THE YOUNGER, THE BETTER? RELATIVE AGE EFFECTS AT UNIVERSITY*

Francesco C. Billari
"Carlo F. Dondena" Centre for Research on Social Dynamics, IGIER and Department of Decision Sciences, Università Bocconi

Michele Pellizzari
IGIER, Università Bocconi, fRDB and IZA

Abstract

In this paper we estimate relative age effects in academic performance at university using a unique database of students at Bocconi University. The identification exploits school entry cut-off ages that generate up to 11 months difference between the youngest and the oldest students within each cohort. Our data allow to control for potential selection issues as well as for differences in cognitive ability as measured at the entry test. Contrary to most of the existing evidence for primary school children, we document that at university younger students perform better compared to their older peers, particularly in the most technical subjects. To rationalize this result we produce additional evidence on relative age effects in cognitive ability and in social behavior using a combination of data from Bocconi admission tests and from a survey on the social behavior of Italian first-year university students. We find that the youngest students in the cohort perform slightly better in cognitive tests and also appear to have less active social lives: they are less likely to do sports, go to discos and have love relationships. These results suggest that negative relative age effects in university performance are generated by two mechanisms: (i) a profile of cognitive development that might be decreasing already around age 20; (ii) psychological relative age effects that lead the youngest in a cohort to develop social skills (self-esteem, leadership) at a slower pace. Younger students will then have less active social lives, plausibly devote more time to studying and, consequently, perform better at university.

January 2008

Draft
Do not quote without the authors' permission

* We would like to thank Bocconi University for granting access to its administrative archives for this project. In particular, the following persons provided invaluable and generous help: Alessandro Ciarlo, Enrica Greggio, Alessandra Startari and Mariangela Vago. Pietro Garibaldi, Francesco Giavazzi, Andrea Ichino and Enrico Rettore, with the precious help of Stefano Gagliarducci, are the ones who first extracted data from the university archives for research purposes and they kindly passed the original version of the dataset to us. We would also like to thank seminar participants at the University of Lausanne and Elsa Artadi for very helpful discussions. Michela Braga provided excellent research assistance. Data on the ISAS survey have been collected in a project coordinated by Gianpiero Dalla Zuanna at the University of Padova. Funding from Bocconi's "*Basic Research Fund*" is gratefully acknowledged.

1. Introduction

The distribution of individual outcomes is very dispersed in almost all areas of life, and such dispersion has been increasing in many dimensions, notably in the labor market. A recent strand of studies emphasizes the role of cognitive development, and especially its early stages, as a key determinant of one's position in such distributions (Heckman, 2006; Blanden *et al*., 2007; Currie and Thomas, 1999). The amount and the quality of human capital accumulated during the first years of life (either at school or within the family) heavily influences all later choices, from schooling to employment, from marriage to fertility. Thus, early policy intervention is often advocated to guarantee equality of opportunity to all members of a society (Carneiro and Heckman, 2003; Cunha and Heckman, 2007b; Heckman and Masterov, 2007).

In this framework, the exact dynamics of cognitive development has received a great deal of attention (Cunha *et al*., 2005; Cunha *et al*., 2006; Cuhna and Heckman, 2007a) and several studies have analyzed issues like pre-school education (Berlinski *et al*., 2006), the long-term effects of early school enrolment (Goodman and Sianesi, 2005) or the impact of maternal employment on future academic and labor market outcomes (Gregg *et al*., 2005).

A key identification problem common to most of these studies is the separation of the dynamics of cognitive ability from the process of human capital accumulation (e.g., Allen and Barnsley, 1993). If we observe older individuals performing better then their younger mates, that may be due either to the fact that their cognitive abilities are better developed or to the fact that they have accumulated human capital over a longer life span. A popular strategy to tackle this problem is to look at *relative age*, by comparing individuals who belong to the same educational cohort (they started school at the same time) but have different biological ages. This approach typically exploits cut-off dates that determine the timing of school enrolment. In the U.S., for example, these cut-off dates are regulated at the subnational (i.e. State) level, thus allowing to use cross-state variation for empirical analysis (see, for example, Mayer and Knutson, 1999). In Italy, the country of this study, pupils enroll in compulsory school the year of their 6^{th} birthday. It is thus possible to compare children born in January and December of the same year, who are 11 months apart in terms of biological age but who started school at the same time.

In this paper we estimate relative age effects on academic performance at university using a sample of undergraduate students enrolled at Bocconi University. Contrary to most of the existing evidence for primary school children, we document that at university younger students perform relatively better compared to their older peers, particularly in the most technical subjects.

Our main estimates of the relative age effect are based on a rich set of information about undergraduate students who enrolled at Bocconi University between 1995 and 1998.[2] This dataset allows to compare a very homogeneous group of students: they all attend the same university, they all take the same courses, they are all taught by the same professors and they are all graded according to the same criteria. Moreover, we have very complete information about their pre-university school careers as well as about their performance in the aptitudinal entry test. We can

[2] The first set of data extracted from the university archives has been used in Garibaldi *et al.* (2007). Our dataset is an extensively updated version of the same sample of students with information on admission tests, teaching classes, course evaluations, labor market outcomes, exchange programs, etc. It is the same dataset used in De Giorgi *et al.* (2007). See Section 2 for details.

thus control for early and late enrollment and for ex-ante measures of cognitive ability. Additionally, we can also look at academic results exam by exam in different fields.

As far as we know, this is the first paper to produce empirical evidence on relative age effects for students at the university level and our results are particularly surprising in the light of previous findings. In fact, most existing studies focus on very early stages of children's schooling, typically on primary education, and find that within cohorts older individuals usually perform better in terms of academic outcomes. For example, using data from a comparative study of OECD countries, Bedard and Dhuey (2006) document that the oldest students in a cohort score 4-12 percentiles higher than their youngest peers at the fourth grade (around age 9) and 2-9 percentiles higher at the eighth grade across a wide range of countries.

At age 5 or 6 (the typical age of primary school enrolment), 11 months difference may justify relatively large variation in child development, both physical and cognitive, and thus in educational outcomes. However, such differences should dissipate over time and disappear at later ages. When relative age differences persist for long periods this is typically attributed to particular institutional features that maintain and sometimes magnify differentials in early child development.

For example, in educational systems where students are streamed into classes on the basis of observed performance already at the very initial stages of their academic careers, older students typically end up in the highest tiers (i.e. the classes of the best performing students) simply because at early ages small differences in childhood development may lead to substantial diversity in outcomes (Allen and Barnsley, 1993). This type of mechanism has been documented to be very important in sports, where a large fraction of professional players are indeed born in the earliest months of the year (Dudink, 1994; Barnsley *et al*., 1992; Helsen *et al*., 2005).

Studies on the Italian university system, show that background family characteristics such as income and social networks are important determinants (together with ability) of academic outcomes (see, e.g., Checchi, 2000). However, Italy is a country where students are never streamed by ability in schools. If anything primary and secondary school classes are formed either completely randomly or with the objective of maintaining a rather uniform distribution of family backgrounds, ethnicity, gender and other key characteristics both across and within classes.[3] Thus, it is very unlikely that our results can be explained with early differences in child development.

Another related strand of papers that might offer an interpretation for our results focuses on early learning, although results from this branch of the literature are still quite controversial. Goodman and Sianesi (2005) analyze data from the 1958 British birth cohort and, controlling for a rich set of factors, they find that pre-compulsory schooling (pre-school or school entry prior to age 5) yields improvements on cognitive test scores that remain significant throughout the school years, up to age 16. In adulthood, pre-compulsory schooling is found to increase the probability of obtaining qualifications at age 33. Skirbekk (2005, Ch. 2) and Skirbekk *et al*. (2004) analyze Swedish data explicitly comparing individuals born in December (before the school cut-off point) with those born in January (after the school cut-off point). They find that individuals born in December have a significantly higher probability of attaining lower secondary education, while

[3] This is certainly the case in public schools while private institutions might adopt different rules although this should not happen too often. However, for the cohorts that we consider the fraction of students who attended a private high-school is around 7%.

the reverse is true for tertiary education. These results are usually interpreted under the assumption that skills accumulated at earlier stages improve later learning, i.e. early investment facilitates the productivity of later investments (Cuhna *et al*., 2005).

However, some studies report opposite findings. Fredriksson and Öckert (2005) using data for the entire Swedish population find that children who start school at an older age do better and go on to have more education than their younger peers.

We are skeptical that early learning could satisfactorily rationalize our results, not only because of the mixed findings of previous studies. First of all, in our analysis we exclude all students who enroll earlier than normal in primary school and focus exclusively on those who went regularly through the standard school system, i.e. neither early enrollment nor grade repetition. Moreover, the effect of early learning should show up equally in all subjects whereas we find relative age differences only in a subset of relatively more technical subjects (mathematics, statistics and economics).

Another possible explanation for our results is based on the idea that the profile of cognitive development should be inversed-U shaped. Individuals start with relatively under-developed cognitive skills when they are young, such skills develop rapidly with age and at some point must stabilize and later deplete. As already mentioned, several studies have attempted to identify the exact profile of cognitive development but most of them have focused primarily on its earlier stages. A few studies on cognitive functioning have looked at later ages. Salthouse *et al*. (2004), for example, show that after the age of 18, younger individuals start performing better than their older peers.

Consistently with this idea, we do find evidence of negative relative age effects (i.e. the youngest doing better) in cognitive ability as measured in the entry test. However, these effects account only for a relatively minor fraction of the relative age differences in academic performance.

We thus explore an additional explanation that is motivated by a series of studies that look at the psychological effects of relative age. For instance, Thomson *et al*. (2004) document, in a study on primary school children, that self-esteem shows a general rise with age for children with the correct age-for-grade range, while the highest self-esteem was reported by the group made up in large part by children who were destined to be the youngest in the class, but whose parents delayed school entry by one year, causing them to be among the oldest. Dhuey and Lipscomb (2006) study the presence of relative age effects on leadership using several sources of data on U.S. high school students. They find that within the same cohort, the relatively oldest students are four to eleven percent more likely to be high school leaders – measured as the probability of being either a club president or a sport team captain - with respect to relatively younger students.

To explore the potential of this psychological mechanism at university, we produce additional evidence from a survey on the social behavior of a sample of first-year university students in Italy (the *International Survey on Affectivity and Sex*). We find that the youngest students in a given birth cohort are also those with less active social lives: they are less likely to do sports, go to discos and have love relationships. Having less active social lives, younger students plausibly devote more time to studying and perform better at university.

These psychological effects become particularly important as students gain more control over their time. In primary - and to a large extent also in secondary - schools, students are relatively strictly monitored by teachers and parents, thus it is only at university that differences in the allocation of time and effort between social activity and studying emerge. This would also explain why our results indicate a relative age effect that is opposite to those found in many previous studies focused on lower schooling levels.

From the policy perspective, our results bear important implications. First, our findings support some recent proposals that have been discussed in the literature. Mayer and Knutson (1999), as well as Lutz and Skirbekk (2005) suggest that a more efficient, and potentially cheaper, school system can be built by providing the same level of qualification with a younger school-entry and school-leaving age.

Second, and perhaps more important, our evidence support the view that psychological relative age effects are important and capable of affecting later outcomes. Unfortunately, such effects cannot be completely eliminated as one will always be either younger or older than her peers. However, a simple and costless policy intervention can at least reduce relative age differences in the school environment. Such policy consists in merely revising the rules of class formation and condition the allocation rule to being born within a 6-months interval so that the maximum age difference between students in a school class will be reduced from 12 to 6 months. Such rule can be costlessly applied in any set up where the school cohort (which is still defined over a 12 month period) is divided into more than just one class.

The paper is organized as follows. Section 2 describes our data and the institutional details of both the Italian school system and Bocconi university. Section 3 presents the main results on the relative age effects at university, including a series of robustness checks. Section 4 provides additional evidence to rationalize our results in the light of previous findings in the literature. Section 5 concludes.

2. Data and institutional details

The Italian educational system is such that most students turn 19 during their freshmen year at university.[4] The typical pupil would in fact start primary school the year she turned 6. Primary school lasts 5 years, unless the student fails one (or more) grades, in which case she would have to retake it and spend one (or more) additional years in primary school. At the end of the fifth grade all students take an exam to obtain their primary school certificate. The next schooling level is a 3-year middle high school, which also finishes with a national exam. Most students would enroll at this school the year they turn 11 and take the final exam the year of their 14^{th} birthday. Primary and middle-high schools are compulsory so, regardless of the outcome of the primary school final exam, all children are required to enroll at a middle-high school.[5] Both primary and middle-high schools are completely homogeneous with no differentiation in curricula.

---

[4] As we discuss later in this section, the main data used in our analysis include students born between 1976 and 1979. The school system described in this section is the one pupils born in these years were subject to. The system has been modified since then with the most important change occurring in 1999, when compulsory schooling was increased by one year. None of the students in our data is affected by this change.

[5] The pre-1999 actual legal requirement imposes that all pupils aged between 6 and 14 should compulsorily attend school. However, students can satisfy the requirement by either passing the middle-high school final exam (thus even before they turn 14) or by having attended at least 8 years of full-time schooling as they turn 14.

After middle-high school, students can voluntarily continue their studies at one of the several different types of high schools (lyceums, technical schools, et.). Students willing to go to high school could not be refused a place (at least within the public system) regardless of their middle-high school leaving grade. High school lasts normally for 5 years although some technical institutes offer 3-year curricula. However, only students graduating from 5-year high schools can go to university. Thus, unless a student anticipated enrolment in primary school and/or failed one (or more) grades during her educational track, she would normally enroll at university the year she turns 19.

Our data come from the administrative archives of Bocconi university, a private and highly selective institution of higher education that specializes in Economics and Management, and cover all students enrolled between 1995 and 1998.[6]

Table 1 synthetically describes the distribution of birth months for the students in these 4 cohorts. The first column shows the year of actual enrolment at Bocconi while in the second column we report the year of birth for the "regular" students in each cohort, that is those who turn 19 during the year of enrolment. The third column shows the fraction of these "regular" students in each cohort, while the following columns report the fraction of "older" and "younger" students (i.e. students who were older or younger than 19 when they enrolled). As these numbers indicate, "regular" students are on average about 86% of the cohort. Younger students enroll earlier at university because they started their educational career in advance of one year, i.e. they enrolled at primary school one year in advance.[7] The older students, instead, are typically those who failed one or more grades in their previous educational tracks and some (few) students who enrolled at Bocconi after having enrolled at a different university and then changed their minds.

[Table 1 about here]

For the purpose of our analysis we focus exclusively on the so called "regular" students, although we will produce some evidence on the others as a robustness check (see Section 3.1). In fact, younger and older students are likely to be quite strongly selected on the basis, for example, of family background (since it is typically the parents who decide whether a child should go to school earlier) or ability (if they enroll later because they have failed earlier grades) or preferences (if they enroll later because they decided to study economics/management after having tried a different subject before).[8] Table 2 describes the distribution of month of birth within the "regular" students in each cohort. The bimodal pattern of birth months (with local maxima in April and August) is consistent with what is known from research on the seasonality of births on the overall population (Rizzi and Dalla-Zuanna, 2007).

---

[6] The most complete version of our data covers all students enrolled from 1989 to 2004. We exclude the earlier cohorts because data on the admission tests are not available. Moreover, we also limit the sample to cohorts with at least 80% of students who have completed their degrees, thus leading to our focus on the 1995-1998 freshmen.

[7] Parents have some limited freedom to decide when exactly to enroll their children in primary school. Regulations have changed over the years but the students in our cohorts could attend preparatory classes (typically in private, mostly religious, institutions) at age 5 during their last year in kindergarten and apply to enter directly into the second grade in primary school at age 6. Admission was subject to an entry test and not all primary schools accepted younger children.

[8] In our data we can univocally identify students who enrolled at another university before Bocconi and those who anticipated primary school enrollment. We don't know whether someone failed grades in any previous school level. Our definition of "regular" students excludes all early and late enrollers.

[Table 2 about here]

Eventually we end up working with a sample of 5,269 "regular" students. The university's administrative archives contain detailed data about the entire academic history of these students, including major choices, passed courses (denomination of the course, date and grade of the final exam) and final graduation date and mark.

Additionally, since tuition fees vary with family income, it is also possible to recover information on both annual incomes and annual fees from the administrative archives. Moreover, admission to Bocconi was (and still is) subject to an entry test. Together with their applications, perspective students also submit their high school final mark as well as the grades in a number of courses taken during the last two years at high school. Then, they take an entry test that consists of various sections, from reading comprehension to problem solving, from computer use to logic. Admission is decided on the basis of an overall ranking of the candidate students that combines both the test score and the high school grades.

The basic empirical strategy of our approach consists in comparing the youngest and the oldest individuals within each cohort of regularly enrolled students, that is those born in January with those born in December. Table 3 reports the descriptive statistics for the variables used in our analysis separately for the students born in January, December ad the months between February and November.

The numbers in Table 3 show that the youngest students tend to perform slightly better in terms of final graduation mark and in all subjects (but foreign languages). All these differences are significant at conventional statistical levels, apart from the average grades in foreign languages and history courses. Interestingly, all pre-university performance indicators show the same patter: younger students do better at high school and also at the admission test. However, these differences are never significant.

[Table 3 about here]

In Section 4.2 we complement our main results obtained on Bocconi data with some evidence from the Italian sample of the *International Survey on Affectivity and Sex* (*ISAS*).[9] This is an internationally comparable survey of first and second year university students that collects information on various aspects of their social and sexual lives. The Italian data are collected from a sample of 23 public universities selected at random among all those that offer degrees in economics and/or statistics (47 in total). During the academic year 2000-2001 a lecture in one first or second year basic compulsory course of either economics or statistics was selected.[10] At this lecture the students were distributed the questionnaires in sealed envelopes and asked to fill them and put them back into the sealed envelopes so as to guarantee anonymity. These procedures allowed to obtain almost non-existent non-participation rates and non-response rates that are never above 15% for the most delicate questions. For a detailed description of the survey see Billari *et al.* (2007).

For the analysis in Section 3 we selected only regular students (in the sense discussed earlier) enrolled as freshmen in the academic year 2000-2001. Table 4 reports some descriptive statistics

[9] The survey was prepared for a large project in demography which has been published in Billari et al. (2006).
[10] The actual lecture was usually chosen according to the availability of the professors.

for these students distinguishing by month of birth. The first set of variables describe synthetically some features of social behavior. About one fourth of all students are not engaged in any regular sport activity during the school year. Consistently with the interpretation we already suggested in the introduction, this percentage is slightly higher for the December-born individuals and slightly lower for the older January born. A similar patter can be detected also for the other indicators about going to discos and sexual intercourse. Particularly this last set of variables show a marked trend towards more active sexual lives for the older students in the cohort. About 66% of the January-born individuals is in a stable relationship at the time of the interview as compared to about 50% among the younger December-born. Also, 59% of the older students in the cohort have already had their first sexual experience at age 20 while the same percentage is only 50% for their younger mates. This difference is reflected in the average monthly frequency of sex intercourses, which is coded to zero for those students who have not yet had their first experience.[11] This variable refers to the last 3 months and is originally recorded in intervals. Based on reported intervals we construct a continuous estimated frequency of intercourses taking the mid point of each interval.[12] The remaining variables describe other demographic characteristics of the sample.

[Table 4 about here]

3. Relative age effects at university

In this section we present the regression results of a more comprehensive comparison of the academic performance of the youngest and the oldest students within each cohort. Our main results are based on the comparison between students born in January and in December of each year in the Bocconi data. Later (Section 3.1) we also present other comparisons as robustness checks.

In Table 5 we start looking at a series of academic outcomes. In column 1 we regress the log of the graduation mark on the indicators for the month of birth, conditional on a rich set of controls, including high school grades, dummies for the type of high school, cohort and region dummies as well as a set of indicators for the particular degree chosen[13]. In this specification, in particular, we define a dummy equal to one if the student was born in December of the "typical" year of birth – i.e. the year of birth of "regular" students as defined in Table 1 - and a dummy for students born between February and November of the same year. Hence, the coefficient on the December dummy can be readily interpreted as the percentage difference in graduation marks between the youngest and the oldest students in the cohort, students that were born on average 11 months apart. Such age difference amount to 4-5% of total biological age at the time of university attendance (19 to 23 years of age).

---

[11] Differences in this variable across birth months remain strong also within students who have already had their first sexual experience.

[12] The original question reads: *"How often have you had sexual intercourse during the last three months?"* Possible answers are (in brackets the values assigned to each answer to construct our continuous estimate): *never* (0), *less than once a month* (0.5), *once a month* (1), *two or three times a month* (2.5), *once a week* (4.3), *two or three times a week* (10.8), *four or five times a week* (19.5), *almost every day* (30).

[13] In the period covered by our data Bocconi offered 6 types of bachelor degrees with different specializations. The most popular ones were management (with acronym CLEA) and economics (CLEP). A third option was a more academic version of the BA in economics (DES). Other programmes specialised in financial markets (CLEFIN), public administration (CLAPI), law and economics (CLELI).

The results show that this difference is statistically significant and equal to about 0.9%, indicating that younger students perform better than their older peers. The dummy for the months between February and November is also positive – equal to about 0.3% - but not significant. Given an average graduation mark of approximately 102 over 110 in the entire population, our estimates imply that the difference between the youngest and the oldest students in a cohort is on average slightly less than 1 grade point (0.92).

[Table 5 about here]

In the second column we explore how the relative age effect varies over the course of students' university life. To do this, we compute the average grade in the exams taken in each academic year, pooling the fourth year together with any subsequent one.[14] This leads to a dataset with 4 observations for each student. The regression in column 2 of Table 5 pools all observations together and interacts the month-of-birth dummies with indicators for the academic year (the errors are clustered at the individual level). The dependent variable is the log average grade in each course year.

The largest and most significant relative age effect is found in the first year at university, when the difference in average grades is about 1.3% and significant at the 5%-level. Although the coefficients on the interaction dummies are often at the margin of the 10% significance level, they are all negative indicating a decline in age differences over the course of one's university career. During the first one and a half years Bocconi students have very little choice over the courses they want to take whereas later they attend mostly elective subjects. Thus, the fading out of the relative age effect with time spent at university is likely to be due to heterogeneity in preferences and subject complexity as students start to self-select into different courses and majors. Moreover, the presence of peer effects, which have been widely documented in the educational setting and particularly also within Bocconi (see De Giorgi *et al*., 2007), should mitigate the impact of differences in age levels as students interact with peers of various ages.

In the last column of Table 5 we explore the effect of age on the duration of university studies. It is a well-known fact that in Italy students tend to remain enrolled at university for a long time after the official duration of their degrees. This is due, at least partly, to the low cost of university education – which is free for everybody in the public system – and the wide geographical distribution of colleges over the Italian territory, thus reducing the indirect costs of higher education (see Garibaldi *et al*., 2006). This is perceived as a very serious anomaly that leads to the lowest employment rates in the 25-29 age group and to over 80% of Italian graduates obtaining their degrees well after the official duration of their curricula.

For our purposes, we compute time to graduation as the difference between September of the year of first enrolment at Bocconi and the date of graduation. The unit of measurement is quarters and we take logs for the regression.[15] Results indicate no significant relative age effect in this dimension although the point estimate suggests shorter durations for the younger students.

---

[14] A good fraction of students (about 10% in our data) graduate after the regular duration of the degree (4 years for all but one program). Late graduation is a well-known problem of the Italian university system, see Garibaldi *et al.* (2007) for an analysis of this phenomenon on our same set of data.
[15] We cannot use the exact date of first enrolment because students usually have time until mid-October to formally register. In the meantime, however, they regularly attend lectures.

The interpretation of this result is ambiguous. In fact, there is often a negative correlation between time-to-graduation and graduation marks as the most determined students may take longer to prepare their exams and especially their final dissertation. The best students may choose the most difficult courses and thus take longer to prepare them and perhaps run a higher risk of failing and retaking. Moreover, the students in the cohorts that we consider were all required to write quite extensive final dissertations (more similar to master theses than undergraduate essays) that often required several months (or even up to a year) to be completed. The final dissertation was also important for one's final mark which could be very substantially improved by a good paper.[16] When we include the log graduation mark in the regression (column 5), the relative age effect on time to graduation declines and becomes even less statistically significant. Thus, other than the impact on performance, there does not seem to be any other channel through which differences in age affect academic outcomes.

[Table 6 about here]

The results in Table 5 show that relative age has a significant effect on overall performance, however, our data allow to explore such effect by subjects. In Table 6 we categorize exams by subject on the basis of the department that is responsible for organizing and teaching the course. For each student we consider (the log of) the grade obtained in the first exam taken in each subject and run separate regressions for each of them. We consider the first exam to focus on compulsory programs and exclude any potential bias due to students self-selecting themselves into the courses that better fit their preferences and abilities.

The results show that students born in December perform better than their older mates born in January in courses in the area of Economics and Math&Statistics, that is the most technical subjects. On the other hand, there appears to be no significant difference for Management, History, Foreign Languages and Law. From the students' evaluation questionnaires, Economics and Math&Statistics also appear to be the course with the heavier workload. The results of Table 6 are confirmed also when differences in the degree of grade dispersion across subjects are taken into account, either by normalizing the dependent variables or by computing standardized coefficients.

3.1. Robustness checks

In the previous section we focused on the comparison between the oldest and the youngest students in each cohort. In this analysis we have excluded students who enrolled earlier or later than usual arguing that they might be a selected group of individuals. The decision to anticipate or postpone enrolment is in fact likely to be affected by the student's (and parents') motivation, ability, et., all factors that certainly influence academic performance as well.

For the same reason, one may also worry that students born at the margins of a each cohort - i.e. those born in January and December, that is those who are the main focus of our analysis – have decided not to postpone or anticipate enrolment. Students born in the more central months of the year have obviously lower incentives to alter their official enrolment year. In fact, almost 25% of all students who enrolled earlier that normal in our data are born in January and more than 50% before March.

[16] Things have changed in the most recent years with final dissertations being shorter and also less influential on one's final mark.

The direction of the bias induced by this type of selection is unclear. On the one hand, if the oldest students in the regular cohorts (i.e. those born in January) are those who could have anticipated school entry but did not, they should be a negatively selected group. This should lead to under-estimate the relative age effect towards a better performance of the youngest students (which is what we find). However, also the parents of the youngest students (i.e. those born in December) could have voluntarily postponed school entry to ensure that their children were the oldest in the class (a fact that was sometimes considered as an advantage for psychological development). It is unclear whether this should happen more often for the more or less able pupils. At the same time, the youngest children in each cohort might have had higher failing rates in previous school levels (primary, middle-high and high school) so that the actual group of students born in December who enroll regularly at university end up being a positively selected sample.

As a first check to control that this particular selection process is not affecting our results, we look at the distribution of birth months for regular students and late enrollers. If the youngest students in a cohort are those with the highest failing rates, one should observe a higher incidence of December born (or, more generally, late months) among the late enrollers. The upper panel of Figure 1 describes the distribution of birth month for the late enrollers as compared to regular students (when a bar is greater than 1 then the percentage of students born in that month is higher among late enrolled than among regular students) for the entire group of students who took part in the admission test (thus, including both those who were admitted and those who were rejected) at Bocconi university in the years considered in our main data (1995-1998).[17]

[Figure 1 about here]

The evidence in Figure 1 seems to exclude the existence of such type of selection. The relative incidence of students born in the later months of the year is very similar in the two groups. Moreover, simple statistical tests indicate that such relative incidence is never significantly different from 1 for any of the 12 months.

The bottom panel of Figure 2 provides evidence against another possible type of selection. It might be that the effect of younger students performing worse in lower school levels does not show up in our data because these students simply do not apply to Bocconi, which is known to be a highly selective university in Italy. To look at this issue we compare the birth month distribution of all the *regular* students who submitted their application to Bocconi in the years considered by our analysis with that of the *regular* students in the entire population of the same cohorts.[18] If the younger students in each cohort are really less likely to send their applications to Bocconi, one should see a lower incidence of such students among Bocconi applicants than in the population.

The numbers in Figure 1 suggests that this type selection is also not affecting our results. Like in the upper panel, the relative incidence of students born in any month is always very close to 1 an

---

[17] We look at all students and not only at admitted candidates (who are instead the focus of the analysis in Section 3) to avoid the possible additional bias arising from a potentially unequal distribution of test performance by month of birth.
[18] We derive the distribution of regular students in the four birth cohorts 1976-1979 from the European Community Household Panel (ECHP) by selecting persons born in those year who completed their secondary education at the age of 19. This leads to 730 individual observations.

never statistically different from 1. If anything, there seems to be a slightly higher incidence of December born students who apply to Bocconi rather than the opposite.

As a further check, we also repeat all estimates comparing students born more towards the central months of the year. Figure 2 shows the coefficients (and robust confidence intervals at the 90% level) obtained from regressions similar to those reported in Table 5 and Table 6 adjusted to compare students born in the months indicated along the horizontal axis. We report the results of this robustness analysis only for those outcomes that were found to have significant relative age effects in the previous section.

Obviously, by comparing months closer to each other we are also reducing the relative age difference between the oldest and the youngest students and we therefore expect the see the effects fading out as birth months gets closer. However, all the results, except for the first grade in economics, are confirmed when comparing students born in February and November of the same year. Further restricting the age differential leads to statistically insignificant estimates although along a clearly declining trend.

[Figure 2 about here]

In Figure 3 we report an even more detailed analysis with relative age effects estimated for each single month of birth and for the same outcomes of Figure 2. The effects are reported in absolute levels so that on the vertical axis one can read the (conditional) average of the dependent variable for each month of birth. For comparison purposes, we also include effects for the early and late enroller, i.e. students born from October of the year before the regular one to March of the following year.

As expected, students older than normal (those born between October and December of year *t-1*) do worse. In fact, these students typically enroll late because they have failed one or more grades in some previous school level (primary, middle-high or high school) although some of them might have tried a different university before moving to Bocconi. Consistently with the descriptive evidence presented in Table 3, the small number of later enrollers leads to very wide confidence intervals around the mean outcomes estimated for these students. The evidence for early enrollers is less clear. The conditional mean outcomes estimated for this group are higher than for the others but such difference does not appear to be statistically significant, especially when compared with the youngest regular students. For the rest, the simple visual inspection of Figure 3 suggests the existence of a mild trend towards better outcomes for the younger students within each "regular" cohort although the exact statistical significance of such trend is better described by the estimates reported in Figure 1.

[Figure 3 about here]

Notice, finally, that in the next section we will compare relative age effects estimated conditional and unconditional to students' results in the aptitudinal admission test (see Table 9 and Table 10). As long as such test captures the dimensions of ability that drive potential selection effects of the type discusses in the paragraphs above, those estimates will further clarify the absence of biases in our results.

In Table 7 we perform another robustness check. Several previous studies have documented statistically significant differences in various outcomes between children born in different seasons of the year (Wilson, 2000; Lawlor *et al.*, 2006). Usually, such differences, especially as far as health outcomes are concerned, are explained with environmental, biological and medical factors like weather conditions and temperature at the time of gestation or birth. These factors are documented to affect the health conditions of newborn children such as birth weight and height. When other outcomes are considered, either physiological or educational, season of birth effects are often confounded with relative age effects and the possibility to separate them depends on the exact position of cut-off dates. For example, in the UK were the cut-off date for primary school enrolment has been traditionally placed towards the end of the summer.[19] This implies that students born in the summer months would also be the youngest in their classes, thus making it difficult to disentangle relative age effects and season of birth effects.

[Table 7 about here]

Fortunately, the relevant cut-off date for our analysis is in the middle of the winter season (December 31st) so that the comparison of students born in January and December should not be affected by season of birth effects. Moreover, even when season of birth effects have been detected, they have also been shown to disappear rather rapidly over time, especially in industrialized countries. However, for robustness and comparison, Table 7 reports estimates of relative age effects conditional on season of birth for our students. Like in Figures 1 and 2, we consider only outcomes for which relative age differences have been detected by our previous analysis.

Although our main comparison is between students born in January and December of the same year, who were both born in winter, they were born in the winter seasons of different years, which might have indeed been meteorologically different. And if there is a secular trend towards winter seasons changing systematically over the years, than our estimates might be capturing such trend.[20] To make our specification robust to this particular issue, we include in the set of control variables a full set of interactions between month of birth and cohort dummies.

The estimates of Table 7 show that relative age effects remain significant also in this more sophisticated specification. Only the significance of the effect on the first economics exam goes below the conventional 10% level, although only marginally (the coefficient is significant at the 11% level). In general, the effects seem to be slightly lower than in previous specifications.

As far as season effects are concerned, students born in the spring (the reference season inour specification) seem to be slightly advantaged as compared to their mates. Although the estimated coefficients on winter, summer and fall are never statistically distinguishable from each other, the point estimates indicate a trend that mimics fluctuations in temperature across seasons.

4. Why are relatively younger students performing better?

We can think of at least three possible explanations for the relative age effects that we uncovered in Section 3. First, if early learning is really more productive, as documented by some authors (although results on this specific issue are still controversial), it might well be that the youngest students perform better than their older mates in the same cohort.

---

[19] For the coming 2008-2009 school year, children who will be 5 on or before August 19th 2008 must start school on that date.

[20] The obvious suspect here is climate change that might have made winter seasons milder and milder over time.

Our interpretation of the evidence from Bocconi students is that early learning is unlikely to be among the main determinants of relative age effects. In fact, if that was the case one should see younger students performing better in all subjects and not necessarily only in the most technical ones.

The second explanation is based on the idea that the age profile of cognitive abilities should be inversed-U shaped over the individual lifecycle. Although such profile is still far from being properly identified (Cunha *et al.*, 2005), it is probably fair to assume that intellectual skills initially develop as one grows from very young ages to adulthood and later deplete as people age. The same pattern is well documented in the medical literature for various dimensions of physical strength. And similarly to physical strength, the peak of cognitive development might in fact occur around age 20, so that in our data we might be seeing the very initial declining trend of cognitive skills. The very young ages of some inventors might actually be consistent with this interpretation (Jones, 2005).

In this section we present some evidence to support this view. In particular, we show that younger students perform better than their older mates within the same cohort at the entry test, which is a test of cognitive abilities. For the most recent cohorts of students we can also decompose the test into its various categories and look at which specific dimensions of ability are mostly affected by age effects.

However, we also show that relative age effects in academic performance are only very mildly affected by the conditioning on the students' results in the entry test, thus suggesting that differences in cognitive ability cannot fully explain the variation in performance with cohorts.

We, thus, consider a the third possible explanation. Several psychological studies have documented the existence of relative age effects in the development of personality traits such as self-esteem and leadership (Dhuey and Lipscomb, 2006; Thomson *et al*., 2004). Consistently with these findings, we use the *ISAS* data to document that the oldest students in each cohort are those with the most active social lives: they are more likely to participate in sport activities and to go out to discos and clubs (although results along these two dimensions are not statistically significant) and are more frequently involved in love and sex relationships. As a consequence, they will plausibly devote less time to studying and thus perform worse than their younger mates at university.

Overall, the evidence that we present later in this section supports the view that relative age differences in academic performance at university are generated by a combination of slowly depleting cognitive abilities and this last psychological mechanism.

This interpretation also allows to reconcile our results with most previous studies that found opposite relative age effects in earlier school levels. Early learning always goes in the direction of benefiting the youngest in a cohort but at young ages the oldest are favored by the increasing profile of cognitive development. At later ages, like the ones we look at here, the profile of cognitive development flattens and perhaps also inverts direction, thus leading to negative relative age effects (i.e. the youngest do better). And since this process is driven mostly by ability it is also natural that it shows up more clearly in the most technical subjects.

Moreover, the psychological mechanism mentioned above works through a simple process of efficient allocation of time (and possibly also effort) to activities with different marginal utilities or costs. Obviously, such process can only emerge when students have enough control over their time and, in many instances, university is the first occasion to fully control one's activities.

Consequently, relative age effects at earlier stages of pupils' education are affected more by differences in cognitive development than by the rational allocation of time and effort.

In the following paragraphs we will first (Section 4.1) document the presence of some relative age differences in cognitive ability as measured with the results of the admission entry test at Bocconi and later (Section 4.2) we use the *ISAS* data to provide evidence of the more active social lives of the older students in the cohort.

Before moving on to the actual results, it is fair to stress that the pieces of evidence presented in this section are not always directly comparable with each other, as they often refer to different samples. Moreover, we will not be able to test directly that students with more active social lives perform worse or devote less time to studying. However, we believe that the combination of the results presented here is at the minimum consistent with our interpretation of the relative age effects documented in Section 3.

4.1. Relative age differences in cognitive ability and academic performance

Table 8 explores the existence of relative age effects in cognitive ability in our Bocconi data by analyzing students' results in the admission test. Such test was – and still is – meant to measure ability rather than actual knowledge and was designed by educational psychologists. It includes several different sections such as reading comprehension, problem solving and others but, unfortunately, for the earlier cohorts information on the results obtained in each single section of the test is not available. Moreover, the actual format of the test has changed over time and results across groups of cohorts will not be directly comparable.

In the first column of Table 8 we consider the same cohorts that we used for our analysis in Section 3 and we regress the (log) test result on month-of-birth dummies and our usual set of controls.[21] The results show an advantage of about 1% in favor of the youngest students.

In the following columns (2 to 9) we analyze in details the different sections of the test for some more recent cohorts, namely for students who applied for entrance at Bocconi in the years 2000, 2001 and 2002. These cohorts were administered a different newer version of the test which consisted of 8 sections and results have been recorded separately for each of those sections. The sections were: reading comprehension, spatial and perceptive abilities, computer use, mathematical reasoning, verbal relations, logics of images, verbal patterns and general culture. In Table A.1 we present a brief description of what these 8 sections actually mean and how they work. Note that two of the sections refer directly to skills that come mostly from the accumulation of previous knowledge, namely computer use and general culture. In Table 8 we do not report results for general culture (where age differences are not significant) while we do present the estimates for computer use as well as for all the other sections that are meant to directly measure different types of cognitive abilities.

In all columns of Table 8 the dependent variable is the standardized test result so that the estimated coefficients can be readily compared across columns. We start in column 2 with the overall result, which is simply a weighted average of the results in the single sections, where the youngest students seems to have a relatively large advantage of over 14%. Also students born in

[21] Both admitted and rejected students are included in the regression although results change only slightly when the analysis is limited to admitted students.

the middle months February to November show a considerable 8% advantage over the oldest born in January. These are much larger effects that the ones estimated in column 1 for the earlier cohorts. However, comparing these results is complicated because the structure of the test was changed. In particular, the section on computer use, where relative age effects seem very important, was not present in the earlier version of the test.

The following columns (3 to 9) present results for the different test sections (excluding only general culture). All the point estimates indicate a relative advantage of the youngest over the oldest students in the cohort, however such differences are statistically significant only in three sections - spatial perception, computer use and logics of images - and are particularly strong in computer use.

These results suggest that cognitive ability is subject to mild relative age differences while our interpretation of the effect on computer use is more in line with the psychological mechanism we discussed above. Students with more active social lives also have more time to spend on other things such as using a computer, an activity that does not necessarily require interacting with others.

In Table 9 and Table 10 we explore the relationship between relative age effects in academic performance and cognitive ability. If our main results (Table 5 and Table 6) were due exclusively to differences in cognitive ability, relative age effects should disappear once conditioning on the student's result at the entry test. The estimates in Table 9 and Table 10 show that this is not what happens.

First, in Table 9 we estimate relative age effects in graduation marks and in the average exam grades of the first two academic years conditioning on entry test scores. For comparison, in columns 2 and 4, we also report the original unconditional estimates presented earlier in Table 5. For neither of the two outcomes considered the inclusion of the test result in the set of controls changes the estimated relative age effects significantly. The estimates are affected only marginally and decrease by approximately 10% once the entry test score is added to the set of controls.

Table 10 repeats this exercise for the first exams of the different subjects. In column 1 we report the estimates of the difference between students born in December and those born in January (the reference category) including the test result as a control variable, while in column 2 we report for comparison the same estimates of Table 6. These results confirm what had already been documented in Table 9, that conditioning on the admission test affects the estimated relative age effects only marginally.

Overall, these results suggest that differences in cognitive ability are only one of the channels through which age differences influence academic performance (and perhaps not the most important).

4.2. Relative age differences in social behavior

The final set of results that we present come from the *ISAS* survey. In Table 11 we analyze the differences in various aspects of social behavior between the oldest and the youngest students in the cohort.[22] As for the previous analyses we concentrate only on regular students, thus excluding early and later enrollers.

In the first column of Table 11 we look at sport activity. The dependent variable is a dummy equal to 1 if the respondent answers *never* to the following question: “During the school year, do you practice any sport or physical activity?”. The other possible answers are *sometimes*, *often* and *very often* and are all coded to zero in our right-hand-side variable. The model is estimated using a probit specification and conditioning on a large set of controls. The estimated effect of being born in December is not significant although the sign of the coefficient is positive and increasing over the calendar year of birth (0.045 for February to November and it doubles to 0.083 for December) suggesting that younger individuals are more likely to do very little sport.

We obtain very similar results in column 2 for another aspect of social behavior. The dependent variable is coded 1 for students who answer *never* to the question “Do you go to clubs or other places where you can dance?”.

The last two columns of Table 11 explore love and sexual behaviors. In column 3 we run a linear regression of the self-reported mean number of monthly sexual intercourses on our month-of-birth dummies and the usual set of controls. The estimates show a very large effect with the youngest students in the cohort having on average 1.2 intercourses less than their oldest mates. This is about 35% over the average of approximately 3 and corresponds to almost 20% of a standard deviation.

Finally, in the last column we explore the probability of being in a stable love relationship at the time of the interview. Here we also find a very strong and significant effect of the youngest students being 18 percentage points less likely to be in such relationship over an average of approximately 60%.

To the extent that these differences in social behaviors also reflect differences in the allocation of time and effort between studying and other activities - a link that we unfortunately cannot test directly with the available data –, these results support the interpretation that relative age effects in psychological development might be a powerful determinant of differences in academic outcomes.

5. Conclusions

In this paper we documented that relative age effects are still present at the age of university attendance and such effects work in favor of the youngest students within each cohort. This contrasts with the results of most previous studies that looked primarily at earlier schooling stages and typically found older students doing better.

Exploring data on cognitive entry test and a survey of social behaviors of first-year university students, we produce some additional evidence that help rationalize our results according to two main mechanisms.

[22] The ISAS survey is designed to be a representative sample of first year students in faculties of Economics and Statistics in the academic year 2000-2001.

On the one hand, cognitive development appears to flatten and even invert direction already at the age of university enrolment thus penalizing the performance of the oldest students in each cohort. Moreover, the youngest students in a cohort also appear to have less active social lives and thus plausibly devote more time to studying. This argument is consistent with results from psychological studies showing that being the youngest in a reference group slows down the development of personality traits like self-esteem and leadership at early ages.

Our results have important implications for the study of cognitive development and show that the mechanical evolution of abilities over the life cycle interacts with endogenous individual choices about the allocation of time and effort. Moreover, such interaction involve both productive and non-productive skills and attitudes.

In a policy perspective, the most commonly discussed options focus on the advantages and disadvantages of anticipating the age of school entry. Our results support the idea that anticipating school entry might indeed improve performance, however such policy intervention cannot eliminate relative age differences and thus their implications.

Rather, if the policy objective is guaranteeing equal opportunities to everybody in a society, relative age differences – which are shown to be an important source of later inequality in outcomes - should be reduced for everyone. In principle, achieving this result is relatively easy, at least as far as the schooling environment is concerned. For example, one could simply redefine the rules of class formation by conditioning students in a class to be at most 6 months apart in terms of biological age.

Implementing this type of policy is straightforward and costless, other than in some very special cases, for example when there is only one class in a school grade. One may also think of changing the definition of school grades per se, by having a grade for each semester instead than for each year. This additional change, however, might require additional inputs in the education production process (smaller class sizes, more teacher, et.).

References

Allen, J. and R. Barnsley (1993). Streams and Tiers: The Interaction of Ability, Maturity and Training in Systems with Age-Dependent Recursive Selection. *The Journal of Human Resources* 28(3), 649-659.

Barnsley, R.H., A.H. Thompson and P. Legault (1992). Family planning: Football style, the relative age effect in football. *International Review for the Sociology of Sport* 27(1), 77-88.

Bedard, K. and E. Dhuey. (2006). The Persistence of Early Childhood Maturity: International Evidence of Long-Run Age Effects. Working Paper, Department of Economics, University of California, Santa Barbara.

Berlinski, S., S. Galiani and P.J. Gertler. (2006). The Effect of Pre-Primary Education on Primary School Performance. IFS Working Papers, W06/04.

Billari, F.C., M. Caltabiano and G. Dalla Zuanna (edited by). (2007). Sexual and affective behaviour of students. An international research. Cleup Editrice, Padova.

Blanden J., Gregg P. and L. Macmillan. (2007). Accounting for Intergenerational Income Persistence: Noncognitive Skills, Ability and Education. *Economic Journal*, 117, C43-C60.

Carneiro, P. and J. Heckman. (2003). Human Capital Policy. In J. Heckman and A. Krueger, eds., *Inequality in America: What Role for Human Capital Policy?* MIT Press.

Checchi D (2000). University education in Italy. *International Journal of Manpower* 21(3/4), 177-205.

Cunha, F., J.J. Heckman, L. Lochner and D.V. Masterov. (2005) Interpreting the Evidence on Life Skill Formation. NBER Working Paper 11331, National Bureau of Economic Research, Washington.

Cunha, F., J.J. Heckman and S. Schennach. (2006). Estimating the Technology of Cognitive and Noncognitive Skill Formation. Mimeo, University of Chicago.

Cunha F and J.J. Heckman. (2007a). The Technology of Skill Formation. *American Economic Review* (forthcoming).

Cunha F and J.J. Heckman. (2007b). Investing in our Young People. Mimeo, University of Chicago.

Currie, J. and D. Thomas. (1999). Early Test Scores, Socioeconomic Status and Future Outcomes. NBER Working Paper 6943, National Bureau of Economic Research, Washington.

De Giorgi, G., M. Pellizzari and S. Redaelli. (2007). Be as Careful of the Books you Read as of the Company you Keep: Evidence on Peer-Effects in Educational Choices, mimeo.

Del Bono, E. and F. Galindo-Rueda. (2004). Do a few months of compulsory schooling matter? The education and labour market impact of school leaving rules. IZA Discussion Paper No. 1233.

Dhuey, E. and S. Lipscomb. (2006). What Makes a Leader? Relative Age and High School Leadership. Working Paper, Department of Economics, University of California, Santa Barbara.

Dudink, A. (1994). Birth date and sporting success. *Nature*, 368, 592.

Fredriksson P. and B. Öckert. (2005). Is Early Learning Really More Productive? The Effect of School Starting Age on School and Labor Market Performance. IZA Discussion Paper No. 1659, IZA, Bonn.

Garibaldi, P., F. Giavazzi, A. Ichino and E. Rettore (2007). College cost and time to complete a degree: Evidence from tuition discontinuities, mimeo.

Goodman, A. and B. Sianesi. (2005). Early Education and Children's Outcomes: How Long do the Impact Last? *Fiscal Studies* 26(4), 513-548.

Gregg, P., E. Washbrook , C. Propper C. and S. Burgess. (2005). The effects of a mother's return to work decision on child development in the UK. *Economic Journal* 115, F48-F80.

Jones, J. (2005). Age and Great Invention. NBER Working Paper n. 11359.

Heckman, J.J. (2006) Skill Formation and the Economics of Investing in Disadvantaged Children. *Science*, 312(5782): 1900-1902.

Heckman, J.J. and D. V. Masterov. (2007). The Productivity Argument for Investing in Young Children. *Review of Agricultural Economics*, 29(3), 446-493.

Helsen, W.F., J. Van Winckel and M. Williams. (2005). The Relative Age Effect in Youth Soccer Across Europe. *Journal of Sports Sciences* 23(6), 629-636.

Lawlor, D., H. Clark, G. Ronalds and D.A. Leon. (2006). Season of birth and childhood intelligence: Findings from the Aberdeen Children of the 1950s cohort study. *British Journal of Educational Psychology*, 76(3), 481-499.

Lutz W, Skirbekk V (2005). Policies Addressing the Tempo Effect in Low-Fertility Countries. *Population and Development Review* 31(4), 699-720.

Mayer, S.E. and D. Knutson. (1999). Does the Timing of School Affect How Much Children Learn? In S.E. Mayer, P.E. Peterson (Eds.), Earning and Learning: How Schools Matter. Brookings Institution Press, Washington, D.C., 79-102.

Plug, E.J.S. (2001). Season of Birth, Schooling and Earnings. *Journal of Economic Psychology* 22, 641-660.

Rizzi, E.L. and G. Dalla-Zuanna (2007). The Seasonality of Conception. *Demography* 44(4), 705-728.

Salthouse, T.A., D.H. Schroeder and E. Ferrer (2004). Estimating Retest Effects in Longitudinal Assessments of Cognitive Functioning in Adults Between 18 and 60 Years of Age. *Developmental Psychology* 40(5), 813-822.

Skirbekk, V., H-P. Kohler and A. Prskawetz. (2004). Birth Month, School Graduation and the Timing of Births and Marriages. *Demography* 41(3), 547-568.

Skirbekk, V. (2005). *Why Not Start Younger? Implications of the Timing and Duration of Schooling for Fertility, Human Capital, Productivity, and Public Pensions*. RR-05-002, International Institute for Applied Systems Analysis, Laxenburg.

Thompson, A.H., R.H. Barnsley and J. Battle. (2004). The relative age effect and the development of self-esteem. *Educational Research* 46, 313-320.

Wilson, G. (2000). The Effects of Season of Birth, Sex, and Cognitive Abilities on the Assessment of Special Educational Needs. *Educational Psychology*, 20(2), 153-166.

Figure 1. Relative distributions of births by month

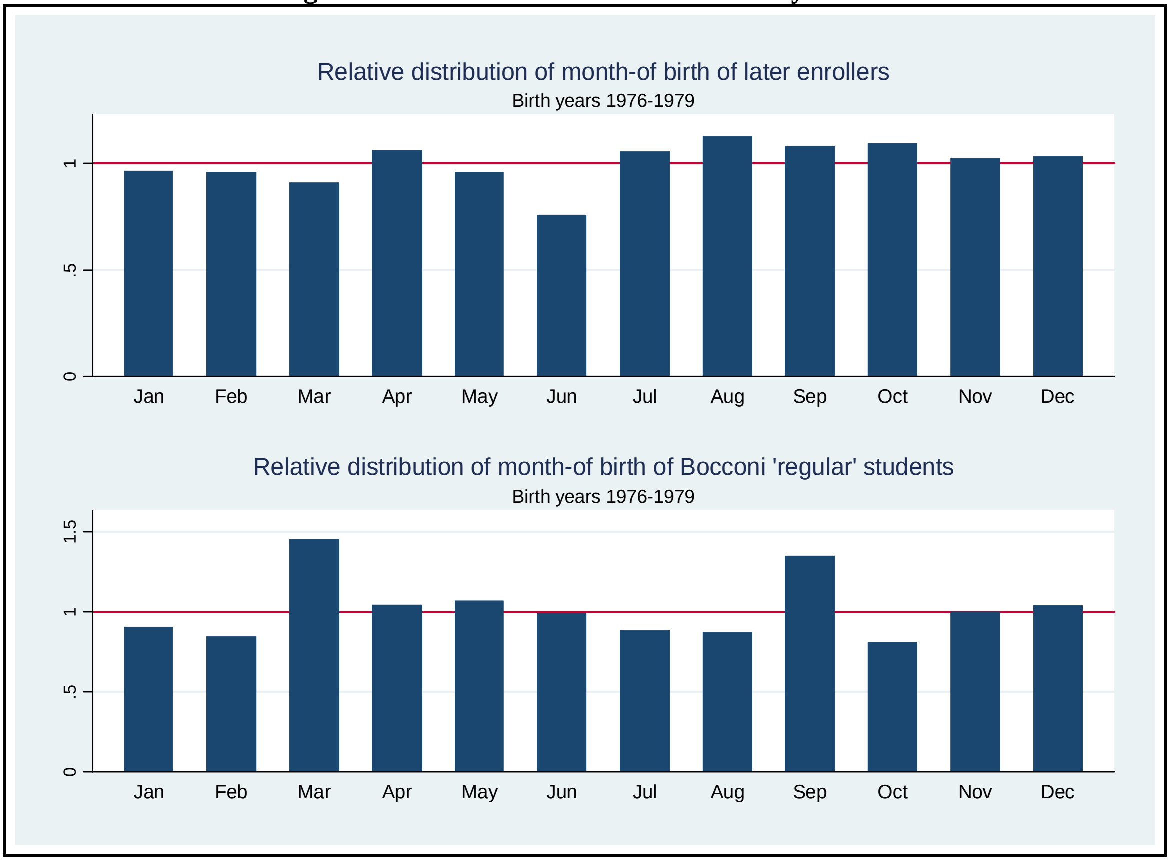

Figure 2. Conditional differences in academic performance

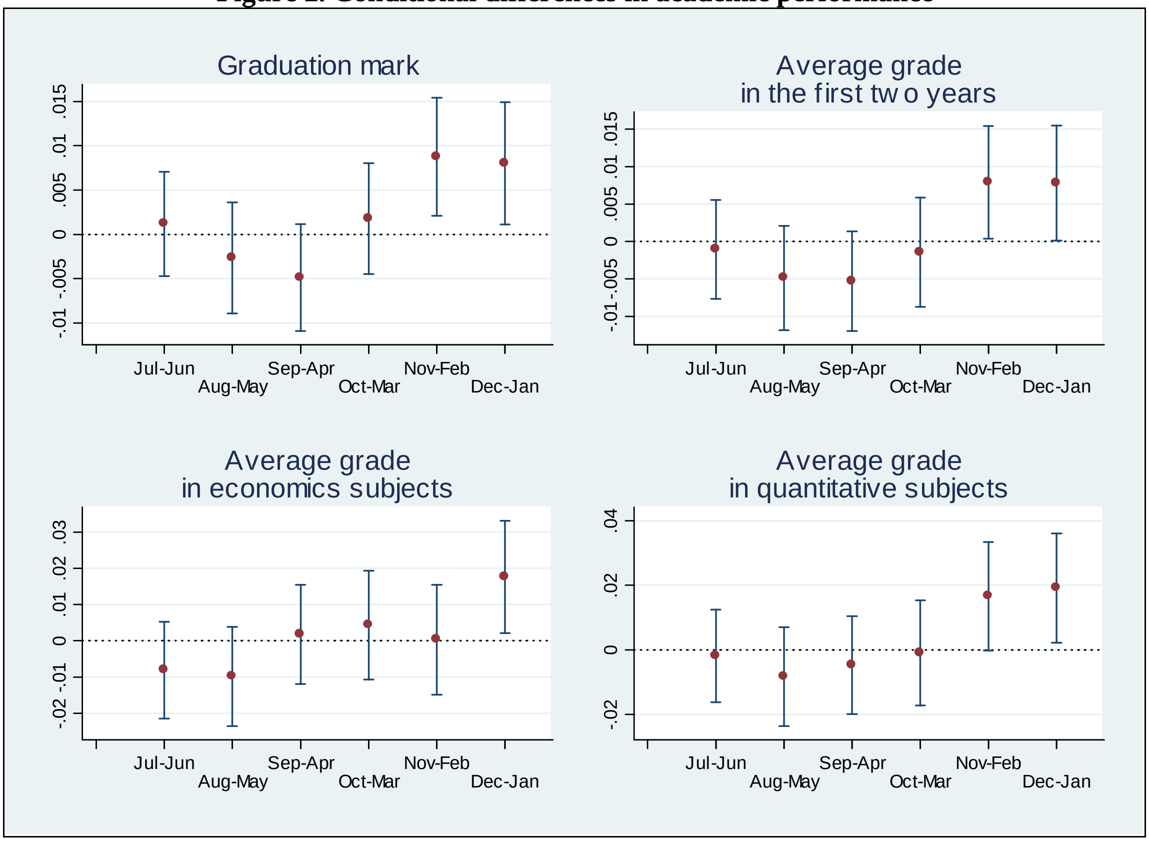

Figure 3. Conditional academic performance by month of birth

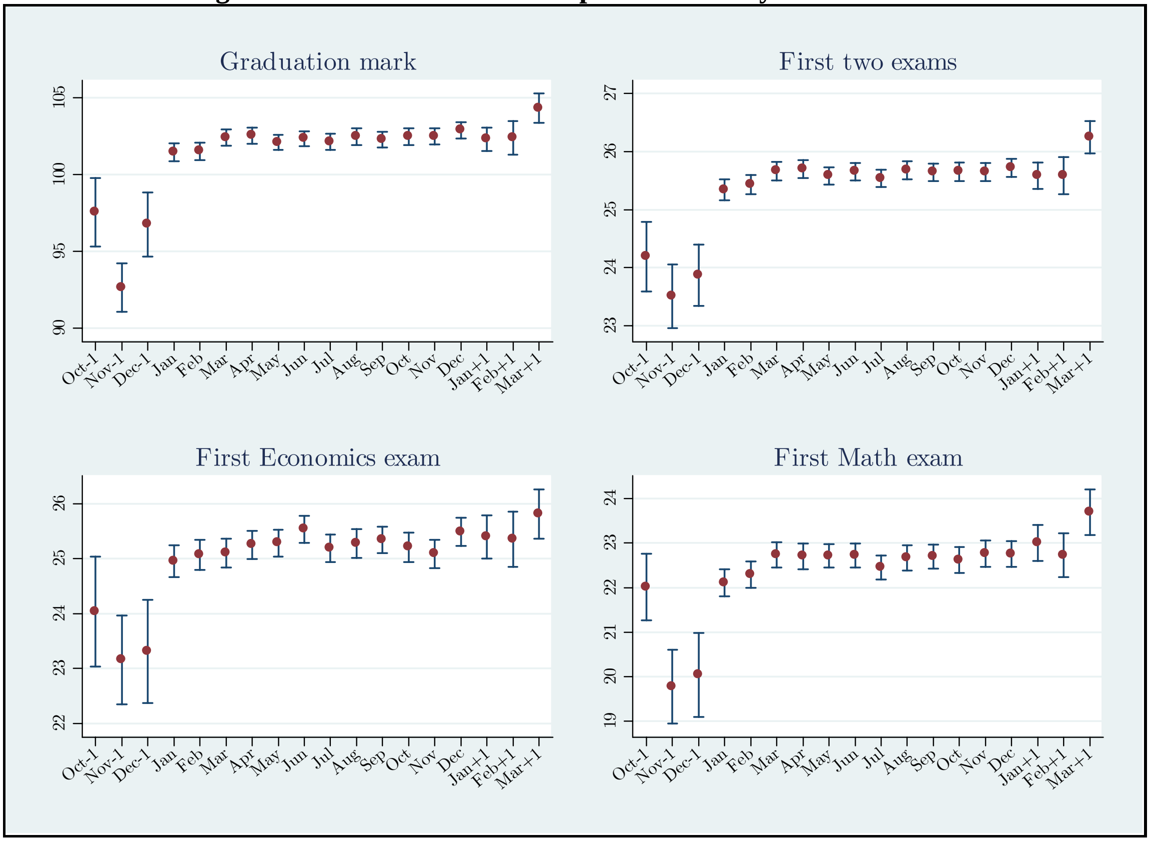

Table 1. Distribution of student births by cohort

year of first enrolment	"typical" year of birth	% of "regular" students	% of "older" students	% of "younger" students
1995	1976	0.837	0.069	0.108
1996	1977	0.857	0.059	0.106
1997	1978	0.882	0.047	0.093
1998	1979	0.861	0.044	0.123
	Total	0.857	0.045	0.121

Table 2. Distribution of month of birth by cohort

	Year of first enrolment				
	1995	**1996**	**1997**	**1998**	**Total**
January	0.066	0.062	0.074	0.058	0.065
February	0.073	0.074	0.068	0.066	0.070
March	0.084	0.076	0.083	0.076	0.080
April	0.087	0.081	0.086	0.089	0.086
May	0.107	0.109	0.092	0.114	0.105
June	0.106	0.091	0.094	0.100	0.098
July	0.085	0.091	0.075	0.092	0.086
August	0.073	0.083	0.078	0.082	0.079
September	0.093	0.082	0.093	0.094	0.090
October	0.065	0.085	0.080	0.085	0.080
November	0.078	0.079	0.083	0.075	0.079
December	0.084	0.088	0.093	0.069	0.083
Total	1.00	1.00	1.00	1.00	1.00

Table 3. Descriptive statistics of Bocconi data

Variable	January mean	January (s.d.)	February to November mean	February to November (s.d.)	December mean	December (s.d.)	Total mean	Total (s.d.)
Graduation mark[1]	101.51	(7.61)	102.27	(7.31)	102.86	(6.92)	102.27	(7.30)
Average grades by subject[2]:								
management	26.50	(2.04)	26.69	(1.89)	26.83	(1.81)	26.69	(1.90)
economics	25.80	(2.47)	26.04	(2.43)	26.16	(2.34)	26.03	(2.43)
math	23.78	(2.92)	24.09	(2.93)	24.34	(2.89)	24.09	(2.92)
history	27.51	(2.78)	27.52	(2.59)	27.71	(2.35)	27.53	(2.59)
foreign languages	27.63	(2.15)	27.56	(2.22)	27.53	(2.20)	27.56	(2.21)
law	25.44	(2.42)	25.58	(2.39)	25.82	(2.22)	25.59	(2.38)
Specialization:								
public administration	0.07	-	0.05	-	0.06	-	0.05	-
management	0.59	-	0.60	-	0.54	-	0.59	-
financial markets	0.09	-	0.09	-	0.09	-	0.09	-
law & economics	0.11	-	0.12	-	0.14	-	0.12	-
economics	0.07	-	0.09	-	0.10	-	0.09	-
economics & social sciences	0.07	-	0.06	-	0.07	-	0.06	-
High school results[3]	59.61	(33.22)	57.85	(35.06)	61.78	(32.66)	58.29	(34.76)
Admission test score[4]	70.75	(7.53)	71.41	(7.57)	71.38	(7.51)	71.36	(7.56)
Time to graduation[5]	22.10	(4.10)	21.95	(3.92)	21.81	(3.71)	21.95	(3.91)
Type of high school:								
lyceum	0.79	-	0.75	-	0.75	-	0.76	-
technical-professional school	0.20	-	0.23	-	0.24	-	0.23	-
foreign school	0.01	-	0.01	-	0.01	-	0.01	-
1=female	0.42	-	0.44	-	0.46	-	0.44	-
1=resident outside Milan[6]	0.56	-	0.61	-	0.61	-	0.61	-
Family income (log)[7]	10.26	(1.01)	10.30	(1.15)	10.27	(1.26)	10.29	(1.15)
1=highest income bracket[7]	0.18	-	0.18	-	0.24	-	0.19	-
Number of students	340		4,488		441		5,269	

1. Maximum = 110; pass = 66.

2. Maximum = 30; pass = 18.

3. Summary evaluation of high school performance, including final grade and marks in selected courses during the last two years. Range 0-100.

4. Range 0-100. Average over various sections (reading comprehension, problem solving, computer use, et.)

5. Time between September of the year of first enrolment and the graduation date (measured in quarters).

6. Dummy = 1 if residence of the family of origin is outside the province of Milan.

7. As recorded on the first year of registration. For students in the highest income bracket the actual income is not recorded.

Table 4. Descriptive statistics of ISAS data

Variable	January mean	January (s.d.)	February to November mean	February to November (s.d.)	December mean	December (s.d.)	Total mean	Total (s.d.)
Social behavior								
1=no sport[1]	0.22	-	0.25	-	0.27	-	0.25	-
1=no discos[2]	0.12	-	0.11	-	0.14	-	0.11	-
1=stable relationship[3]	0.66	-	0.60	-	0.50	-	0.60	-
1=ever had sex[4]	0.59	-	0.58	-	0.51	-	0.58	-
monthly frequency of sex intercourses	3.44	(6.29)	3.16	(5.62)	1.84	(4.13)	3.06	(5.56)
Background characteristics								
1=female	0.57	-	0.59	-	0.60	-	0.60	-
1=live with parents	0.81	-	0.72	-	0.68	-	0.72	-
High school grade[5]	83.13	(13.34)	84.72	(11.77)	83.15	(11.79)	84.47	(11.89)
Father's education								
secondary	0.46	-	0.42	-	0.45	-	0.43	-
tertiary	0.16	-	0.17	-	0.21	-	0.17	-
Mother's education								
secondary	0.48	-	0.42	-	0.39	-	0.42	-
tertiary	0.16	-	0.14	-	0.18	-	0.15	-
Number of students	124		1,551		162		1,837	

1. Dummy coded 1 for students who answer *"never"* to the following question: *During the school year, do you practice any sport or physical activity?*
2. Dummy coded 1 for students who answer *"never"* to the following question: *Do you go to clubs or other places where you can dance?*
3. Dummy coded 1 for students who have a steady relationship at the time of the interview.
4. Dummy coded 1 for students who answer *"yes"* to the following question: *Have you ever had sexual intercourse?*
5. Range 0-100.

Table 5. Month of birth and academic performance

	(log) graduation mark[1] [1]	(log) average grade by academic year [2]	Time to graduation[3] [3]	Time to graduation[3] [4]
Month of birth				
1=February to November [F_N]	0.003 (0.003)	0.005 (0.005)	-0.004 (0.008)	-0.001 (0.008)
1= December [Dec]	0.009** (0.004)	0.013** (0.006)	-0.012 (0.011)	-0.004 (0.010)
Interactions with academic year				
[Dec] x [acc. year=2]	-	-0.008 (0.006)	-	-
[Dec] x [acc. year=3]	-	-0.011* (0.006)	-	-
[Dec] x [acc. year≥4]	-	-0.008 (0.006)	-	-
[F_N] x [acc. year=2]	-	0.001 (0.005)	-	-
[F_N] x [acc. year=3]	-	-0.007 (0.005)	-	-
[F_N] x [acc. year≥4]	-	-0.005 (0.005)	-	-
Controls				
1=female	-0.001 (0.002)	-0.003** (0.001)	0.001 (0.004)	0.001 (0.004)
High school results[4]	0.454*** (0.009)	0.437*** (0.010)	-0.602*** (0.024)	-0.148*** (0.028)
1=resident outside Milan (province)	0.000 (0.002)	0.001 (0.002)	-0.010* (0.006)	-0.009* (0.005)
Family income (log)[5]	0.001 (0.001)	0.001 (0.001)	-0.006*** (0.002)	-0.005*** (0.002)
1=highest income bracket[5]	0.012 (0.010)	0.015* (0.009)	-0.095*** (0.027)	-0.084*** (0.025)
Average grade in previous years	-	0.008*** (0.000)	-	-
Graduation mark (log)	-	-	-	-0.999*** (0.035)
Dummies for academic year	No	Yes	No	No
Dummies for degree type (6)	Yes	Yes	Yes	Yes
Dummies for type of high school (5)	Yes	Yes	Yes	Yes
Regional dummies (18)	Yes	Yes	Yes	Yes
Cohort dummies (4)	Yes	Yes	Yes	Yes
Observations	5,269	20,947	5,269	5,269
R-squared	0.40	0.44	0.19	0.31

1. Maximum = 110; pass = 66.
2. Probit regression
3. Time between September of the year of first enrolment and the graduation date (measured in quarters).
4. Summary evaluation of high school performance, including final grade and marks in selected courses during the last two years. Range 0-100.
5. As recorded on the first year of registration. For students in the highest income bracket the actual income is not recorded.
Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 6. The effect of month of birth on first grades by subject areas[1]

	Manag. [1]	Econ. [2]	Math [3]	History [4]	Language [5]	Law [6]
Month of birth						
1=February to November	0.001	0.007	0.013*	-0.002	-0.000	-0.000
	(0.005)	(0.008)	(0.008)	(0.006)	(0.005)	(0.007)
1=December	0.003	0.018*	0.021**	0.006	0.004	0.009
	(0.006)	(0.010)	(0.010)	(0.007)	(0.006)	(0.009)
Controls						
1=female	-0.001	-0.026***	-0.019***	0.001	0.007***	0.003
	(0.002)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)
High school results[2]	0.489***	0.597***	0.693***	0.342***	0.354***	0.528***
	(0.014)	(0.021)	(0.023)	(0.016)	(0.015)	(0.020)
1=resident outside Milan (province)	0.006*	0.000	0.003	0.002	0.003	-0.011**
	(0.003)	(0.005)	(0.005)	(0.004)	(0.003)	(0.005)
Family income (log)[3]	0.000	0.003*	0.000	0.001	0.001	0.001
	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)
1=highest income bracket[3]	-0.000	0.032	-0.001	0.010	0.021	0.017
	(0.014)	(0.020)	(0.021)	(0.016)	(0.018)	(0.022)
Dummies for degree type (6)	Yes	Yes	Yes	Yes	Yes	Yes
Dummies for type of high school (5)	Yes	Yes	Yes	Yes	Yes	Yes
Regional dummies (18)	Yes	Yes	Yes	Yes	Yes	Yes
Cohort dummies (4)	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5,269	5,269	5,269	5,269	5,269	5,269
R-squared	0.27	0.21	0.30	0.14	0.16	0.18

1. Defined according to the department responsible for organising and teaching the subject. The dependent variable is the log of the grade obtained in the first exam taken in each subject area, which ranges from 18 (pass) to 31 (full marks with honours)
2. Normalized between 0 and 1.
3. As recorded on the first year of registration with the university. For students with income in the highest income bracket the actual income value is not recorded.
Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 7. Season of birth and academic performance

	(log) graduation mark[1]	(log) av. grade in the first two years[2]	(log) first Economics grade[2]	(log) first Math/Stat. grade[2]
	[1]	[2]	[3]	[4]
Month of birth				
1=February to November	-0.004	-0.002	-0.002	-0.000
	(0.004)	(0.005)	(0.006)	(0.007)
1=December	0.009**	0.009*	0.009	0.017**
	(0.004)	(0.005)	(0.006)	(0.007)
***Season of birth*[3]**				
1=winter	-0.015***	-0.018***	-0.018**	-0.001
	(0.005)	(0.006)	(0.007)	(0.009)
1=summer	-0.011**	-0.015***	-0.015***	-0.005
	(0.004)	(0.005)	(0.006)	(0.008)
1=fall	-0.007	-0.009*	-0.013**	0.010
	(0.005)	(0.005)	(0.006)	(0.008)
Controls				
1=female	-0.001	-0.007***	-0.013***	-0.005*
	(0.002)	(0.002)	(0.002)	(0.003)
High school results[4]	0.456***	0.550***	0.527***	0.577***
	(0.009)	(0.010)	(0.012)	(0.016)
1=resident outside Milan (province)	0.001	0.001	0.001	0.000
	(0.002)	(0.002)	(0.003)	(0.004)
Family income (log)[5]	0.001	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)
1=highest income bracket[5]	0.012	0.016	0.011	0.009
	(0.010)	(0.011)	(0.014)	(0.014)
Interactions of cohort and season of birth	Yes	Yes	Yes	Yes
Dummies for degree type (6)	Yes	Yes	Yes	Yes
Dummies for type of high school (5)	Yes	Yes	Yes	Yes
Regional dummies (18)	Yes	Yes	Yes	Yes
Cohort dummies (4)	Yes	Yes	Yes	Yes
Observations	5,269	5,269	5,269	5,269
R-squared	0.41	0.42	0.36	0.37

1. Maximum = 110; pass = 66.
2. Exam grades range from 18 (pass) to 31 (full marks with honours)
3. Spring is reference category.
4. Normalized between 0 and 1.
5. As recorded on the first year of registration with the university. For students with income in the highest income bracket the actual income value is not recorded.

Robust standard errors in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 8. Month of birth and admission test by areas

Admission years:	*1995-1998*	*2000-2002*							
	Overall result [1]	Overall result [2]	reading compreh. [3]	spatial-perception [4]	computer use [5]	math reasoning [6]	verbal relations [7]	logics of images [8]	verbal patterns [9]
Month of birth									
1=February to November	0.006	0.084*	0.041	0.075	0.108**	0.022	0.023	0.007	0.030
	(0.004)	(0.046)	(0.048)	(0.059)	(0.052)	(0.045)	(0.047)	(0.044)	(0.050)
1=December	0.009*	0.142**	0.081	0.130*	0.186***	0.032	0.041	0.105*	0.077
	(0.005)	(0.057)	(0.059)	(0.067)	(0.063)	(0.058)	(0.059)	(0.054)	(0.062)
Controls									
1=female	-0.027***	-0.352***	-0.104***	-0.069***	-0.161***	-0.481***	-0.142***	-0.021	-0.043*
	(0.002)	(0.021)	(0.023)	(0.024)	(0.023)	(0.022)	(0.023)	(0.022)	(0.023)
High school results[2]	0.564***	2.118***	1.238***	0.544***	0.841***	1.713***	1.376***	0.401***	0.885***
	(0.008)	(0.082)	(0.085)	(0.101)	(0.088)	(0.083)	(0.086)	(0.091)	(0.085)
1=resident outside	-0.002	0.093***	0.065*	0.020	0.018	0.115***	0.004	-0.073**	0.080**
Milan (province)	(0.003)	(0.033)	(0.034)	(0.034)	(0.033)	(0.034)	(0.035)	(0.035)	(0.035)
Dummies for degree type (6)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Dummies for type of high school (5)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Regional dummies (18)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cohort dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9,607	7,619	7,619	7,619	7,619	7,619	7,619	7,619	7,619
R-squared	0.10	0.19	0.09	0.03	0.04	0.14	0.10	0.02	0.05

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 9. Month of birth, admission test and academic performance

	(log) Graduation mark[1]		(log) average grade in the first two ac. years[2]	
	[1]	[2]	[3]	[4]
Month of birth				
1=February to November	0.002	0.003	0.004	0.005
	(0.003)	(0.003)	(0.004)	(0.004)
1= December	0.008*	0.009**	0.008*	0.009*
	(0.004)	(0.004)	(0.005)	(0.005)
(log) admission test score[5]	0.087***	-	0.137***	-
	(0.009)		(0.011)	
Observations	5,269	5,269	5,269	5,269
R-squared	0.41	0.40	0.43	0.42

1. Maximum = 110; pass = 66.
2. Time between September of the year of first enrolment and the graduation date (measured in quarters).
All regressions include the following set of controls: gender, high school results, residence outside Milan, family income, dummies for academic year, high school type, regional dummies, cohort dummies and a constant.
Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 10. Month of birth, admission test and academic performance by subject area

Subject[1]	[1]	[2]
Management		
1= December	0.002	0.003
	(0.006)	(0.006)
(log) admission test score[2]	0.107***	-
	(0.015)	
Economics		
1= December	0.017*	0.018*
	(0.009)	(0.010)
(log) admission test score[2]	0.236***	-
	(0.021)	
Mathematics & Statistics		
1= December	0.019*	0.021**
	(0.010)	(0.010)
(log) admission test score[2]	0.221***	-
	(0.024)	
History		
1= December	0.005	0.006
	(0.007)	(0.007)
(log) admission test score[2]	0.076***	-
	(0.015)	
Language		
1= December	0.004	0.004
	(0.006)	(0.006)
(log) admission test score[2]	0.087***	-
	(0.016)	
Law		
1= December	0.008	0.009
	(0.009)	(0.009)
(log) admission test score[2]	0.138***	-
	(0.020)	

1. The dependent variable is the log of the grade obtained in the first exam taken in each subject area.
1. Range 0-100. Average over various sections (reading comprehension, problem solving, computer use, et.).
All regressions include the following set of controls: a dummy for month of birth between February and November, gender, high school results, residence outside Milan, family income, dummies for academic year, high school type, regional dummies, cohort dummies and a constant.
Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 11. Month of birth and social behaviour

	1=no sport[1]	1=no discos[2]	monthly sex frequency[3]	1=current relationship[4]
Estimation method	probit	probit	OLS	probit
mean of dep. variable	*0.24*	*0.11*	*3.06*	*0.59*
	[1]	[2]	[3]	[4]
Month of birth				
1=February to November	0.045	-0.072	0.184	-0.160
	(0.139)	(0.159)	(0.544)	(0.153)
marg. effect	*0.007*	*-0.013*	*0.184*	*-0.062*
1=December	0.083	0.076	-1.223*	-0.460**
	(0.177)	(0.198)	(0.629)	(0.188)
marg. effect	*0.011*	*0.014*	*-1.223**	*-0.181***
Controls				
1=female	0.625***	0.024	0.578**	0.392***
	(0.077)	(0.084)	(0.279)	(0.076)
(log) High school results[5]	0.255	0.170	-3.420***	0.404
	(0.253)	(0.295)	(1.044)	(0.258)
1=live on one's own	0.114	-0.196**	0.188	0.004
	(0.080)	(0.099)	(0.332)	(0.086)
Dummies for region of birth (3)	Yes	Yes	Yes	Yes
Dummies for university region (3)	Yes	Yes	Yes	Yes
Home-town size dummies (3)	Yes	Yes	Yes	Yes
Dummies for father's education (3)	Yes	Yes	Yes	Yes
Dummies for mother's education (3)	Yes	Yes	Yes	Yes
Observations	1,689	1,690	1,647	1,319

1. Dummy coded 1 for students who answer *"never"* to the following question: *During the school year, do you practice any sport or physical activity?*
2. Dummy coded 1 for students who answer *"never"* to the following question: *Do you go to clubs or other places where you can dance?*
3. Coded to zero for students who have never had sexual intercourse.
4. Dummy coded 1 for students who have a steady relationship at the time of the interview.
5. Range 0-100.

Robust standard errors in parentheses. The marginal effects are computed at the average of the explanatory variables.
* significant at 10%; ** significant at 5%; *** significant at 1%