



Catching up over time: The impact of early school entry on school performance

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Abstract

This thesis examines the impact of early school entry on school performance in Italy using national standardized test data (*INVALSI*). Since student's age of entry in primary school may be endogenous, I employ an instrumental variable estimation strategy that leverages variations in the quarter of birth to compare test scores of younger and older students within the same cohort. Additionally, I use a propensity score matching approach to assess the impact of early school entry on similarly aged students from two adjacent cohorts. Results show that early entrants score significantly lower in both verbal and mathematics tests in grade 2. However, this score gap diminishes over time, becoming insignificant in verbal tests by grade 5 and narrowing in mathematics tests by grade 10. Furthermore, the analysis examines the existence of spillover effects at classroom-level, finding that the proportion of early entrants in a class does *not* negatively affect the performance of regular students. These findings suggest that while early school entrants may face initial challenges, supportive interventions can help mitigate the gap with respect to older peers over time. Policymakers should consider flexible strategies that aim at providing anticipating students with additional support, rather than prohibiting early entry.

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Resumo

Esta tese analisa o impacto da entrada precoce na escola no desempenho escolar em Itália, utilizando dados nacionais de testes padronizados (INVALSI). Uma vez que a idade de entrada do aluno no ensino primário pode ser endógena, utilizo uma estratégia de estimação de variáveis instrumentais que aproveita as variações nos trimestres de nascimento para comparar os resultados dos testes de alunos mais novos e mais velhos dentro da mesma coorte. Além disso, utilizo uma abordagem de correspondência de pontuação de propensão para avaliar o impacto da entrada precoce na escola em alunos com idades semelhantes de duas coortes adjacentes. Os resultados mostram que os alunos que entram mais cedo na escola têm resultados significativamente mais baixos nos testes verbais e de matemática no 2º ano. No entanto, esta diferença de resultados diminui ao longo do tempo, tornando-se insignificante nos testes verbais no 5º ano e diminuindo nos testes de matemática no 10º ano. Além disso, a análise examina a existência de repercussões ao nível da sala de aula, concluindo que a proporção de alunos que entram precocemente na escola numa turma não afecta negativamente o desempenho dos alunos regulares. Estes resultados sugerem que, embora os alunos que entram cedo na escola possam enfrentar desafios iniciais, as intervenções de apoio podem ajudar a reduzir o fosso relativamente aos colegas mais velhos ao longo do tempo. Os decisores políticos devem considerar estratégias flexíveis que visem dar apoio adicional aos alunos que entram mais cedo, em vez de proibir a entrada precoce.

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Palavras-chave: Economia Aplicada, Educação, Microeconometria

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1. Introduction

The decision of whether to anticipate school entry is a critical one, with potentially long-lasting implications for the school performance and future academic and labour market outcomes of students. While it can be intuitive that younger students tend to face disadvantages compared to their older peers, measuring the effects of early school entry remains challenging. Important studies in the academic literature have investigated the impact of the age at which students begin their schooling on their educational and later labour market outcomes. However, the heterogeneity in findings regarding school performance indicators (such as grades, secondary school choices, and years of schooling) and labour market outcomes (including income and occupational status) indicates that the debate is far from settled. The question of whether it is advantageous to advance school entry is crucial not only for individual decision-making but also for understanding its aggregate effects on education and productivity within a cohort of students.

This thesis aims to contribute to this discussion by providing new evidence from national standardized test in Italy, focusing on the effects of early primary school entry as defined by Italian law. The Italian case is particularly interesting due to the unique regulatory environment and comprehensive data availability, making this study a significant addition to the existing literature. Additionally, a peculiar aspect that makes this case worthy of analysis is the pronounced geographical variation in early school entry: the anticipation choice is in fact remarkably more diffused in southern and insular regions, with respect to the rest of Italy. Additional evidence on this issue can highlight one of the many factors that distinguish southern from northern Italy.

The thesis analyses the difference in national standardized tests (*INVALSI*¹) scores between regular and *anticipating* students across the Country. That is, this study approaches the topic from a new perspective by examining the effects of opting for early entry into primary school, as defined by Italian law, rather than directly focusing on the impact of age upon school performance. Specifically, this research investigates the impact of being an early entrant (namely, an *anticipating* student) on the scores achieved in national standardized tests, at both primary and secondary education levels.

¹ I want to acknowledge the *INVALSI* Institute (*Istituto Nazionale per la VALutazione del Sistema e di Istruzione*) for providing the access to the test's microdata, which have been analysed and used for this research project.

Using both *Propensity Score Matching (PSM)* and *Instrumental Variable (IV)* estimation methodologies, the analysis is conducted at two levels: within and between cohorts. First, I employ an IV approach to compare the test scores of early entrants and regular students within the same cohort for the school year 2022-23. Second, I use a PSM approach to compare the scores of similarly aged students, all born between January and April, from two consecutive cohorts (school years 2021-22 and 2022-23), who differ in their choice of early school entry.

The analysis conducted reveals a notable trend regarding early entrants, indicating a significant initial gap in both verbal and mathematics scores during primary school. However, this performance deficit gradually diminishes over time, with the gap becoming statistically insignificant in verbal tests by grade 5 and markedly reduced in mathematics assessments by grade 10. These findings hint at the presence of a "catch-up" mechanism, wherein the initial school disadvantage experienced by early entrants fades away as they progress through higher educational tiers. This trend mirrors research on kindergarten entry age, which similarly illustrates a diminishing performance divide over time (Datar, 2006; Elder and Lubotsky, 2009). Nevertheless, in specific cases such as mathematics tests, the gap between early entrants and their older counterparts may narrow in secondary school but still persists, aligning with research findings that underscore the disadvantages experienced by comparatively younger students, extending even into secondary school levels (Ponzo and Scoppa, 2014; Bedard and Dhuey, 2006). However, the results are in contrast with evidence coming from Germany, for which the impact of entry age on school performance appears to be negligible (Fertig and Kluwe, 2006).

While the focus of this thesis primarily centers on the immediate school performance of early entrants, it's crucial to acknowledge the broader body of literature concerning the long-term ramifications of school entry age on adulthood. For instance, studies conducted in Sweden suggest that early entrants exhibit inferior labour market outcomes (Fredriksson and Öckert, 2013). Conversely, investigations from Norway and the U.S. offer a spectrum of results, ranging from positive impacts on earnings to negligible effects on employment or income (Black, Devereux, and Salvanes, 2011; Dobkin and Ferreira, 2010). Additionally, some scholars found that younger entrants could face more schooling year, through the mechanism of compulsory school attendance laws (Angrist and Krueger, 1992).

Given the diversity of outcomes observed in various studies, it seems necessary for policymakers to adopt flexible approaches that support early entrants rather than imposing

rigid restrictions on early entry. Implementing additional resources and targeted interventions could significantly aid the students in catching up with their peers more effectively.

The thesis' structure is designed to provide a comprehensive understanding of the topic: Chapter 2 provides an overview of the Italian school system and the regulatory framework concerning early primary school entry as defined by Italian law, while Chapter 3 delineates the datasets and methodologies employed. Chapter 4 exposes the research findings, and finally, Chapter 5 reflects on the conclusions drawn from the study.

2. Institutional setting

The Italian school system is divided into two main cycles of studies². The primary education cycle covers the elementary schools (from grade 1 to 5): at the entry, children are 5 or 6 years old, and around 10 when they are supposed to end the cycle.

The regular entry framework provides that children can join primary school in September if they are six years old at most on the 31st of December of the first school year. However, the *Legge 53/2003*, that is the law emanated by the Italian Parliament in 2003 regarding the rules for the anticipation of school entry, gave the families of children born between the 1st of January and the 30th of April the possibility to choose for anticipating the beginning of their child's first grade of primary school. This implies that, potentially, the older child of a class could be born on the 1st of January of a given year while the youngest on the 30th of April of the following year (more than a year of age difference).

This thesis focuses on the difference in national standardized test scores between anticipating and non-anticipating students. The within cohort analysis (*IV* approach) basically compares younger versus older peers, while the between cohorts one (*PSM* approach) compares students born between the 1st of January and the 30th of April, that have the same age when taking the test but differ in the anticipation choice.

Since the analysis that is going to be presented will focus both on primary (grade 2 and 5) and secondary (grade 8 and 10) education levels, it can still be useful to describe the education steps after the primary school in Italy. The secondary education cycle is divided

² The very same framework holds true for both public and private schools.

into lower secondary education (middle schools³, grade 6 to 8), with the same education programs for every student in the Country, and upper secondary education (high schools, from grade 9 to 13). If middle schools are (expected to be) identical for each student with respect to course contents, the high schools are not. After the last year of middle school (grade 8), students can freely decide (given the authorization of their families) to enrol in one among three categories of high schools, *Lycea*, vocational or technical schools. The first one are the more academically oriented and culturally prestigious schools, while the vocational schools aim at giving the students the right expertise to join a profession (such as waiter, chef, host *et cetera*) after the end of high schools. The last category, the technical schools, use to provide programs to enable students to start their careers as certified accountants, chemistry, or IT technician, *et cetera*. Each student achieving the high school diploma in one of this three categories of schools, is free to apply for any faculty at college or university in Italy, without any sort of distinction. However, the preparation given by each type of school is different and can indeed effectively impact the likelihood of a given student to decide to attend a university degree course, rather than directly joining the labour market.

While several studies have been conducted to evaluate the effect of the age at school entry on secondary education choice (that can ultimately impact the years of education and the expected labour market outcomes), for instance in Italy (Ponzo and Scoppa, 2014) and Germany (Puhani and Weber, 2007; Jürges and Schneider, 2007), concluding that younger students at school entry are less likely to choose a more academic oriented secondary schools, this paper will not focus on this kind of impact nor is able to discern the test scores in high school by school category, due to a lack of data specificity in this sense. Additionally, this research will assess the impact of the anticipation choice up to grade 10, that is the last grade in High School were a minimum of homogeneity in the school programs is kept among different types of upper secondary education.

The national assessments are dispensed to students in grades 2, 5, 8, 10 and 13 by the *INVALSI* Institute, that is the Italian public institution deputed, among other objectives, to evaluate the preparation and the learning outcomes of Italian students, both at primary and secondary levels of education. These assessments are made through national standardized

³ Middle schools are typically less in numbers of institutes with respect to primary schools, as they gather more students. This results in a smaller number of observations for grade 8 tests, as the sampling method of the *INVALSI* involves first drawing the schools in a random sample, and then the classes. This will be explained in more detail in the following section.

tests taken in the same days by each student⁴ in Italy. The *INVALSI* assessments aims at evaluating mainly the performance of students in both verbal (in Italian language) and mathematical skills.

As will be shown in the following sections, starting from the data related to the *INVALSI* tests, this thesis is able to show further insights into the relationship between the anticipation status of the student and test performances, by grade and subject.

3. Data

a. Datasets

The datasets employed for the analysis consist in several cross-sections of test records of grades 2, 5, 8 and 10, sampled in school years 2021-22 and 2022-23, coming from the *INVALSI* microdata database. The samples have been collected by the Institute implementing a two-layer sampling method: first, the panel of schools has been randomly selected across the whole country, then in a second stage from the selected schools have been randomly drawn the classes whose student will be in the final sample.

The original (unfiltered) samples sum up to (about) 100'000 test records per school, year, considering both primary and secondary school students. For each (anonymous) record there is student's information about the family situation (education and job of the parents, socio-economic index), the month and year of birth, the region which the student belongs to, the citizenship of the parents and pre-school attendance (i.e. kindergarten).

In all the datasets, the dummy variable *anticip* takes the value of "0" if the student did not anticipate school entry (namely, is born between the 1st of January and the 31st of December of the beginning year of the first grade of school) and takes the value of "1" if the student anticipated (that is, if the birth date falls between the 1st of January and the 30th of April of the following year).

⁴ The *INVALSI* tests are compulsory for each student, as they are obliged to justify their eventual absence from school in the day of the assessment. However, the results are anonymous and accessible at individual level only by the interested student forwarding a formal request to the *INVALSI* Institute. A direct consequence of this framework is that (till now) the results of the tests do not impact the school career of the students (no impact in GPA nor in the diploma's grade). Considered this, it is reasonable to assume that students have not been disincentivized into participating at the *INVALSI* assessment (excluding mere indolence related motivations), and that the results should not suffer from this kind of bias.

In the between cohort analysis, the final datasets employed are instead composed with a different merging scheme: for all grades of education have been considered two adjacent cohorts taking the INVALSI tests in s.y. 2021-22 and 2022-23, as mentioned before. The samples have then been merged filtering just the records of the students born between the 1st of January and the 30th of April. The dummy variable *anticip*, as mentioned, takes value of 0 if the student did not anticipate primary school, hence, if he/she is one class behind and consequently took the same test one year later, in S.Y. 2022-23, and 1 otherwise (students one class ahead, taking the same test one year before, in S.Y. 2021-22). In other words, in the between-cohorts datasets, one for each grade, there are students born around neighbour months of the same year, taking the test when they have similar ages, but different in the age of entry in primary school (for example, a student born on the 1st of March who anticipated primary school takes the test in 2022, while another student also born on the 1st of March of the same year who did not anticipate is one class behind, taking the same test in 2023).

Furthermore, at both analysis levels, “repeating” students, that are students who have failed (and had to repeat) a given school grade, have been filtered out. The decision of limiting the analysis to just non-repeating students has been made to control for additional potential sources of bias in the results. As a matter of fact, some scholars concluded that younger entrants are more likely to repeat a grade than others (Elder and Lubotsky, 2009). Considering that repeating students by definition have worse performances with respect to their (regular) peers, the average in the two groups could be *a priori* biased, if it is assumed a relationship between repeating a school grade and the anticipation choice. Furthermore, to isolate the core of the anticipating student group, exceptional students anticipating outside the perimeter of the law have been ruled out. Those are students born after the cut-off date of the 30th of April, but still allowed exceptionally to anticipate primary school’s entry, for individually assessed reasons.

Lastly, a useful feature of the datasets is the *INVALSI* score system (*WLE* score), based on the “Rasch scoring system”. This scoring procedure first provides that the average national raw score of the tests (for each year) is set at 200 points, then each individual test is graded accordingly⁵. This implies that the scores are adjusted to the performance of the

⁵ For example, if out of 100 points for each subsection of the test, the weighted average score for that grade in that year is 70, the students scoring 70 in all subsections of the test will have an *INVALSI* score of 200. Then the other tests will be graded accordingly, weighting each subsection of the test with respect to the “average test”. This scoring system is also adjusted for a *cheating* factor: the *INVALSI*, through the measure of some intra-test and inter-tests factors adjusts the grades of a given class reducing the scores proportionally to the likelihood that

whole cohort, allowing for comparisons between cohorts without the need of time-invariant cohort controls. Consequently, this scoring system allows to easily evaluate a singular test record: if the student scores less than 200 that means that the student achieved a lower level of competences with respect to other peers countrywide, and *vice versa*.

The next subsection will briefly go through the summary and descriptive statistics.

b. Descriptive statistics

An interesting fact emerging from the data is the strong territorial differences in primary school anticipation choice. Like in many other aspects at both social and economic level, Italy is divided in two different frames, the Centre-North and the South (and islands) of the Country. As it is possible to see in Table I, in both southern and insular regions the percentage of anticipating students is consistently higher with respect to the regions of the Centre and North of Italy. Furthermore, about 70% of anticipating students are within the Southern or Insular regions (which account only for about 20% of the whole resident population of Italy). Since as it is known southern and northern regions of Italy account for several differences, while addressing the research question the geographical differences must be taken into consideration: the following sections will show how the analysis tried to control for the related issues of endogeneity, among the other factors.

In addition to the geographical divergences, looking at the descriptive statistics in Table I it is possible to notice closely some socio-demographic differences. For instance, the two groups differ in the education of the parents: anticipating students have a higher share of parents that achieved at least a high school diploma; additionally, mothers of anticipating students are more likely to have attained at least a bachelor's degree.

Furthermore, the share of parents having the Italian citizenship is slightly higher for anticipating students. This suggests that the early entry option is marginally more preferred among family sharing Italian citizenship.

Lastly, the students differ with respect to their background in terms of pre-school attendance (i.e. kindergarten), and obviously by age of entry in primary school.

the class cheated on the tests. The INVALSI also uses third party personnel to assess the right development of testing procedures: the *cheating* factor also considers the reporting of suspicious in-class activities during the assessments.

	Not anticipating	Anticipating	
	mean	mean	Difference
Family background			
Socio-economic index	0.009	0.008	0.001
Father high school	0.652	0.742	-0.09
Mother high school	0.752	0.794	-0.042
Father degree	0.316	0.234	0.082
Mother degree	0.354	0.438	-0.084
Father Italian citizen	0.850	0.904	-0.054
Mother Italian citizen	0.821	0.884	-0.063
Student background			
Pre-school attendance	0.579	0.628	-0.049
Age of entry in grade 1 (in months)	74	67	7
Region			
North-West	0.199	0.074	0.125
North-East	0.215	0.071	0.144
Centre	0.200	0.106	-0.189
South	0.210	0.389	-0.179
Islands	0.175	0.360	-0.185

Table I – Socio-demographic summary statistics by anticipation status.

To try to disentangle the effect of the anticipation choice on test scores, the following sections will show the econometric methodologies implemented.

4. Methodology

a. Instrumental Variable approach

As mentioned in the introduction, as age of entry in school could be endogenous, I employ an instrumental variable estimation strategy to try to isolate the causal effect of interest. The reason is that the age of entry in primary school could be correlated with other characteristics, which could ultimately lead a simple OLS estimate of Y (the score) over an intercept and a treatment dummy D (the anticipation status), to biased results (Ponzo and Scoppa, 2014). In this work, it will be attempted the estimation of the *Local Average Treatment Effect (LATE)* of anticipating the entry in primary school.

The instrumental approach proposed tries to exert the variation in the quarter of birth, as many other important works in the broader literature on education (Angrist and Krueger, 1992; Card, 2001): in particular, the proposed instrument (Z) takes value of “1” if the student is born in the first quarter, “0” otherwise. Therefore, the econometric setting showing up is a standard situation for which both treatment (potentially endogenous) and instrument are dummy variables. Hence, the probability limit of the *IV* estimator, pooling random samples of students born within and outside the first quarter (Card, 2001) and using Z_i as an instrument for anticipation choice is:

$$\begin{aligned} \text{plim } \beta_{iv}^{anticip} &= \frac{\text{cov}[\log \text{score}_i, Z_i]}{\text{cov}[\text{anticip}_i, Z_i]} \\ &= \frac{E[\log \text{score}_i | Z_i = 1] - E[\log \text{score}_i | Z_i = 0]}{E[\text{anticip}_i | Z_i = 1] - E[\text{anticip}_i | Z_i = 0]} \end{aligned}$$

Therefore, in this framework, with a dummy for the treatment and the instrument, and without covariates, the 2SLS is the Wald estimator (Pischke, 2016).

It is now necessary to discuss the two main conditions necessary for the instrument to consistently allow an estimation of the *LATE*, that are the «existence of the instrument» and the «monotonicity» (Angrist and Imbens, 1994). The first condition (existence of the instrument) requires that the instrument is a random variable Z such that it does not directly affect the outcomes, but instead is correlated with the participation into the treatment. It seems the case that this assumption holds true in this setting. Bedard and Dhuey (2006), through a cross-country comparison where countries have different school entry cut-off

dates, confirmed that the month of birth itself has no direct influence on achievement, indicating no “season of birth” effects. Elder and Lubotsky (2009) and Datar (2006) have reached similar conclusions by examining different cut-off dates among US States. Furthermore, being born in the first quarter does not *univocally* identify the age of entry in school of the student (which could be correlated with actual age, thus the score), since students born in the first quarter could be older or younger entrants. Additionally, the relevance of the instrument (that is the direct relationship between the treatment status and the instrument) is ensured by the law on the anticipation of school entry, which entitles only students born in earlier months of the year to anticipate their entry in primary school. This framework ensures that students born outside the anticipation window (namely, the vast majority of students born outside the first quarter, $Z_i=0$) have zero (or low) probability of participating into the treatment. This feature is useful as the existence of a value z , such that P_z (probability of getting the treatment conditioning on the instrument) is equal to zero (Heckman, 1990), prevents the treatment effects to be influenced by cross-shifts in participation status due to a change in the instrument (Angrist and Imbens, 1994).

The second condition, that is the (strict) monotonicity, aims at ensuring that the relationship between the selection into the treatment and the instrument is monotonic. This implies that, if the likelihood of selection into the treatment is higher when $Z = 1$, with respect to $Z = 0$, then treated individuals with $Z = 0$ must receive the treatment also given $Z = 1$ (Angrist and Imbens, 1991). Again, it is reasonable to assume that this condition holds true in the setting of this research. For the reason presented above (the regulatory framework), first we can say that the likelihood of anticipating entry in primary school is increasing with respect to the instrument, that is people born in the first quarter have higher chances of anticipating their entry in school; additionally, it is also reasonable to assume the hypothesis that an anticipating student born outside the first quarter would have anticipated also if born in the first quarter.

Holding true the two conditions discussed above, it is possible a consistent estimate of the *Local Average Treatment Effect* for the subset of “compliers”, that can be identified as students that are induced to anticipate their entry in primary school, given their quarter of birth. In particular, when the second condition is met, it is possible to prevent the so-called “defiers”, that are individuals that self-select out of the treatment when the instrument is «switched-on» (Pischke, 2016), to affect the IV estimates. Furthermore, “always takers” and “never takers”, that are individuals whose treatment status is independent, in one way

or in another, from the instrument, have their influence ruled out holding true the first condition.

As mentioned, the IV strategy in this setting allows only for a *local* estimation of the treatment effects: this limitation is tried to be compensated with another attempt of estimation of the treatment effects, through a *Propensity Score Matching* approach, which will be presented in the following subsection.

b. Propensity Score Matching

In this section, it will be presented another methodology used to address the research question, the *Propensity Score Matching (PSM)*, which has indeed not been explored yet by the literature regarding early school entry.

The decision of proposing also a *Propensity Score Matching* technique goes in the direction of further dealing with potential issues of endogeneity, since as mentioned the choice of anticipating the entry in primary school could be correlated with other unmeasured factors, and the instrumental variable approach, again, aims at estimating only locally the average treatment effect (*LATE*). The *PSM* approach in this setting is proposed to aim at a plausible estimate of the average treatment effect on the treated, *ATT* (Cameron and Trivedi, 2005).

As stressed before, most of the literature about the topic focus on the implementation of *IV* strategies to isolate the causal effect of interest; however, since the choice of anticipating the entry in primary school is mostly driven by the family willingness to, a *PSM* approach could in principle better disentangle the relationship between family and social context characteristics with the effective choice of anticipating primary school, ultimately allowing to match students with very similar background characteristics but different in the anticipation choice. In other words, if the choice of anticipating the entry in school depends on families, it is useful to implement a strategy, such as the *PSM*, which allows, at the same time, to have some insights into the main drivers of the choice and to compare individuals (students) as similar as possible, with respect to background and context.

To try to compare students as similar as possible, the *PSM* analysis proposed is restricted only to students born between January and April of two adjacent cohorts, that are students born in the very same year, around near months, but different in the choice of anticipating

their entry in primary school. In other words, the students compared in each grade are born in the same year, between January and April, however anticipating students are one class ahead and thus take the same test one year before their peers who did not anticipate grade 1 entry.

Within the method presented above, the choice of the matching variables is linked to the literature on education, in particular to an application of the performance comparison between pupils attending catholic school vs not (Nguyen, Taylor and Bradley, 2006).

The *PSM* approach involves a two-step procedure, that is choosing a link function (logit or probit, for instance) and estimating accordingly a conditioned probability model. The second step, after having estimated the predicted probabilities according to the model, consists in matching the units following an algorithm, based on the *scores* (predicted probabilities). After the units are matched, to get an estimate of the *ATT* it's sufficient to compare treated (anticipating students) against non-treated sample averages, in the simplest matching setting.

The choice of the link function is based on contributions in the literature on education economics (Powell, Hull and Beaujeanby, 2020). Hence the *PSM* approach in this analysis starts first estimating the following logit model (1):

$$P(\text{anticip}_i = 1 | X_i) = \Lambda(\beta_0 + \beta_1 \text{ESCS}_i + \beta_2 \text{kinderg}_i + \beta_3 \text{italianmoth} + \beta_4 \text{italianfath} + \sum_{r=1}^{R-1} \beta_{4+r} \text{region}_{r,i} + \sum_{f=1}^{F-1} \beta_{4+R+f} \text{fatheduc}_{f,i} + \varepsilon_i + \sum_{m=1}^{M-1} \beta_{4+R+F+m} \text{motheduc}_{m,i}) \quad (1)$$

Through this non-linear model it is possible to fit expected probabilities given a set of regressors related to the student's family background (as in the education literature): in particular, the model considers the education of both parents (with a dummy for each level of educational attainment, from elementary school to a doctorate degree), their socio-economic index (ESCS), whether the student attended some kind of pre-school (i.e. kindergarten), as it could have impact in later education stages (Datar, 2006; Elder and Lubotsky, 2009), and lastly the student's region and whether the parents are Italian citizens or not.

As mentioned, the second step of the methodology involves using a matching algorithm, which matches the observations between the two groups (anticipating and non-anticipating students) based on the estimated conditioned probabilities (the *scores*) assigned at each unit. The algorithm chosen is the *nearest neighbour*, based again on some examples in the literature (Powell, Hull and Beaujeanby, 2019). Even if, by construction, the downside of

this method could be the reduced sample size of the matched individuals, it is still the most straightforward method (Nguyen, Taylor and Bradley, 2006). In other words, the conceptual simplicity of this algorithm could be preferred in a context where the initial datasets are not very limited in the number of observations, since the number of assumptions and parameters required for the *nearest neighbour* is much more restrained with respect to other algorithms or procedures, such as the *stratification method*, whose implementation involves setting score ranges to define the strata and repeated adjustments to find the right covariates balance (Dehejia and Wahba, 2002).

After the second step, that is once the units are matched and the covariates are balanced for both groups, the treated and non-treated units are as comparable as possible with respect to their family background (that is the aspect on which the choice of anticipating primary school can mostly depend on). Basically, through this method it is possible to construct a counterfactual, considering the non-treated matched units as a control for our observed treated group. To have an estimate of the *ATT*, it is then possible to fit the following model (2) on matched data, through OLS:

$$\ln(score_i) = \beta_0 + \beta_1 anticip_i + \varepsilon_i \quad (2)$$

Even if family characteristics could influence the most, in principle, the choice of anticipating school entry, it is still needed to assume that ability is independent on the anticipation choice, conditioning on family characteristics. In other words, to consistently estimate the *ATT* it is needed to assume that the potential outcomes in scores are independent from the anticipation choice, conditioned on the probability of anticipating school entry given a vector X of pre-treatment characteristics (Rosenbaum and Rubin, 1983; Nguyen, Taylor and Bradley, 2006).

5. Results

a. Instrumental variable approach: estimation of the LATE

The following Table II shows the results of the 2SLS estimation of the student's score on the anticipation status, using the quarter of birth as instrument, as discussed previously.

Panel A: verbal and language test (ITA)				
Dependent variable:				
	log(score)			
	Grade 2	Grade 5	Grade 8	Grade 10
	(1)	(2)	(3)	(4)
anticip _{iv}	-0.030*** (0.009)	-0.002 (0.007)	-0.001 (0.012)	-0.007 (0.006)
Constant	5.248*** (0.002)	5.264*** (0.002)	5.274*** (0.003)	5.291*** (0.002)
Observations	15,382	16,164	3,655	16,536
R ²	0.001	0.00001	-0.00001	0.0002
Adjusted R ²	0.001	-0.0001	-0.0003	0.0001
Residual Std. Error	0.268 (df = 15380)	0.216 (df = 16162)	0.188 (df = 3653)	0.201 (df = 16534)
<i>Note:</i>	*p<0.1; **p<0.05; ***p<0.01			

Panel B: mathematics test (MAT)				
Dependent variable:				
	log(score)			
	Grade 2	Grade 5	Grade 8	Grade 10
	(1)	(2)	(3)	(4)
anticip _{iv}	-0.049*** (0.008)	-0.013* (0.007)	-0.021 (0.014)	-0.029*** (0.005)
Constant	5.230*** (0.002)	5.236*** (0.002)	5.255*** (0.004)	5.290*** (0.001)
Observations	15,914	16,492	3,652	16,275
R ²	0.002	0.0002	0.0004	0.002
Adjusted R ²	0.002	0.0001	0.0001	0.002
Residual Std. Error	0.255 (df = 15912)	0.222 (df = 16490)	0.211 (df = 3650)	0.178 (df = 16273)
<i>Note:</i>	*p<0.1; **p<0.05; ***p<0.01			

Table II – Two Stage Least Square (2SLS) estimation.

Looking at Panel A (verbal and language test), on average, anticipating students gain lower scores by (around) 3% with respect to regular students only in grade 2. In higher education grades, this gap seems to be filled, as the results show no more significant negative differences in the two groups.

However, the results in Panel B (mathematics test) show a slightly different pattern in the anticipation gap. The difference in scores in grade 2 has the highest value: anticipating students, according to the estimates, score around 4.9% less than their older peers on average. This gap tends to close in higher education stages, but it does not fade away completely, as in verbal and language assessments. As a matter of fact, up to grade 10, anticipating students suffer from a negative gap in scores by approximately 2.9%.

Since grade 2 and grade 10 are near the beginning of primary school and high school, respectively, it seems that anticipating students face lower scores more when they start a new school cycle. In fact, in grade 5 and 8 that are the final grades of primary school and middle school respectively, the gap is lower or null.

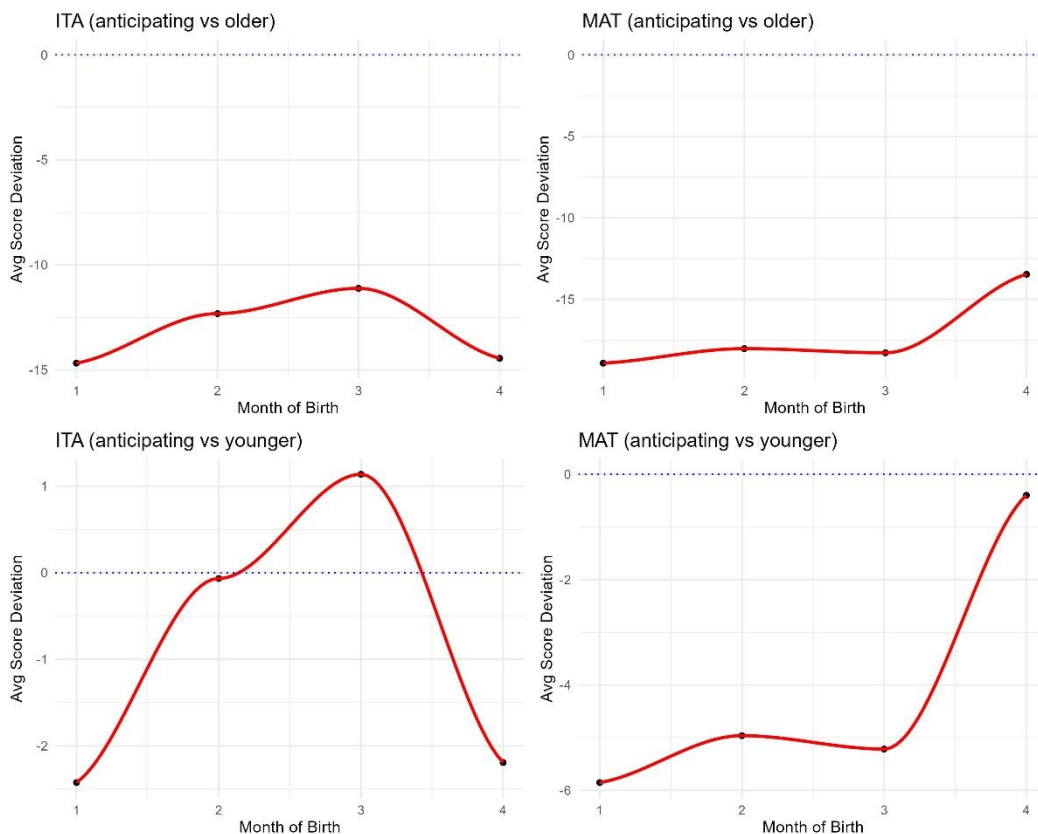


Figure I – Distribution of scores by anticipation status and grade.

Furthermore, looking at Figure I it is possible to see that the magnitude of the anticipation gap is linked with age. Looking at the scores of anticipating students by month (from

January to April) compared with scores of regular students, it seems clear that the average deviation in scores is higher with respect to older regulars (i.e. born in January of the previous year) than to younger regulars (i.e. born in December).

The main reason for the lower scores that anticipating students face at some stages can be reconciled with the relative maturity of the student, directly linked with the age of entry. Early entrants can be less prepared to face the challenges of school, mainly when they are not mature or experienced enough. This effect is in fact stronger when students are around 5 or 6, and becomes less pronounced in later grades, as Figure II shows.

The persistence of the gap, in the case of mathematics test scores, can be read as a result of the compounding effects of the disadvantage faced in early grades. That is, the relatively low level of maturity of anticipating students at the beginning of their education path, may prevent them from efficient learning (Ponzo and Scoppa, 2014). This circumstance, as the mathematics assessments show, can have long-lasting consequences, even if small, up to grade 10 in high school.

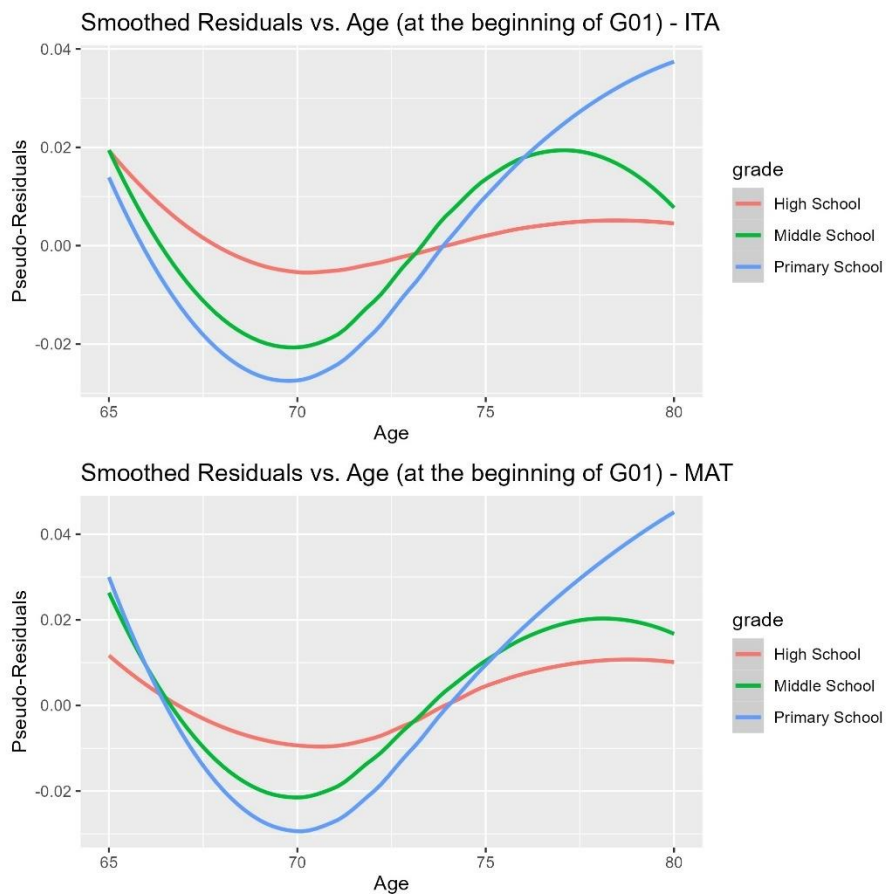


Figure II – Residual variance of the 2SLS estimated scores in a non-parametric fitting against age of entry in school (in months)

b. Propensity Score Matching: estimation of the ATT

Table III shows the estimated *ATT* of the anticipation choice over scores, considering only students born between January and April of two adjacent cohorts, as mentioned in the introduction. The results are consistent with the previous *LATE* estimation in finding a negative gap between the two groups in early stages. That is, anticipating students that have similar age when attempting the test, and have similar family and social background with respect to their regular peers, still score lower in both types of assessment in grade 2. In particular matched anticipating students, according to the estimates, score approximately 2% lower than their older peers in the language and verbal assessment, while around 4.4% less in mathematics tests.

As noted in the previous analysis setting, the anticipation gap tends to close as the education grade increases. Considering only students born in the first term, the differences in the scores become not significant among the two groups earlier, starting from grade 5 (both in verbal and in mathematics assessments). This suggests again that age plays a role, not only considering the one of entry, but also the age at which the test is taken.

A further remark is that the gap confirms to be deeper in mathematics than in verbal and language tests, suggesting that relatively low level of maturity at the beginning of primary school can have higher negative returns in subjects more logic-oriented like mathematics. However further evidence and research is needed to fully disentangle this aspect of the more general issue of early school entry.

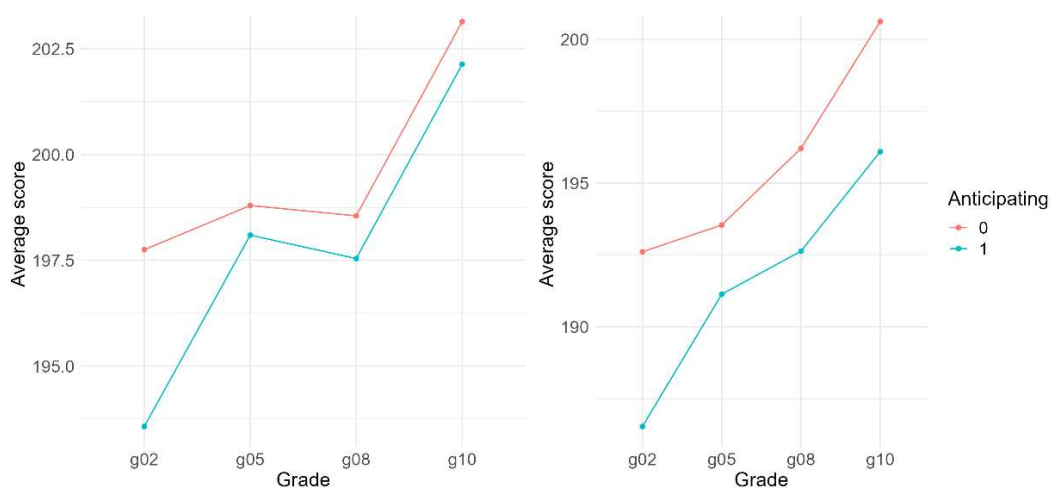


Figure II – Pre-matching average scores by anticipation status: verbal and language test on the left and mathematics test on the right, by grade.

Panel A: verbal and language test (ITA)				
Dependent variable:				
	log(score)			
	Grade 2	Grade 5	Grade 8	Grade 10
	(1)	(2)	(3)	(4)
anticip _{psm}	-0.020* (0.011)	-0.008 (0.007)	-0.021 (0.014)	-0.008 (0.005)
Constant	5.274*** (0.008)	5.285*** (0.005)	5.308*** (0.010)	5.301*** (0.004)
Observations	2,274	3,276	678	5,042
R ²	0.001	0.0004	0.003	0.0005
Adjusted R ²	0.001	0.0001	0.002	0.0003
Residual Std. Error	0.258 (df = 2272)	0.193 (df = 3274)	0.185 (df = 676)	0.185 (df = 5040)
<i>Note:</i>	*p<0.1; **p<0.05; ***p<0.01			
Panel B: mathematics test (MAT)				
Dependent variable:				
	log(score)			
	Grade 2	Grade 5	Grade 8	Grade 10
	(1)	(2)	(3)	(4)
anticip _{psm}	-0.044*** (0.009)	-0.010 (0.008)	-0.017 (0.016)	-0.002 (0.005)
Constant	5.259*** (0.007)	5.247*** (0.005)	5.276*** (0.011)	5.276*** (0.003)
Observations	2,336	3,298	674	4,980
R ²	0.009	0.001	0.002	0.00004
Adjusted R ²	0.009	0.0002	0.0001	-0.0002
Residual Std. Error	0.226 (df = 2334)	0.223 (df = 3296)	0.209 (df = 672)	0.174 (df = 4978)
<i>Note:</i>	*p<0.1; **p<0.05; ***p<0.01			

Table III – Estimation of the ATT of anticipation choice on a sample of matched students.

c. Spillovers at class level: effects on regular students' scores

As anticipating students could need additional support by the teachers, in particular in early grades of school, it would be a reasonable hypothesis that in classes with many early entrants, regular students could get less attention. For this reason, it could be interesting to analyse the impact of the proportion of anticipating students in class on the performances of regulars (namely, non-anticipating students) in primary school.

Region	Percentage of anticipating students in class					
	mean	Grade 2 max	sd	mean	Grade 5 max	sd
North-West	2.64	28.57	4.30	2.70	21.43	3.94
North-East	2.44	16.67	3.67	2.20	13.33	3.48
Centre	3.86	23.08	5.41	4.80	36.36	6.19
South	12.29	46.67	10.30	13.69	43.75	10.19
Islands	13.01	42.86	10.89	15.16	56.25	11.74

Table IV – Summary statistics at class level on the percentage of anticipating students, by region.

As mentioned previously, the anticipation of primary school has a strong geographic characterization in Italy. As it is possible to see in Table IV, in primary school, the classes where the share of anticipating students is the highest on average, are the ones from southern and insular regions. In some cases, classes can have up to half of their students anticipating primary school entry.

A simple OLS estimate of the scores of regulars over an intercept and the proportions of anticipating students in class, could suffer from endogeneity related issues. Classes with different shares of early entrants could systematically differ from each other through controllable and uncontrollable factors, that could ultimately be correlated with school performance. For this reason, an *IV* approach is again proposed, following closely the framework presented in previous sections.

The instrument proposed is based again on the quarter of birth. The proportion of anticipating students (P_c^a) in class is instrumented with the proportion of students born in the first quarter (P_c^{fq}), within the first stage estimation:

$$P_c^a = \beta_0 + \beta_1 P_c^{fq} + \epsilon_c$$

In the second stage estimation $\log(Y_c^{na})$, that is the logarithm of the average score of non-anticipating students in class c , is regressed on the instrumented proportion of anticipating students in class c , derived from the previous first stage, $P_c^{a,iv}$:

$$\log(Y_c^{na}) = \beta_0 + \beta_1 P_c^{a,iv} + \epsilon_c$$

The following Table V show the results of the 2SLS estimation, considering only the southern regions, in which, as discussed, the phenomenon of school anticipation is more marked.

2SLS: second stage estimation				
Dependent variable:				
	$\log(Y_c^{na})$			
	Grade 2			Grade 5
	(1)	(2)	(3)	(4)
$P_c^{a,iv}$	0.010 (0.025)	0.014 (0.026)	-0.0003 (0.015)	0.002 (0.015)
$size_c$		0.002 (0.002)		0.005*** (0.001)
Constant	5.288*** (0.047)	5.256*** (0.053)	5.267*** (0.028)	5.186*** (0.036)
Observations	316	316	345	345
R ²	0.001	0.006	0.00000	0.036
Adjusted R ²	-0.003	-0.0001	-0.003	0.030
Residual Std. Error	0.113 (df = 314)	0.113 (df = 313)	0.104 (df = 343)	0.102 (df = 342)
<i>Note:</i>	*p<0.1; **p<0.05; ***p<0.01			

Table V – Second stage estimation of 2SLS regression of regulars' scores over proportion of anticipating students by class.

Looking at the estimates in Table V, it is possible to conclude that the share of early entrants in a given class does not affect the average scores of non-anticipating students at primary school level. It would be reasonable also to conclude that if anticipating students require a higher portion of the support that a teacher, by time constraints, can limitedly allocate to a certain class, this does not impact, on average, the scores of regular students. Alternatively, the anticipation status could be not correlated at all, in principle, with the share of attention that a teacher provides to a certain student.

6. Conclusions

This thesis investigates the effects of early school entry in Italy, providing evidence of its short-term and long-term school impact. The analysis is conducted implementing national standardized test data (*INVALSI*) and employing two different methodologies such as the *Propensity Score Matching (PSM)* and the *Instrumental Variable (IV)* estimation.

The analysis provided in the thesis consistently shows that students who start school earlier, referred to as *anticipating* students, tend to perform worse in the initial stages of their education path with respect to their peers who start at the regular age. The gap in scores is evident in both verbal and mathematics assessments in grade 2, where early entrants scoring approximately 3% lower in verbal tests and nearly 5% lower in mathematics. These findings align with much of the existing literature that highlights the initial disadvantages faced by younger students in school paragraph. Furthermore, the disadvantage faced by early entrants diminishes as they progress through their educational path. For instance, by grade 5, the gap in verbal test scores becomes statistically insignificant. In mathematics, even if the gap persists longer, it significantly narrows by grade 10. These results indicate that the initial maturity differences, which is likely to contribute to the score gaps in early stages, become less impactful as students grow older and gain more educational experience. It suggests the existence of a "catch-up" mechanism, for which younger students eventually fill the gap with their older peers in terms of school performance in later education stages.

An additional aspect examined by this research is whether the proportion of early entrants in class affects the school performance, namely the scores, of regular students. The results from the IV estimation show that the share of early entrants does not significantly impact

the scores of non-anticipating students. This suggests that any additional support that early entrants might require does not undermine the attention and resources made available to regular students by teachers, at least in primary school environments.

The findings of this thesis have important policy implications. Given the initial disadvantages faced by early entrants, it would be advisable to provide additional support to these students, particularly in the early school years. However, as the performance gap narrows over time, completely prohibiting early entry may be unnecessary and potentially counterproductive. Instead, policies should aim to address the specific needs of early entrants, helping them catch up more quickly with their older peers.

Moreover, this thesis suggests several opportunities for further research. Firstly, a richer analysis of the mechanisms behind the catch-up effect could provide more targeted strategies for supporting early entrants. Longitudinal studies tracking students after secondary school into higher education and the labour market would also be valuable in understanding the long-term adulthood consequences of opting for early school entry.

In conclusion, while early school entry presents initial challenges for students, the evidence suggests that these disadvantages fade away over time, partially or completely. Policymakers should consider flexible and supportive approaches rather than restrictive ones, ensuring that all students, regardless of their age of entry, have equal opportunities of performing well in national tests. The findings of this research contribute to a broader literature in education economics, in particular to the discussion on the effects of age onto school attainments.

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