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How age at school entry affects future educational and socioemotional outcomes: Evidence from PISA.

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Abstract

This study provides new empirical evidence of birthday effects over a range of educational and socioemotional outcomes. It relies on data from the recent cycles of the Program for International School Assessment (PISA) for six European countries. Age at entry has a significant and sizeable impact on cognitive outcomes for 15-year-old students as measured in PISA. The magnitude of the birthday effects on socioemotional skills varies, but overall the results suggest that those students who enter school relatively younger have more negative relationships with their teachers and peers at school. These students also have lower intrinsic motivation and self-esteem and have less ambitious educational expectations than their peers who entered school older.

Key words: Birthday effects, PISA, Instrumental variables, socioemotional outcomes.

1 Introduction

This study provides new empirical evidence on 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 from the Program for International School Assessment (PISA). The PISA survey makes it possible to estimate how age at primary school entry affects 15-year-old students not only in their school performance, but also in their socioemotional skills, especially those related to the quality of their relations at school, their attitudes towards learning and their level of self-confidence.

Investigating these dimensions provides new avenues for understanding why birthday effects may have long lasting consequences on future outcomes. Indeed, while birthday effects on educational outcomes have been widely documented (Bedard and Dhuey, 2006; Grenet, 2010; Ponzo and Scoppa, 2014; Crawford et al., 2010; Attar and Cohen-Zada, 2018; Peña, 2020; Fredriksson and Öckert, 2014), suggesting that month of birth appears to be related not only to performance at school, but also to educational attainment and labor market outcomes, the interpretation of these correlations is still widely debated. Such differences between birth 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 "cutoff" date. Within a school cohort, children who are born just after the cutoff are likely to be older by almost one year than those born just before this cutoff.

Differences in cognitive maturity may explain why students who sit exams on the same date perform differently. As the eldest students (those born just after the cutoff) in a school cohort are more mature when they sit for tests or exams, they are more likely to perform well than the youngest students in the school cohort (those born just before the cutoff). This "age at test" effect on school performance is 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% older than their youngest classmates - while they are only 6% older when they are aged 15. However, empirical evidence suggests that school starting

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age effects may not decline, and in some cases may increase with levels (Attar and Cohen-Zada, 2018). A potential explanation for this persistence may be that the initial effect of age at school entry may affect children's emotional development. If the youngest children are not "ready" enough when they start formal schooling, their future perceptions 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. Evidence shows that students entering school early 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), which may affect their educational paths and emotional development. Furthermore, being held back may undermine the self-esteem and thus motivation to learn of the relatively 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 having a lower view of their own scholastic competence than their elderly peers, which is not fully explained by actual differences due to their lower age at the time of testing. 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 ranked highly in a subject (such as English, mathematics or science) among the students in their class in primary school usually attained higher test scores in that same subject throughout secondary school than did students with a similar absolute level of performance but who ranked lower in their primary school class. These results suggest that birthday effects may not only be due to maturity effects, as they may affect the self-confidence and motivation of children. This may explain the lasting impact of age at school entry observed in several countries. Students who are more mature when they start school may achieve early success, 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 evidence suggests that those who were the oldest in their school-entry cohort have more ambitious career and educational expectations (Peña, 2020) and are overrepresented in leadership positions in the political (Muller and Page, 2016; Tukiainen et al., 2019) and economic fields (Du et al., 2012). Differences in self-esteem and self-confidence may also result in distinct attitudes towards competition, as students who were the eldest in their classes at school entry are more often in a position to achieve better results than their peers, and thus to enjoy the competition that places them in a winning position.

However, as has already been widely discussed in the literature (see for instance Dhuey et al., 2019), the reasons why month of birth has an impact on educational outcomes are difficult to identify. Because the age at which students sit tests, the age at which they started school, and the grade in which they are 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 cutoff date are usually the eldest in their school cohort, and are thus expected to be the eldest among students who sit the test. When measures are provided at the grade level, students may be selected depending on their previous educational path, which may depend on their relative age. For instance, if the youngest students in a cohort are more likely to be held back in their first years of schooling, those of a normal age in later grades are more likely to be the brightest in their cohort. As school starting age may affect the quality of the first experience of children with formal schooling, it may have consequences on their perception and attitude towards school. As the youngest students in a school cohort may be confronted with difficulties in learning because of their lower intellectual maturity, they may have difficulties with some tasks and thus may receive positive feedback from their teachers less often. Consequently, they may feel that their efforts are not rewarded enough.

It may also affect their motivation and self-confidence.

To date, few empirical studies have questioned whether these effects may vary depending on students' individual characteristics, but existing evidences suggest that the impact of school starting age may be higher for disadvantaged students. Using using Swedish longitudinal data, Fredriksson and Öckert (2014) show that school starting age have impact on prime-age earnings for individuals individuals with low-educated parents. Bernardi (2014) als observes that the impact of school starting age on the probability of being held back in primary school in France is lower for children with more educated parents than for those with less-educated parents, a fact that he explains through the theory of "compensatory advantage", meaning that children from advantaged backgrounds may benefit of higher level of parental investment that helps to soften the negative consequences of prior adverse outcomes. Gender is another dimension along which it may be possible to expect a distinct "path-dependency" in the impact of school starting age on educational outcomes. It is usually observed that girls mature more quickly than boys. They may thus be less prone to the school starting age effect, at least regarding cognitive performance - as relatively lower maturity may still affect their self-confidence.[1]

The PISA data have several features that make it possible to provide new insights into these topics. As the PISA sample is age-based, it is representative within a country of students aged approximatively 15 years old (between 15 years and 4 months to 16 years and 3 months), regardless the type of school and the grade in which they are enrolled. In addition, PISA data provide measures of cognitive (math, reading and sciences performance) and socioemotional (self-confidence, motivation, and relations with teachers and their peers) skills that are comparable over a set of countries. One may thus compare the magnitude of the estimates across characteristics (such as gender or socio-economic status) and across countries. Alternative specifications provide estimations of the impact of the relative age at school entry interacted separately with gender and socioeconomic status (defined by quartiles of the national distribution of the PISA index of socioeconomic and cultural status) on educational outcomes. One may plausibly assume that the age-at-test effects on cognitive and socioemotional outcomes would be similar from one country to another and among children of different socioeconomic statuses within the same country, as they 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 received 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 schooling organizations, notably regarding school starting age and the use of ability-grouping practices in primary schools. These features may explain why the relative-age effect may have a more or less pervasive impact on children's development. The impact of relative age at school entry is 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, notably as in France, Germany, Italy and Spain. By contrast, Finland has a comprehensive schooling system. 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, such as Germany (tracking first occurs at 10) and, to a smaller extent, Italy (students may be tracked when they are 14) they are thus more likely to be held back. The rationale for these practices is that students should 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, age at school entry has a significant and sizeable impact on cognitive outcomes at 15, as measured on PISA. The magnitude of the birthday effects on socioemotional skills depends on the country, but overall, the results suggest that students who enter school relatively young compared to their peers often have worse student-teacher relationships and attitudes. They are also more frequently exposed to bullying at school. Relative age at entry positively affects

[1] For a recent review of the reasons that may explain the differences in boys' and girls' performance at school, see for instance Reilly and Andrews (2019).

intrinsic motivation and self-esteem. One key issue is whether the lower performance of students who were younger in their school entry cohort may have long-term consequences. According to the results, in almost all countries analyzed here, those who were the eldest in their school entry cohort also tend to have more ambitious educational expectations. This means that month of birth may have consequences for educational attainment and thus for 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 PISA. PISA is a survey conducted every three years by the Organisation for Economic Co-operation and Development (OECD) in a large set of countries. 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,[2] Finland, France, Germany, Italy and Spain. Comparing a set of distinct school systems is a way to identify whether birthday effects are a constant, or whether they may have distinct impacts on certain outcomes depending on the context. The set of European countries analyzed here are indeed quite similar in terms of economic development and school enrollment,[3] but their school systems have distinctive features. For instance, the compulsory age for primary school is 7 in Finland, while it is 5 in the UK, and 6 in the other countries. School systems also differ in the age of first selection into differentiated systems. The age of first selection is 12 or below in Germany, 14 in Italy, 15 in France and 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 effects of one or other of these features on the magnitude of birthday effects on educational outcomes, these distinctive features of the school systems may be useful for contextualizing the magnitude of these effects.

[Insert Table 1 here]

In PISA information is 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 into differentiated 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 cutoff date (dd/mm) for eligibility to enroll in school. The cutoff date is defined as the date at which a child should have reached the theoretical starting age for primary school, i.e., the age at which the child is eligible to enroll in school (see Table 1).[4] In Germany, England and Wales, this cutoff date coincides or almost coincides with the first day of schooling, meaning that all children are expected to have attained the compulsory age for primary school entry the day that they begin school or by the end of that month. However, in Finland, France, Italy and Spain, the cutoff date for eligibility for 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 school entry even when they comply with the 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.

[2] PISA data include data for the United-Kingdom, but the school regulations in Scotland appear to be different from those in England and Wales.

[3] In all these countries, the upper age limit for compulsory education is above 16, and as a consequence, 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 and more than 90% in other countries.

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

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 had repeated or skipped a grade since their entry into school.[5] In addition, one of the specific features of the PISA test is that the sample is age-based, while most existing tests are usually grade-based. The average age is approximatively 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).[6]

The PISA sample may be considered to be based on theoretical school cohorts at school entry, as defined by a strict application of the school entry regulations. However, in some countries, the PISA sample encompasses two grade cohorts, as determined by the school start date and the cutoff date for determining age eligibility. For this study, only students who belong to one theoretical grade have been selected (see the Appendix). This corresponds to a restriction of the sample based on the fact that month of birth is expected to be random and thus is not expected to alter the identification of the impact of relative age on educational outcomes.

2.2 Contextual variables and educational outcomes

PISA measures of literacy are completed through contextual questionnaires, notably providing information about students' backgrounds (for instance gender, date of birth, and occupations and education of parents), their educational path (age at primary school entry, grade repetition). These variables make it possible to control for individual characteristics (such as the socioeconomic background, measured by 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 the grade repetition 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 range from "4 years" to " 9 years or older" (and include "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's birthday and the date of the first day of the school year.

In PISA, students are also asked about their attitudes, beliefs, motivation and aspirations (for details, see OCDE, 2019 and details on the variables used in this article in the Appendix B).[7]

For this study, several dimensions are explored. The first set of variables is related to the quality of student/teacher relationships as reported by the students. In PISA 2018, students were asked several questions to measure whether they perceived their teacher as showing interest in teaching ("enthusiasm") and inspiring them and whether they suffered from a negative disciplinary climate in class. PISA 2015 provides an index for the perceptions of "teachers' unfairness". All these dimensions are subjective and cannot be analyzed as a "true" measure of teacher behavior or the disciplinary climate within a class; nevertheless, they are informative about the perceptions that students have about school.

A second group of indices captures the social connections of the students with their peers at

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

[6] According to its technical standards, PISA is expected to cover 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 within this age definition is permitted so long as the birth date range is maintained as a 12 month period.

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

school: whether they report having been bullied by other students, whether they report feeling they belong at school and whether they enjoy cooperation (see OECD, 2017, 2019 for details).

A third group of outcomes may be related to the students' motivation: one index measures their motivation to master tasks, whether they have a positive attitude towards learning activities and whether they set ambitious learning goals (see the Appendix B for details). Finally, some variables are more related to self-confidence, including, notably, a measure of self-efficacy (an index estimated from 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"), whether they enjoy competition and whether they expect to complete tertiary education.[8]

2.3 Identification issues and econometric models

The actual age at school entry of one child may differ from the theoretical starting age for primary education. For instance, in Germany, it is quite common for parents to delay the school entry 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, while 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 school entry by one year (Cirin and Lubwama, 2018). In contrast, in Italy, for instance, it is quite common that some families may favor early entry into primary school, which is perceived as more stimulating than kindergarten (Ponzo and Scoppa, 2014). In any case, it is likely that decisions to postpone or advance school entry are endogenous, as they usually depend on the child's maturity at the time of school entry.[9] For this reason, even though the proportions of late and early entry differ widely from one country to another, at the individual level such decisions usually depend on the relative position of the child in the theoretical school cohort (Givord, 2020): those who start school earlier are more often the children born just after the cutoff (those are the eldest in their theoretical school cohort) and those who start school later are children born just before the cutoff (the youngest in their theoretical school cohort).

As actual age at school entry is endogenous, one should be cautious in measuring the birthday effects on educational outcomes. OLS estimates of the impact of 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 errors may occur because the variable measuring age at entry in primary school is self-reported. Some of the students who had been enrolled in preprimary school may have no clear memory of the age at which they entered preprimary school, as opposed to primary school.

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

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

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

[8]The variables related to these socioemotional skills vary depending on the PISA cycle. Indices related to whether students enjoy cooperation and measures of their perceptions of teachers' unfair attitudes are available in PISA 2015 only. For these variables, the underlying assumption is that the cutoff date used for school entry was the same for the cohorts who sat the PISA test in 2015 as for those who sat the PISA test in 2018.

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

The equation 1a is the main equation relating the educational outcomes Y_i (score performance on PISA, grade repetition, expectations for completing tertiary education, self-efficacy, etc.) of student i to his or her actual school starting age SSA_i as calculated from the PISA report (in years and months, defined on the basis of the reported age and first day of schooling) and controlling for the individual characteristics of students X_i (gender, immigration background and socioeconomic status as measured by the student's position in the national distribution of the PISA ESCS index, defined by quartile). The equation 1b corresponds to the first stage, which relates the actual school starting age with the theoretical age at entry SSA_i^{th}, as defined by a strict application of the school entry regulation and calculated using the birthday and cutoff 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 cutoff date and 12 months for those born just after the cutoff date. Defined this way, the variable measures the theoretical relative ages of students within their cohorts 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 largest 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 estimations are conducted separately by country, meaning that the estimates correspond, within a country, to how educational outcomes vary with age at entry intp primary school relative to the average. To take into account the complexity of the PISA survey design, standard errors are computed using balanced-repeated-replication (BRR) weights .[10].

The theoretical relative age at entry SSA_i^{th} is a valid instrument if it is related to actual age at entry (meaning that $\alpha \neq 0$ in equation 1b) and is unrelated to the unobserved characteristics v_i of the outcome, conditional on observable X_i. The first assumption may be directly measured, as shown in the Table 2. In all six countries analyzed here, actual age at school entry is strongly related to 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 school 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 such a decision usually depends on the maturity of the child: students who are the eldest 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. This makes the observed age at entry endogenous to educational outcomes, and this is the reason naive estimations of the link between the school starting age and outcomes may provide spurious results.

[Insert Table 2 here]

The identification assumption 2 means that conditional on observable characteristics, the theoretical starting age has no direct effect on educational outcomes except through its 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 to other unobserved determinants of the outcomes.

Additional estimations are also conducted by interacting theoretical relative age at entry and observed relative age at entry with either a gender dummy or with four dummies corresponding to the student's position in the country distribution of the index of socioeconomic status, defined by quartiles. This makes it possible to estimate potential distinct effects of school starting age for boys and girls or across socioeconomic backgrounds. As the identification of these heterogenous effects relies on subgroups, these parameters are however less precisely estimated. In the remainder of the paper, only the estimates measuring the impact of relative age at entry, rathe than observed age at entry are presented for all educational outcomes, as measured for the entire sample, for boys and girls (measured in a second regression), and for students located in the lowest and the highest quarter of the national distribution of the socioeconomic status (estimated in a third regression).

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

3 Results

3.1 Relative age and performance on cognitive tests

The Figure 1, which represents the average PISA score in math by the theoretical age at entry SSA^{th}, measured in months, illustrates that the month of birth has significant and sizeable effects on the cognitive results measured by PISA for 15-year-old students. This relationship is also observed in the reduced-form estimates, which correspond to direct estimates of effect of theoretical age at entry, as the age that would be observed from a strict application of the regulations regarding school entry, on educational outcomes. As illustrated by the Table 3 for mathematics performance, the reduced-form estimates are statistically significant in all countries.[11] These reduced form estimates are informative by themselves. They can be interpreted as the difference in outcomes between two children, one born just after the cutoff date and one born almost one year later, but just before the cutoff date. Because of these small birthday differences, the former student is expected to be among the oldest in his or her theoretical school-entry cohort, while the latter is expected to be among the youngest students in this same theoretical school-entry cohort.

[Insert Figure 1 here]

The OLS estimates of the impact of actual age at entry on educational outcomes are much smaller, usually not significant and even negative in Germany, France and Italy, as shown in Table 3 for the mathematics performance. This illustrates that observed age at entry may be endogenous. Some children may be enrolled earlier or later than scheduled, and these decisions are usually based on the observed maturity of the children. Those students who entered school earlier for instance are more likely to have had higher cognitive performance, while being the youngest students in their class; conversely, children who entered school later than scheduled, are more likely to have had lower cognitive performance while being the eldest in their cohort.

[Insert Table 3 here]

The 2SLS estimates, using theoretical age at entry as an instrument for the measured relative age at entry, provide a very different picture. They show that relative age at entry has a significant impact on performance in mathematics (Table 3). Being the eldest in one's class at school entry is positively related to performance on PISA. A one-year difference in age at school entry is associated with more than 30 score points in math in Italy and Germany and at least 15 score points in Finland, France and Spain. 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 the average PISA score between students in the first quarter of the ESCS distribution and the second quarter of the ESCS distribution (see Table C.3)

The 2SLS estimates are not significant for the UK, which may because the instrument is weaker for this country. Similar results are observed for the two other main domains measured by PISA, reading and science (see Table 4).

[Insert Table 4 here]

In several cases, the impact of relative age at entry varies with the individual characteristics of the students, even though the parameters are less precisely estimated and the differences are not statistically significant. Regarding gender, the point estimates related to the impact of relative age at entry on performance in PISA appear higher for boys than for girls, even though the differences are not statistically significantly different. In England and Wales, the impact of relative age at entry is significant only for boys. This relatively higher impact for boys is consistent with the observation that girls usually mature more quickly than boys, and may thus be less prone to the relative-age effect. In France and Italy, and to a smaller extent in Germany, the impact of school

[11] For the sake of simplicity, the reduced-form and OLS estimates are shown only for mathematics performance, but similar conclusions can be drawn for reading and science.

entry age appears to be higher for disadvantaged students (those located in the bottom quarter of the national distribution of the socioeconomic index) than for advantaged students (those located in the top quarter of this distribution). This may be explained by the fact that the youngest children in a cohort benefit from greater support to compensate for their initial disadvantage when they come from a high-status background (Bernardi, 2014). This compensatory advantage may be especially important in school systems in which path dependency may be increased by ability tracking, either by early grade repetition (in France and Spain) or early tracking (in Germany). However, Italy is an exception, as one can observe that the point estimates of the impact of relative age are higher for students with high status. This may be explained by the fact that in this country, parents have some discretion in deciding their children's school entry age, and in particular they can anticipate their children's entry into school (Ponzo and Scoppa, 2014). Advantaged families may anticipate early entry more often than disadvantaged families.[12]

3.2 Relative age and grade repetition

As discussed above, one should be cautious when interpreting these differences. Birthday effects may be due to school starting age, but may also be due to 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) still observe a significant impact of age at testing on IQ test taking at age 18 in Norway. However, the use of retrospective variables, such as the likelihood of having repeated a grade in primary school, may provide some distinct information, as it cannot be linked to age at testing.

It is possible to analyze whether the month of birth has an impact on the probability of repeating a grade using the PISA data. Students who sat 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 have school systems in which grade repetition is frequently used as a remediation tool, as a large proportion of students from these countries reported in PISA 2018 than they had repeated a grade in primary school (see Table C.1 in the Appendix). In all of these countries except Germany, 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 older by one year at school entry reduces the probability of repeating a grade by at least 10 percentage points on average (see Table 5). The point estimates are greater for disadvantaged students than for advantaged students: in France, a one-year difference in age at entry increases the likelihood of grade repetition by 20 percentage points for disadvantaged students (those in the lowest quarter of the distribution of the PISA index of economic, social and cultural status), and only by 4 percentage points for advantaged students (those in the highest quarter of the distribution of this index). This is consistent with the results observed for the socioeconomic gradient in the impact of school starting age on cognitive performance. This effect is not significant in Germany. In this country, delayed entry into primary school are more common, especially for students who are born just before the cutoff (Givord, 2020). These students are also the youngest in their school cohort at entry, are probably the least mature among their peers and are thus those who would have been more likely to repeat a grade, if enrolled at the normal age. The impact of age at entry is much lower when measuring grade repetition in middle school rather than primary school, consistently with the fact that such repetition is mediated by a lack of maturity in the early years of schooling that fades with age (see Table C.4 in the Appendix).

[Insert Table 5 here]

[12] In a related paper, Givord (2020) observes that 9% of PISA students started primary school earlier than scheduled when they came from an advantaged family, while this proportion is only 5% for students from disadvantaged families.

3.3 Relative age, social connections and motivation

3.3.1 Relationships with teachers and peers

In almost all countries analyzed here, age at primary school entry negatively affects one or more measures of the quality of students' relationships with their teachers. In Germany, Finland and Italy, school entry age is positively related to the index that measures the disciplinary climate.A higher value for this index is related to a better disciplinary climate, meaning that younger students report a harsher 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 into low-ability groups. Even in school systems without formal tracking into distinct schools or without grade repetition, ability grouping may occur within the school. The youngest students therefore may more often be in classes with low-ability peers, who also experience disciplinary issues more often.

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

In all countries except Germany, for girls, relative age at entry is related to their perceptions of whether their teacher is inspiring - 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 high-achieving classes, and because the youngest students are less likely to be assigned to those classes, those students have a lower chance to be exposed to the best teaching practices. Another explanation could be that if these youngest students have negative first experiences with school (for instance, if they felt that they had to work hard in their first classes and received insufficient rewards from their teachers), they may maintain uneasy feelings when they interact with their teachers. Taken together, these results suggest that age at entry into primary school has an impact on the quality of the teaching that students may experience when they are 15 years old.

Such negative perceptions are also observed regarding their relationships with their peers. In France and Italy, the students who were the youngest at primary school entry were more exposed to bullying when they were 15.[13] This effect appears to be higher among boys (see Table C.6 in the Appendix). In these countries, physical bullying may be more frequent, especially for boys, and power imbalances due to differences in physical maturity may have direct consequences. In Finland and France, older peers more often reported valuing relationships with their peers and being engaged in collaborative activities for others' own benefit (they more often reported 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 the motivation and self-confidence of students. In Italy, Spain, England and Wales, being the oldest at school entry positively affects the students' motivation to master tasks and their self-efficacy. In Italy and Spain, it increases the propensity to set ambitious learning goals, and in Italy, England and Wales, students who were the oldest in their school cohort reported enjoying competition when aged 15 years old more often. These results are not driven by the fact that students who were relatively older at school entry perform better in school, as the estimates are still significant when controlling for performance (see Table C.9 in the Appendix). In all countries except Italy, the oldest students expressed stronger feelings of perceived competence in reading. Again, the differences may be gender related, but in a different way. For instance, for Germany birthday effects on self-perceived competence in reading were observed only for girls, while such effects are observed only for boys in England and Wales. This suggests that these birthday effects may not be due only to differences in maturity at school entry

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

age between boys and girls. Depending on the country and school system, children may be exposed to distinct norms regarding the attitudes and roles expected from boys and girls respectively, and this may explain the differences in these results.

[Insert Table 6 here]

3.4 Expectations for completing tertiary education

In all countries except Finland, relative age at entry is positively related to expectations of completing higher education 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 school entry 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 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 is a significant effect observed for disadvantaged students. As educational expectations are a measure of the way young individuals see their future prospects, and what they are willing to achieve, it is likely that lower expectations may result in lower achievements. This means that month of birth may have a long term impact on future outcomes.

[Insert Table 7 here]

The fact that the magnitude of the birthday effect varies across school systems, and within countries across different types of students, suggests that birthday effects do not measure only difference differences in maturity. It is most likely that they correspond to the different types of experiences children may have at school, depending on the school system.

While the PISA data do not allow for the isolation of the specific features that explain these differences, one may note that in Germany the largest birthday effect on educational expectations, that of being one year older at the start of school increases the probability of expecting to complete tertiary education by 12 percentage points. Germany is one the European countries where children are tracked to different school tracks at a very young age (as early as age of 10). Only one of those tracks, the Gymnasium (the most academically focused curriculum), provides direct access to tertiary education. Large and significant effects are also observed in Italy (7 percentage points), where 14-year-old students are tracked into general or vocational tracks. The youngest students in a school cohort are more likely to be tracked into less academic school tracks (as shown for Germany by Mühlenweg and Puhani, 2010 and for Italy by Ponzo and Scoppa, 2014), and thus correctly expect that they have a low probability of entering higher education. However, early tracking may not be the sole explanations for birthday effects on educational expectation. Statistically significant birthday effects on educational outcome are also observed in England (11 percentage points) and Spain (5 percentage points), where students are tracked late, at the age of 16. The consequences of low self-esteem, developed at an early age, may be another potential explanation for why students who are the youngest in their school cohort develop lower expectations 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 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 learned more complex concepts, and thus to achieve higher scores on the PISA test than those enrolled in a lower grade. The duration of schooling may also have consequences for the socioemotional 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 a lower grade than the oldest students, part of the measured differences between the eldest and the youngest students may be because that they are enrolled in different grades.

Using school systems where two school cohorts are sampled by design makes it possible to determine the magnitude of this effect. Among the set of countries analyzed here, only Finland and Germany meet this criterion.[14] Using this subset of countries, it is in principle possible to simultaneously estimate the impact of age at primary school entry, as well as the effect of being enrolled in a higher grade. As the grade a student is actually enrolled in when he or she sits the PISA test is also likely to be endogenous, this variable is instrumented by the theoretical grade the student should be enrolled, according to his or her birthday 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 cutoff date. The alternative specification is now:

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

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

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

where $Grad_i$ stands for the grade a student is actually enrolled in, $month\_birth_i$ is his or her month of birth, and $cutoff$ is the cutoff date that defines a school cohort. The coefficient δ measures the effect of being in a grade $n+1$ instead of grade n on 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 cutoff date on the probability of being enrolled in one grade or another, while the latter is identified through the assumption that the impact of age at entry on outcomes is linear. This assumption implies, 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 nonlinear (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 nonlinear shape of relative-age effects.

Regarding academic outcomes, in the two countries where the estimates can be made separately, these estimates for both grade and age at school entry are significant when estimated and instrumented simultaneously (Table 8). According to these estimates, the "grade-equivalent" effect, meaning the effect of having attended an additional year of schooling, is around 20 score points in Germany and in Finland. Regarding the impact of age at entry, for Finland the point estimates are very close to those obtained without controlling for grade. However, the estimates obtained for Germany are much lower than those obtained without controlling for grade: for instance, the point estimate of the impact of age at entry on reading is now 18 score points, instead of the 44 score points obtained when the estimates do not control for grade. Using this correction, the estimates are thus of a similar magnitude to 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 regulations regarding school entry are flexible. In Germany, it is quite common to postpone entry for some children, and this decision is more likely to be made 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 cohort, especially among the youngest students.[15]

[14] In England and Wales, only 300 students born in August 2002 sat the PISA test, while the sample size by month of birth was around three times higher for other months. The performance of these students appears to be much higher on average than that observed for students born just after the cutoff. As these students may not be fully representative of the students born in the same month, they have been excluded.

[15] Another potential reason for the differences observed for Germany could be that the sample restriction to one single school cohort is more severe for Germany than for Finland. In Germany, one quarter of the initial sample is excluded when computing the main estimates. 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 sample restricted to one single school cohort)

[Insert Table 8 here]

Regarding the socioemotional skills, the estimates of the impact of age at entry for these two countries are very similar when controlling for grade and not. Notably, the estimates of the impact of relative age on expectations for completing tertiary education are still high and significant in Germany. This means that at least in Germany, the impact of being younger in a cohort may have long lasting effects on the future outcomes of students.

4 Conclusion

This study on six European countries confirms the previous results observed in the literature that birthday effects may have sizeable consequences for several outcomes. In this set of countries, that have quite distinctive school systems, the birthday effects on the cognitive outcomes of 15-year-old students are sizeable and significant in all countries analyzed here. In the main specifications, the estimates are higher in Italy and especially in Germany, the two countries where students are sorted into distinct schooling tracks earlier than in the other four countries. In Spain and France, two countries that rely more on grade repetition as a remedial tool, being the youngest in a cohort appears to have a significant impact on being retained in primary school. These birthday effects appear to be higher for disadvantaged students, suggesting that the most advantaged students may benefit from support from their family making it possible to compensate them for the initial disadvantage of being the youngest at school entry. Regarding gender differences, the cognitive performance of boys appears to be more sensitive to birthday effects, in accordance with the observation that boys may often be less mature at the same age than girls, and that their initial age disadvantage at school entry may thus be, in proportion, higher than that of girls.

The consequences of month of birth on socioemotional skills, which may be related to students' self-esteem or their ability to cooperate with others, are more varied by school system.

However, in several countries, birthday effects appear to have long-term consequences, notably on students' self-esteem. Students who were the youngest at entry not only had lower performance on PISA at age 15, but also expressed negative feelings about school more often. Students who were the youngest in their school cohort more often reported negative school disciplinary climate, lower interest from their teachers or the feeling that they were treated in a unfair ways by their teachers. Being the youngest at school entry may also increase the probability of being exposed to bullying, especially for boys in Italy and France. In addition, being the youngest at school entry seems to have long term consequences for measures related to self-confidence, such as the ability to set ambitious learning goals, or self-efficacy. Among the six European countries analyzed here, only in two cases (Finland and France) did being the youngest at school entry have no significant impact on the likelihood expecting to complete tertiary education. These birthday effects on socioemotional outcomes may be partly explained by the impact of month of birth on cognitive performance, but not completely so. In Spain, England and Wales, sizeable and statistical effects are observed even when individual performance on the PISA test is taken into account. In England and Wales, being the oldest in a school entry cohort increases the probability of having high educational expectations by more than ten percentage points, even when controlling for cognitive performance.

It is worth emphasizing that these results cannot distinguish among the main reasons behind these birthday effects, specifically whether these effects may be solely explained by maturity ("age at testing ") or relative age. These two effects may be mutually reinforcing ones, rather than two alternative explanations. 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 on PISA - emotional development (such as self-esteem or competitiveness) may also

and the alternative one (using the entire sample with three quarters of the students in one school cohort, and one quarter in a younger school cohort) provide similar point estimates for the impact of age at entry on educational outcomes in Estonia. This suggests that sample restriction should not be the main explanation for the differences in the results observed between the two specifications for Germany.

plausibly be more sensitive to social comparisons and thus to relative age effects. Because they may be compared to their older peers in an unfavorable way in their first years of schooling, the youngest children may develop lower self-confidence, which may undermine their expectations for the future. However, the features of the school systems may help to mitigate, or on the contrary, may contribute to amplifying these initial differences.

This may call for policies to adequately inform 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 less mature students and their peers (Crawford et al., 2014). Such adjustments could be made for instance for standardized tests (such age-based standardization has been introduced in the last decade in Ireland; see Shiel et al., 2020). Adjustments for age should be recommended specifically for tests that are used as 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 into distinct types of schooling. In addition, age adjustments may be advocated to reduce the overclassification of the youngest children as having learning difficulties or psychiatric conditions, as 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 of 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 are also related to greater relative-age effects, as such requirements may necessitate an investment that the youngest students are not mature enough to make. Larger classes are also related to greater relative-age effects, probably because they reduce the capacity of teachers to devote individualized attention to all students, according to their needs.

At the individual level, it would be difficult to infer from the results here that more flexibility should be provided to parents regarding when to enrol their children in school depending on their maturity. While these results suggest caution against the tendency to enroll children earlier than planned in some countries (as in Italy, see Ponzo and Scoppa, 2014), they also do not support the possibility of postponing school entry for less mature children. Indeed, the estimates in this paper suggest that in Germany where this practice is very common, the observed effects on cognitive and socioemotional skills appear to be the same as in other countries that provide less flexibility to parents. In the related literature, these practices are highly debated and the evidence is 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 scores, 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 the child had attended preschool, and on the quality of that experience. However, the PISA data cannot provide sufficiently relevant information on these issues, and this calls for further investigations.

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5 Tables and Figures

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

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.

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

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

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						
Low ESCS	50.96**	14.33**	18.82**	8.49	22.86***	19.06***
	(23.49)	(7.31)	(8.13)	(14.12)	(8.60)	(5.83)
High ESCS	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						
Low ESCS	32.43	18.45**	26.52***	18.28	16.96*	na
	(20.77)	(8.01)	(8.57)	(13.49)	(9.70)	
High ESCS	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						
Low ESCS	40.13*	21.04***	16.14**	7.41	21.52**	17.13***
	(21.02)	(7.97)	(7.26)	(13.76)	(8.90)	(5.90)
High ESCS	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) are reported, from separate estimations. The coefficients for boys and girls are obtained when interacting the instrument and endogenous variable with boy and girls dummies, those for low and high ESCS when interacting these variables with four dummies of quartile in the national distribution of the socio-economic index (only the first and fourth quartiles are reported). Models include as additional controls variables: gender, socio-economic status (4 dummies), immigrant background, dummies for PISA cycle. Standard Errors in parenthesis.

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						
Low ESCS	0.09	−0.01	−0.19***	0.08***	−0.02	−0.14***
	(0.07)	(0.02)	(0.04)	(0.03)	(0.02)	(0.03)
High ESCS	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) are reported, obtained from separate estimations. The coefficients for boys and girls are obtained when interacting the instrument and endogenous variable with boy and girls dummies, those for low and high ESCS when interacting these variables with four dummies of quartile in the country distribution of the socio-economic index (only the first and fourth quartiles are reported). Models include as additional controls variables: gender, socio-economic status (4 dummies), immigrant background. Standard Errors in parenthesis.

Table 6: Impact of relative age on no cognitive outcomes

	DEU	FIN	FRA	GBR	ITA	ESP
Quality of the students' relationships with their						
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) are reported, obtained from separate estimations. The coefficients for boys and girls are obtained when interacting the instrument and endogenous variable with boy and girls dummies, those for low and high ESCS when interacting these variables with four dummies of quartile in the country distribution of the socio-economic index (only the first and fourth quartiles are reported). Models include as additional controls variables: gender, socio-economic status (4 dummies), immigrant background. Standard Errors in parenthesis.

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						
Low ESCS	0.08	0.08	0.01	0.06	0.01	0.08^{**}
	(0.06)	(0.05)	(0.04)	(0.06)	(0.05)	(0.04)
High ESCS	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.

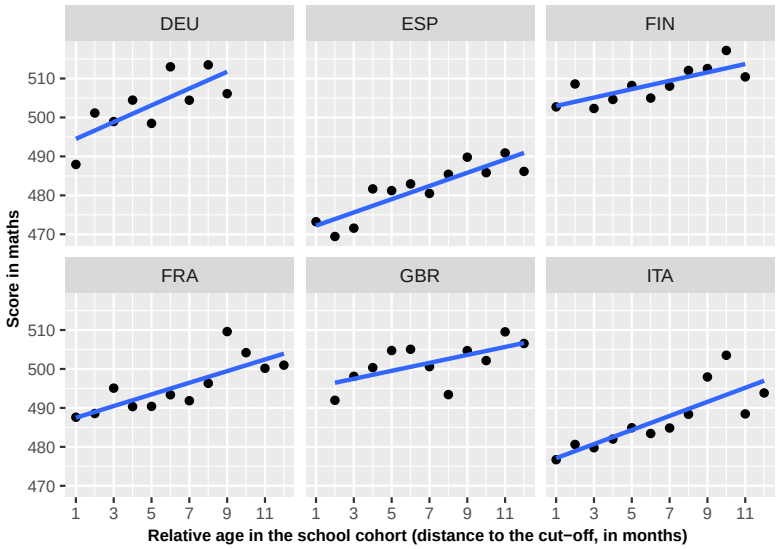
Note: Only the 2SLS estimates of the impact of the relative age at school entry (instrument: theoretical age at entry) are reported, obtained from separate estimations. The coefficients for boys and girls are obtained when interacting the instrument and endogenous variable with boy and girls dummies, those for low and high ESCS when interacting these variables with four dummies of quartile in the country distribution of the socio-economic index (only the first and fourth quartiles are reported). Models include as additional controls variables: gender, socio-economic status (4 dummies), immigrant background. Standard Errors in parenthesis.

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.



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

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

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 cutoff. 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 cutoff date for school entry is August 31st).[16]

In case where the PISA sample encompasses two countries, the link between the age at the

[16]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.

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.

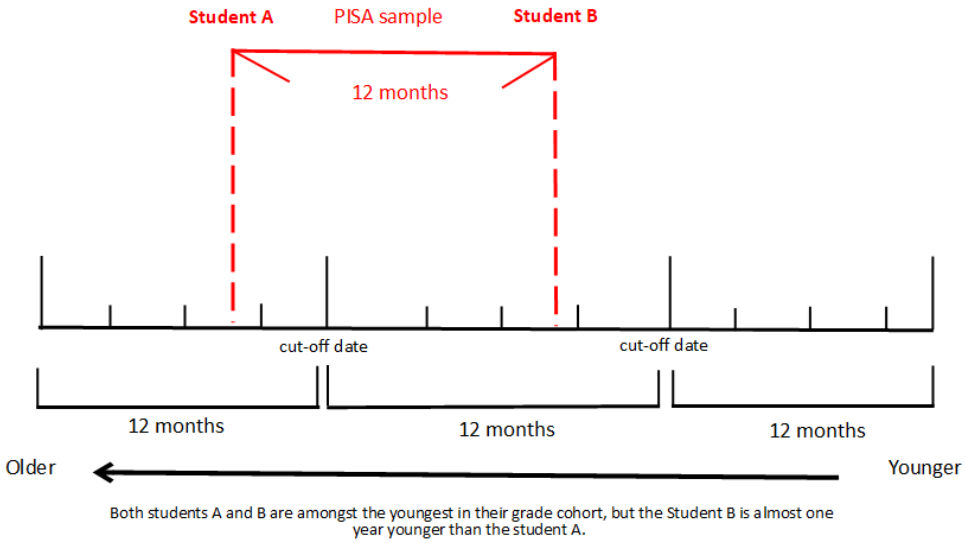


Figure A.1: Structure of the PISA Sample with two theoretical school cohorts

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 cutoff 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.

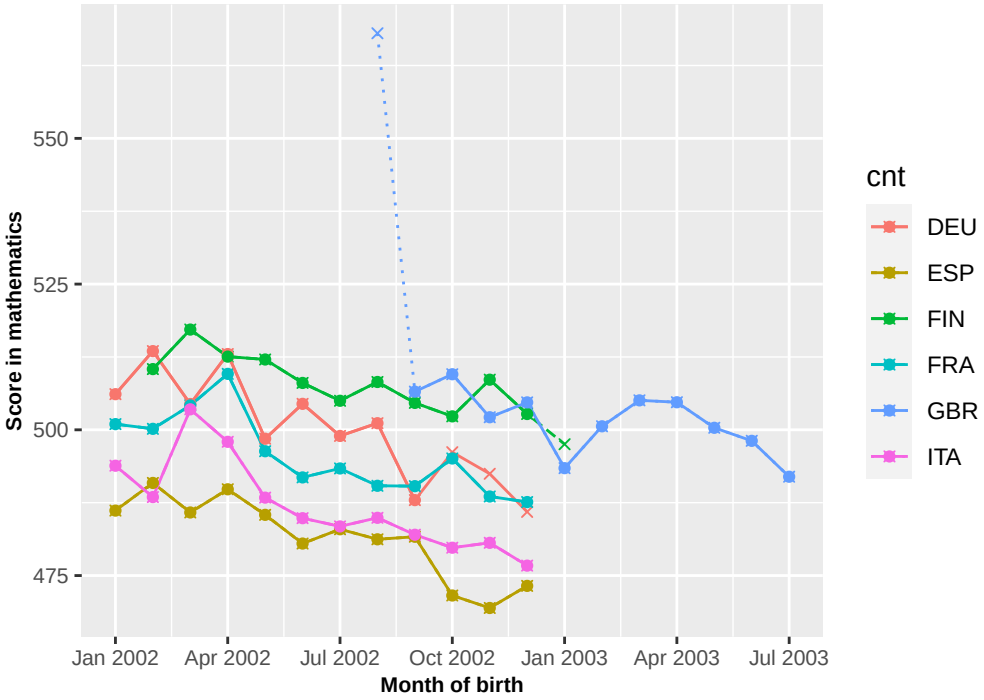


Figure A.2: Age at the test and age at school entry depending on the month of birth

B socioemotional Variables

In PISA 2015 and 2018, students are asked several questions in the context questionnaire that makes it possible to construct indices measuring socio emotional dimensions relied notably on motivation and self-esteem. The variables used in this article are described below.

Disciplinary climate In PISA 2015 and 2018, students are asked about how often ("every lesson", "most lessons", "some lessons", "never or hardly ever") the following happened in their language-of-instruction lessons (ST097): "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 (disclima). Positive values on this scale mean that the student enjoyed a better disciplinary climate in language-of-instruction lessons than the average student across OECD countries.

Teacher enthusiasm PISA 2018 asked (ST213) students whether they agree ("strongly agree", "agree", "disagree", "strongly disagree") with the following statements about the two language-of-instruction lessons they attended prior to sitting the PISA test: "It was clear to me that the teacher liked teaching us"; "The enthusiasm of the teacher inspired me"; "It was clear that the teacher likes to deal with the topic of the lesson"; and "The teacher showed enjoyment in teaching". These statements were combined to create the index of teacher enthusiasm (TEACHINT). Positive values in this index mean that students perceived their language-of-instruction teachers to be more enthusiastic than did the average student across OECD countries.

Teacher unfairness In PISA 2015, students are asked (variable ST039) about how often (" Never or almost never", "a few times a year", "a few times a month", "once a weak or more") they had the following experiences at school? : "Teachers disciplined them more harshly than other students", "Teachers ridiculed them in front of others", and "Teachers said something insulting to them in front of others". Perception of teachers behaving unfairly refers to students reporting "a few times a month" or "once a week or more" to one of these three statements in their responses to this question.

Exposure to bullying In PISA 2018 the students are asked how often ("never or almost never", "a few times a year", "a few times a month", "once a week or more") during the 12 months prior to the PISA test they had the following experiences in school, including those that happen in social media: "Other students left me out of things on purpose"; "Other students made fun of me"; "I was threatened by other students"; "Other students took away or destroyed things that belong to me"; "I got hit or pushed around by other students"; and "Other students spread nasty rumours about me". These statements were combined to construct the index of exposure to bullying (variable beingbullied). Positive values on this scale indicate that the student was more exposed to bullying at school than the average student in OECD countries; negative values on this scale indicate that the student was less exposed to bullying at school than the average student across OECD countries.

Motivation to master tasks PISA 2018 asked students (ST182) to report the extent to which they agree ("strongly disagree", "disagree", "agree", "strongly agree") with the following statements about themselves: "I find satisfaction in working as hard as I can"; "Once I start a task, I persist until it is finished"; "Part of the enjoyment I get from doing things is when I improve on my past performance"; and "If I am not good at something, I would rather keep struggling to master it than move on to something I may be good at". These statements were combined to create the index of motivation to master tasks (variable workmast). Positive values in the index indicate greater motivation than the average student across OECD countries.

Ambitious learning goals Students in PISA 2018 were asked (ST208) to respond how true ("not at all true of me", "slightly true of me", "moderately true of me", "very true of me", "extremely true of me") the following statements are for them: "My goal is to learn as much as possible"; "My goal is to completely master the material presented in my classes"; and "My goal is to understand the content of my classes as thoroughly as possible". These statements were combined to construct the index of learning goals (variable mastgoal). Positive values in the index indicate more ambitious learning goals than the average student across OECD countries.

Enjoy competition PISA 2018 asked students (ST182) to report the extent to which they agree ("strongly disagree", "disagree", "agree", "strongly agree") with the following statements about themselves: "I enjoy working in situations involving competition with others"; "It is important for me to perform better than other people on a task"; and "I try harder when I'm in competition with other people". These statements were combined to create the index of motivation to master tasks (variable compete). Positive values on this scale mean that students expressed more favourable attitudes towards competition than did the average student across OECD countries.

Self-efficacy In PISA 2018 the students are asked whether they "Strongly disagree", "Disagree", "Agree" or "Strongly agree" on the following questions: "*I usually manage one way or another*" (i), "*I feel proud that I have accomplished things*", "*I feel that I can handle many things at a time*", "*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*". The answers to these items are summarised in a single index of self-efficacy (variable resilience) that was standardised to have a mean of 0 and a standard deviation of 1 across OECD countries.

Self-perceived competence in reading In PISA 2018 the students are asked whether they "Strongly disagree", "Disagree", "Agree" or "Strongly agree" on the following questions: "*I am a good reader*", "*I am able to understand difficult texts*" and "*I read fluently*". The answers to these three items are used to construct an index of self-concept of competence in reading (variable compread). The indice was standardised to have a mean of 0 and a standard deviation of 1 across OECD countries.

Expectation to complete tertiary education In PISA 20215 and 2018 students were asked (question ST225) which levels of education they expect to complete, using the International Standardised Classification of Education 1997. In this classification, tertiary education corresponds to <ISCED level 5A> and/or <ISCED level 6> (theoretically oriented tertiary and post-graduate).

C Additional Tables and Figures

Table C.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 C.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 C.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 C.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						
Low ESCS	0.09	−0.01	−0.19***	0.08 ***	−0.02	−0.14***
	(0.07)	(0.02)	(0.04)	(0.03)	(0.02)	(0.03)
High ESCS	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						
Low ESCS	0.11	0.01	−0.03	0.01	−0.04	−0.10***
	(0.08)	(0.01)	(0.03)	(0.01)	(0.04)	(0.03)
High ESCS	−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) are reported, obtained from separate estimations. The coefficients for boys and girls are obtained when interacting the instrument and endogenous variable with boy and girls dummies, those for low and high ESCS when interacting these variables with four dummies of quartile in the national distribution of the socio-economic index (only the first and fourth quartiles are reported). Models include as additional controls variables: gender, socio-economic status (4 dummies), immigrant background. Standard Errors in parenthesis.

Table C.5: Impact of relative age on the quality of the students' relationships with their teachers and peers

	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						
Low ESCS	0.12	0.01	−0.01	0.11	0.11	0.00
	(0.23)	(0.12)	(0.08)	(0.29)	(0.17)	(0.08)
High ESCS	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						
Low ESCS	−0.08	0.07	−0.02	0.45	0.06	0.09
	(0.21)	(0.11)	(0.09)	(0.28)	(0.14)	(0.08)
High ESCS	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						
Low ESCS	0.80	0.61	−1.17**	0.06	na	−0.84***
	(1.02)	(0.48)	(0.50)	(0.62)		(0.30)
High ESCS	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) are reported, obtained from separate estimations. The coefficients for boys and girls are obtained when interacting the instrument and endogenous variable with boy and girls dummies, those for low and high ESCS when interacting these variables with four dummies of quartile in the country distribution of the socio-economic index (only the first and fourth quartiles are reported). Models include as additional controls variables: gender, socio-economic status (4 dummies), immigrant background. Standard Errors in parenthesis.

Table C.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						
Low ESCS	−0.18	0.03	0.06	−0.09	−0.39**	−0.08
	(0.36)	(0.14)	(0.17)	(0.28)	(0.18)	(0.07)
High ESCS	−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						
Low ESCS	0.01	0.07	−0.01	0.09	0.09	0.00
	(0.21)	(0.09)	(0.06)	(0.13)	(0.09)	(0.08)
High ESCS	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						
Low ESCS	0.42	0.19	0.17	−0.02	0.15	−0.07
	(0.38)	(0.12)	(0.11)	(0.16)	(0.12)	(0.10)
High ESCS	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 C.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						
Low ESCS	0.24	0.07	0.02	0.59**	0.11	0.06
	(0.24)	(0.13)	(0.08)	(0.29)	(0.14)	(0.08)
High ESCS	−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						
Low ESCS	−0.35	0.10	−0.01	0.37	0.06	0.16**
	(0.26)	(0.12)	(0.10)	(0.25)	(0.17)	(0.08)
High ESCS	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 C.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						
Low ESCS	−0.01	0.08	0.03	0.48*	0.17	0.09
	(0.27)	(0.11)	(0.10)	(0.27)	(0.12)	(0.06)
High ESCS	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						
Low ESCS	0.19	0.11	0.02	0.45*	−0.12	0.04
	(0.34)	(0.12)	(0.11)	(0.25)	(0.18)	(0.07)
High ESCS	−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						
Low ESCS	−0.23	−0.04	0.16*	0.26	0.05	0.09
	(0.25)	(0.13)	(0.10)	(0.25)	(0.11)	(0.07)
High ESCS	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) are reported, obtained from separate estimations. The coefficients for boys and girls are obtained when interacting the instrument and endogenous variable with boy and girls dummies, those for low and high ESCS when interacting these variables with four dummies of quartile in the country distribution of the socio-economic index (only the first and fourth quartiles are reported). Models include as additional controls variables: gender, socio-economic status (4 dummies), immigrant background. Standard Errors in parenthesis.

Table C.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.

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