.16)	(0.09)	(0.07)	(0.14)	(0.10)	(0.04)
Interaction with ESCS Quartile						
ESCS Q1	0.24	0.07	0.02	0.59**	0.11	0.06
	(0.24)	(0.13)	(0.08)	(0.29)	(0.14)	(0.08)
ESCS Q4	−0.03	0.14	−0.02	0.28	−0.14	0.04
	(0.18)	(0.10)	(0.09)	(0.34)	(0.19)	(0.05)
Ambitious learning goals						
	−0.17	0.05	−0.02	0.30**	0.02	0.12***
	(0.11)	(0.05)	(0.06)	(0.12)	(0.07)	(0.04)
Interaction with Gender						
Girl	−0.11	0.01	−0.07	0.39**	0.07	0.14***
	(0.16)	(0.07)	(0.08)	(0.17)	(0.10)	(0.05)
Boy	−0.22	0.09	0.02	0.18	−0.01	0.10*
	(0.18)	(0.07)	(0.07)	(0.18)	(0.11)	(0.06)
Interaction with ESCS Quartile						
ESCS Q1	−0.35	0.10	−0.01	0.37	0.06	0.16**
	(0.26)	(0.12)	(0.10)	(0.25)	(0.17)	(0.08)
ESCS Q4	0.08	0.17*	0.04	0.63**	−0.30	0.15*
	(0.17)	(0.09)	(0.10)	(0.26)	(0.18)	(0.08)

Source: PISA 2018, Author's calculations.

Note: Only the 2SLS estimates of the impact of the relative age at school entry (instrument: theoretical age at entry) is reported. Models include as additional controls variables: gender, socio-economic status (4 dummies), immigrant background. Standard Errors in parenthesis.

Table B.8: Impact of relative age on self-confidence

	DEU	FIN	FRA	GBR	ITA	ESP
Self-efficacy						
	−0.09	0.04	0.05	0.34***	0.13**	0.14***
	(0.11)	(0.06)	(0.05)	(0.11)	(0.06)	(0.03)
Interaction with Gender						
Girl	−0.14	0.06	0.03	0.23	0.20**	0.15***
	(0.18)	(0.09)	(0.08)	(0.15)	(0.10)	(0.04)
Boy	−0.03	0.02	0.07	0.46**	0.07	0.12***
	(0.16)	(0.08)	(0.08)	(0.19)	(0.09)	(0.04)
Interaction with ESCS Quartile						
ESCS Q1	−0.01	0.08	0.03	0.48*	0.17	0.09
	(0.27)	(0.11)	(0.10)	(0.27)	(0.12)	(0.06)
ESCS Q4	0.04	0.08	0.01	0.62**	−0.08	0.15**
	(0.22)	(0.13)	(0.11)	(0.32)	(0.16)	(0.07)
Enjoy Competition						
	−0.04	−0.03	0.07	0.40***	0.04	0.09***
	(0.14)	(0.05)	(0.06)	(0.13)	(0.08)	(0.03)
Interaction with Gender						
Girl	−0.04	−0.08	−0.02	0.32**	−0.03	0.06*
	(0.18)	(0.08)	(0.08)	(0.16)	(0.11)	(0.04)
Boy	−0.04	0.01	0.15*	0.50**	0.10	0.12***
	(0.18)	(0.08)	(0.08)	(0.20)	(0.11)	(0.05)
Interaction with ESCS Quartile						
ESCS Q1	0.19	0.11	0.02	0.45*	−0.12	0.04
	(0.34)	(0.12)	(0.11)	(0.25)	(0.18)	(0.07)
ESCS Q4	−0.00	−0.06	−0.03	0.35	0.12	0.02
	(0.19)	(0.10)	(0.10)	(0.36)	(0.20)	(0.07)
Self perception of competence in reading						
	0.18	0.17***	0.17***	0.25**	0.08	0.08***
	(0.12)	(0.05)	(0.06)	(0.11)	(0.07)	(0.03)
Interaction with Gender						
Girl	0.35**	0.20**	0.19**	0.08	0.14	0.11***
	(0.15)	(0.08)	(0.08)	(0.14)	(0.11)	(0.04)
Boy	0.02	0.14*	0.14*	0.44***	0.02	0.04
	(0.17)	(0.09)	(0.08)	(0.16)	(0.10)	(0.04)
Interaction with ESCS Quartile						
ESCS Q1	−0.23	−0.04	0.16*	0.26	0.05	0.09
	(0.25)	(0.13)	(0.10)	(0.25)	(0.11)	(0.07)
ESCS Q4	0.02	0.32***	0.09	0.30	0.02	0.12*
	(0.21)	(0.11)	(0.13)	(0.30)	(0.15)	(0.06)

Source: PISA 2015 and 2018, Author's calculations.

Note: Only the 2SLS estimates of the impact of the relative age at school entry (instrument: theoretical age at entry) is reported. Models include as additional controls variables: gender, socio-economic status (4 dummies), immigrant background. Standard Errors in parenthesis.

Table B.9: Impact of relative age on no cognitive outcomes (controlled by performance)

	DEU	FIN	FRA	GBR	ITA	ESP
Disciplinary climate						
	0.21 *	0.09 *	−0.04	0.13	0.10	0.01
	(0.12)	(0.05)	(0.06)	(0.13)	(0.08)	(0.03)
Perception of teacher enthousiasm						
	−0.00	0.15 ***	0.02	0.31 **	0.08	0.11 ***
	(0.12)	(0.05)	(0.06)	(0.12)	(0.07)	(0.03)
Perception of teacher unfairness						
	−0.03	0.61 ***	−0.27	−0.24	na	−0.04
	(0.40)	(0.23)	(0.19)	(0.32)		(0.17)
Enjoy cooperation						
	0.05	0.23 ***	0.06	−0.03	0.03	−0.05
	(0.13)	(0.06)	(0.05)	(0.09)	(0.07)	(0.05)
Motivation to master tasks						
	−0.04	0.00	−0.03	0.17	0.08	0.08 ***
	(0.11)	(0.06)	(0.05)	(0.11)	(0.06)	(0.03)
Ambitious learning goals						
	−0.19*	0.01	−0.03	0.29 **	0.02	0.08 **
	(0.11)	(0.05)	(0.06)	(0.12)	(0.07)	(0.04)
Enjoy competition						
	−0.10	−0.07	0.06	0.38 ***	0.00	0.08 **
	(0.14)	(0.05)	(0.06)	(0.13)	(0.08)	(0.03)
Self-efficacy						
	−0.11	0.01	0.05	0.33 ***	0.11 *	0.11 ***
	(0.11)	(0.06)	(0.05)	(0.11)	(0.06)	(0.03)
Self perception of competence in reading						
	0.04	0.08	0.09 *	0.16	−0.03	na
	(0.10)	(0.05)	(0.05)	(0.10)	(0.07)	
Expectation to complete tertiary education						
	0.05	0.01	−0.01	0.10 ***	0.02	0.02
	(0.03)	(0.02)	(0.02)	(0.03)	(0.02)	(0.01)

Source: PISA 2015 and 2018, Author's calculations.

Note: Only the 2SLS estimates of the impact of the relative age at school entry (instrument: theoretical age at entry) is reported. Models include as additional controls variables: gender, socio-economic status (4 dummies), immigrant background. Standard Errors in parenthesis.