**Peer effects and scholastic achievement: evidence of causal effects using age at school entry as exogenous variation for peer quality**

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**Abstract:** This paper evaluates the diffusion of peer effects on academic achievement of 4th grade students in the Brazilian public school system. Using data from *Prova Brasil* 2013, the identification strategy builds on the use of an IV approach, in which the instruments for peers’ performance are the proportions of peers born in the first or second semester of the year. The idea behind the instruments is that compulsory school attendance laws generate variation in the child’s age at school entry, which, in turn, make the date of birth within the year an important determinant of educational achievement and, at the same time, plausibly exogenous to the quality of the student’s peers. The results demonstrate that schools with high proportions of peers born in the 2nd semester *(started school at a relatively older age)* tend to perform better, in average, than those that concentrate children born in the 1st semester, even after the inclusion of a wide range of control variables. For the math evaluation, a one standard deviation increase in the peers’ grade generates an improvement of 32% standard deviations in individual achievement. For the Portuguese language evaluation, this effect represents an increase of 30% SD of the student grade.

**Keywords:** School performance, Peer effects, Instrumental variables.

**Resumo:** Este artigo avalia a difusão do efeito de pares sobre o desempenho acadêmico de alunos do 5º ano no sistema público brasileiro de ensino. Usando dados da Prova Brasil de 2013, a estratégia de identificação se baseia na abordagem de variáveis instrumentais, em que os instrumentos para o desempenho dos pares consistem nas proporções de pares nascidos no primeiro ou segundo semestre do ano. A ideia deste instrumento consiste no fato de que as leis que definem o ingresso na escola geram uma variação na idade que a criança inicia a escola, fazendo com que a data de nascimento ao longo do ano se torne um importante determinante do desempenho escolar sendo, ao mesmo tempo, exógeno à qualidade dos pares. Os resultados demonstram que escolas com maiores proporções de estudantes nascidos no segundo semestre *(que entraram na escola relativamente mais velhos)* tendem a apresentar melhor performance. Para as avaliações de matemática, o aumento de um desvio-padrão na nota média dos pares gera um acréscimo de 32% desvios-padrão da nota individual. Para as avaliações de português, esse efeito representa um aumento de 30% DP da nota do aluno.

**Palavras chave:** Desempenho escolar, Efeito de pares, Variáveis Instrumentais.

**JEL: I20, I24, I25, C13**

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**1 Introduction**

One of the prominent issues within the economics of education is devoted to understanding the role of peers in educational outcomes[[1]](#footnote-1). The behavioral influence received from friends in the social interaction process might affect educational results not only during the schooling period, but also latter in life, having an effect on standards of educational attainment to employment decisions. Friends are a source of interaction, motivation and aspiration in the learning process and their influence operates on slightly distinct mechanisms. For example, in a more subtle way, students can benefit from externalities of knowledge created by discussions and questions from other classmates. Peer effects can also be disseminated by imitation or contagion, in which case students have individual motivations for displaying a behavior/performance that is consistent with the group in which he or she is inserted.

If the individual academic performance increases as the average class performance increases, then peer effects act as a social multiplier providing, as a result, implications for educational policies (Manski, 1993). These policies can guide group formation, and can be applied to school unit organization or to the whole educational system design. Would it be better to mix students with different academic performances instead of segregating them? Do schools that separate students by gender raise students’ academic performance? Should students of different ages be in the same class, or is the coexistence between younger and older students not beneficial? Should the child study in the neighborhood where he/ she lives? Does mixing students with special needs with other students improve the outcome of the former without impacting the performance of the latter? Questions like these support the development of educational policies and are important to school managers, parents, students and the society as a whole to consider.

Empirical identification of peer effects, however, is an arduous exercise. As first noted by Manski (1993), and after by many other authors, the greatest difficulty is to properly separate endogenous peer effects, from other contextual or correlated effects. In educational contexts, endogenous peer effects represent the influence of peer’s academic outcomes on individual achievement. The contextual effect captures the effects of exogenous peers attributes, such as age, gender, race, etc, on individual outcome. And the correlated or confounding effects correspond to non-observable characteristics shared by individuals in the same group that are correlated with the peer variable of interest. These common traits occur either for being exposed to the same institutional environment, or for homophily, which is the propensity of people with similar attributes to associate with each other.

Despite the fact that the role of peers in educational outcomes has already been vastly exploited in the international literature[[2]](#footnote-2), in Brazil such literature is still scarce with few exceptions, such as the works of Raposo (2015), Firpo *et al.* (2015), Oliveira (2015), Koppensteiner (2012) and Pinto (2008). The present paper contributes with additional evidence for the Brazilian context and addresses the identification issues building on the use of an instrumental variable (IV) which determines peers’ educational performance at school, but which is nonetheless exogenous to any unobserved factor related to the potential individual outcome. Specifically, the instruments being considered here are the proportions of peers born in the first or second semester of the year, as proposed by the work of Goux and Maurin (2007)[[3]](#footnote-3).

The intuition behind such instrument is based on the relative age literature, which demonstrates that date of birth within the year is an important determinant of educational achievement and, at the same time, it is plausibly exogenous to the quality of the student’s peers. The idea is that educational achievement is related to age at school entry because of the age variation induced by compulsory school attendance laws. In many countries there are attendance laws that define the age at school entry based on a specified cut-off date, which induce some children to enter at a relatively older (or younger) age. For instance, in Brazil there is a Federal law establishing that a child should enter in the 1st year of school if he/ she turns six years old until the beginning of the school year (which usually occurs in March)[[4]](#footnote-4), those born after that should wait until the next year. In Chile and other Latin American countries this cut-off is the first semester of the year. In the US and other European countries attendance laws require students to enter school in the fall of the year in which they turn six.

Goux and Maurin (2007) find the proportion of 15 years old children held back a grade in France is about 15 percentage points higher for children born at the end of the year – the least mature of their class – than for children born at the beginning[[5]](#footnote-5). In the case of our study, we find 4th graders students born in the second semester – relatively older in the Brazilian scholar calendar – tend to perform better in math and Portuguese language exams of *Prova Brasil*. Based on such evidence, one simple way to identify the influence of scholar peer effects, in the present paper, is to test whether student's performance at school is affected by the distribution of dates of birth within the year of the other peers from the same school, using data from the *Prova Brasil* exams for the year of 2013.

The rest of the paper is organized into five additional sections. Section two presents the IV identification strategies using information on peer’s date of birth to estimate peer effects on academic performance. The third one describes *Prova Brasil* dataset and offers a descriptive analysis from the sample variables use. The fourth section discusses the relationship between birth seasonal patterns and academic achievement. Section five provides the estimated results, and some robustness tests to verify the validity of the instruments. Finally, the last one brings together the main findings of the article.

**2 Identification using information on peer’s date of birth**

The central question of this paper is whether student’s educational achievement is affected by the performance of other peers from the same grade and school. The identification strategy builds on the use of an instrumental variable which determines peers’ performance at school, but which is nonetheless exogenous to any unobserved factor related to the potential individual outcome. Specifically, the instruments being considered here are the proportions of peers born in the first or second semester of the year, as proposed by the work of Goux and Maurin (2007). The authors use the distribution of neighbors’ dates of birth as instrumental variable to identify the effect of neighbors’ educational advancement on an adolescent's performance at school. Their IV estimates suggest that a one standard-deviation increase in the proportion of neighbors who have already been held back a grade at age 15 increases an adolescent's probability of grade repetition between the age of 15 and 16 by about 10 to 15 percentage points (i.e. about 20% of a SD).

Following this approach, one simple way to identify the influence of scholar peer effects, in our study, is to test whether student's performance at school is affected by the distribution of dates of birth within the year of the other peers from the same school. As already mention, the intuition behind such instrument is based on the compulsory school attendance laws that generate variation in the child’s age at school entry, which, in turn, make the date of birth within the year an important determinant of educational achievement and, at the same time, plausibly exogenous to the quality of the student’s peers.

Based on this argument we propose to estimate the following system of equations based on a Two-Step Generalized Method of Moments (GMM-IV) procedure:

|  |  |
| --- | --- |
|  | (1) |
|  | (2) |

In the first step, we regress the average peer’s grade at school *j[[6]](#footnote-6)*, on the vector of instruments *Zj = (PSem1,j, PSem2,j,)* composed by the proportion of 4th graders born in the first and second semester of the year, excluding the births of December as reference, and on other predetermined variables of student *i* (*Xi,j*) and school *j* (*Wj*), as described in Table 1. In the second step, the instrumented average grade () is included to capture the effect of peer’s performance on the individual outcome of interest *Yij*. There are two target outcomes being considered in this study: the individual achievement on math and on Portuguese language at the *Prova Brasil* exams of 2013.

Two indispensable requirements are necessary for the instruments to be considered valid in the IV approach. The first one is the *independence assumption*, which demands the instruments *Z* to be randomly allocated among individuals, meaning that they are independent of all potential outcomes and treatment intensities. It means that the instruments should be uncorrelated with the error terms in equations (1) and (2). The proportion of 4th graders born in the first and second semester of the year presents this suitable feature, since it is a random event and, as such, tends to be orthogonal to the error terms.

The second condition is the *monotonicity assumption*, which demands the treatment status (the peers’ average performance) to be indeed induced by the instrument status (proportion of 4th graders born by semester). In the present paper, monotonicity means that schools with higher proportion of students born in the second semester should performance at least as well (or better) as they would have performed had they concentrate more students born in the first semester. It is worthwhile to remember that the date of birth within the year is an important determinant of educational achievement only because of the variation in the child’s age at school entry, which is exogenously defined by attendance laws. As a consequence, the intended effect of our instrument is a local average treatment effect (LATE) identified only over the subpopulation of compliers. Here the compliers are the students who turned 6 years old by the beginning of the academic year and enrolled in the 1st grade, as well as those who had to wait one more year to start school if they turned 6 after this period. Notice that this compliance rule, due to the monotonicity assumption, could be violated if students (or their parents) manage to defy the legal age entrance at school. Suppose for instance parents share the beliefs it is better to enter school at a relatively older age and a child who turn 6 years old in March, would be held on one more year before start the 1st grade. This same child would begin the 1st grade relatively older breaking down the instrument status, in which children born in the first semester should be relatively younger. This sort of manipulation turns down the compliance rule and the IV approach is no longer valid.

The independence and monotonicity assumptions cannot be directly checked because it involves unobservable variables[[7]](#footnote-7). Nevertheless, there are some testable implications that can be used as robustness tests, which will be presented in Section 5.1.

**3 The dataset and descriptive statistics of the variables**

This paper uses data from the Brazilian National System to Evaluate Basic Education also known as *Prova Brasil*, for the year of 2013. Created in 2005 by the *National Institute of Educational Research Anísio Teixeira* from the Brazilian Ministry of Education (MEC/ Inep), the *Prova Brasil* evaluation consists of a census assessment involving students from 4th and 8th grades of elementary schools in Brazil, and offers a nationwide measurement of the quality of education. Schools with at least twenty students enrolled in the assessed grades are eligible to participate in the assessment and their pupils are submitted to two types of exams: mathematics and Portuguese language. At the end of the tests, the student answers a questionnaire containing questions about date of birth, age and sex, as well as, scholar history, studying habits and family socioeconomic background. Interviewers also administer two other questionnaires for the school Principals and teachers, in which they collect a large set of information on internal and external aspects of the school environment.

For the present study we consider only the sample of 4th grade students from public schools that had at least ten students being evaluated in the *Prova Brasil* exams of 2013. After the exclusion of individuals with inadequate or missing information, the final sample consists of 599,103 students from 4th grade and 35,707 schools distributed over the 26 Brazilian states and the Federal District.

Table 1 presents the definition and descriptive statistics of the variables selected for the estimated models of this paper. The scale of the *Prova Brasil* evaluations ranges from 0 to 500 and indicates in which position the student of a given school unit is located. Such position reveals the skills the students have already acquired in the learning process, or those that are still being developed. For the 4th grade, the minimum desired level for mathematics should be 225, while in Portuguese language this inferior limit should be 200. In the case of our sample, as presented in Table 1, the 4th graders achieve in average below the minimum level for the math evaluation, with mean grade of 218 in mathematics, and reach the minimum desired level in Portuguese language, with average grade of 200.

**Table 1**

**Definition and descriptive statistics of the variables**

|  | **Definition of Variables** | **Average** | **Standard Deviation** |
| --- | --- | --- | --- |
| ***Dependent Variables (Y)*** |  |  |  |
| Math grade at *Prova Brasil* exam (4th grade) | Grade of student *i* (4th grade) on math test transformed to the scale with mean = 250 and standard deviation = 50 | 217.91 | 51.24 |
| Portuguese Language grade at *Prova Brasil* exam (4th grade) | Grade of student *i* (4th grade) on Portuguese language test transformed to the scale with mean = 250 and standard deviation = 50 | 200.49 | 49.85 |
| ***Instruments (Z)*** |  |  |  |
| Proportion born in the 1st semester | Proportion of 4th graders born in the first semester of the year, at school *j* | 0.53 | 0.10 |
| Proportion born in the 2nd semester | Proportion of 4th graders born in the second semester of the year, at school *j*, excluding the births of December as reference | 0.39 | 0.09 |
| ***Peers’ Educational Achievement*** |  |  |  |
| Peers math grade (4th grade) | Peers average math grade over 4th grade students at school *j* | 212.45 | 27.19 |
| Peers Portuguese language grade (4th grade) | Peers average Portuguese language grade over 4th grade students at school *j* | 195.98 | 24.18 |
| ***Students’ Characteristics (X)*** |  |  |  |
| Semester I | Dummy equals 1 if students were born in the months from January to June | 0.53 | 0.50 |
| Semester II | Dummy equals 1 if students were born in the months from July to November | 0.39 | 0.49 |
| Age | Age of the student, takes values: 1 = 8 years old; 2 = 9 years old; 3 = 10 years old; 4 =11 years old; 5 = 12 years old; 6 = 13 years old; 7 = 14 years old and 8 = 15 years old or more | 3.87 | 1.07 |
| Male sex | Dummy equals 1 if student is male | 0.53 | 0.50 |
| White | Dummy equals 1 if students declare themselves as white | 0.36 | 0.48 |
| Mixed race | Dummy equals 1 if students declare themselves as mixed race | 0.48 | 0.50 |
| Black | Dummy equals 1 if students declare themselves as black | 0.10 | 0.31 |
| Student lives with the mother | Dummy equals 1 if student lives with the mother | 0.91 | 0.28 |
| Educational level (mother) | Educational attainment, takes values: 1 = has never studied; 2 = 4th grade incomplete; 3 = has finish 4th grade, but hasn’t finish 8th grade; 4 = has finish 8th grade, but hasn’t finish high school; 5 = has completed high school; 6 = College degree | 3.92 | 1.48 |
| Literacy (mother) | Dummy equals 1 if student’s mother knows how to read | 0.96 | 0.21 |
| Student lives with the father | Dummy equals 1 if student lives with the father | 0.71 | 0.45 |
| Educational level (father) | Educational attainment, takes values: 1 = has never studied; 2 = 4th grade incomplete; 3 = has finish 4th grade, but hasn’t finish 8th grade; 4 = has finish 8th grade, but hasn’t finish high school; 5 = has completed high school; 6 = College degree | 3.85 | 1.54 |
| Literacy (father) | Dummy equals 1 if student’s father knows how to read | 0.93 | 0.26 |
| Pre school | Age at which student began to frequent school, takes values:1 = between 0 and 3 years old; 2 = between 4 and 5years old; 3 = between 6 and 7 years old; 4 = for 8 years old or more | 1.82 | 0.85 |
| Grade repetition | Variable takes values: 1 = has never repeated; 2 = has repeated one grade; 3 = has repeated two grades or more | 1.33 | 0.60 |
| Frequency student has already abandoned school | Variable takes values: 1 = has never abandoned; 2 = has abandoned one year; 3 = has abandoned two years or more | 1.09 | 0.33 |
| ***Schools’ Characteristics (W)*** |  |  |  |
| Number of enrolled students | Total number of enrolled students at the school *j* | 674.12 | 41.22 |
| Day-shift classes | Classes take place between 7am to 12am | 0.57 | 0.49 |
| Afternoon-shift classes | Classes take place between 1pm to 5pm | 0.43 | 0.49 |
| Night-shift classes | Classes take place between 6pm to 10pm | 0.00 | 0.01 |
| Federal schools | The school is under the responsibility of Federal Government | 0.00 | 0.03 |
| State schools | The school is under the responsibility of State Government | 0.23 | 0.42 |
| Municipal schools | The school is under the responsibility of Municipal Government | 0.76 | 0.42 |
| Urbana | The school is located in urban area | 0.91 | 0.28 |
| **Nº of observations: 599,103** |  |  |  |

Source: MEC/ Inep (2013).

**4 Birth seasonal patterns and academic achievement**

The systemic and regular variation in the birth number along the year is an observed phenomenon in most of the populations. Specifically, it has been documented two seasonal patterns that characterize several countries – the European pattern, with birth concentration in their spring season, reaching a peak in the month of April, and the American pattern, with birth concentration between July and September, both patterns having in common a secondary peak in September (Lam and Miron, 1987).

In Brazil, Moreira (2013) identifies, for the births registered in the period of 2000 to 2010, a birth concentration between the months of March and May[[8]](#footnote-8) and also a secondary peak in September.

In the case of our study, Figure 1 presents the distribution of 4th graders born by month. It shows a birth concentration in the period of March to May, which is consistent with Moreira (2013) and a secondary peak in the months of December and January.

|  |
| --- |
| Figure 1  Birth distribution of 4th graders by month |
| Distribuição_mês_nascimento.png |
| Source: Original compilation based on MEC/ Inep (2013). |

In the demographics literature, there are several classes of explanations to the phenomenon of birth seasonality, but with no consensus [Doblhammer *et al.* (1999), Cummings (2014)]. More recently, it has grown a literature focusing on the effect of environmental aspects, such as daily luminosity (photoperiod), on the birth variability over the time (Cumming, 2009, 2012). Moreira (2013) also highlights biological factors (e.g.: endometrial receptivity, semen quality and ovulation rates).

In the epidemiological literature, there are studies demonstrating associations between birth seasonality and birth outcomes (preterm birth, stillbirth and low birth weight), and also between birth seasonality and disease incidence [Martinez-Bakker *et al.* (2015); Almond and Mazumder (2011); Strand *et al.* (2011); Barreca (2010)]. These effects might, in turn, affect educational outcomes and the linkage mechanism between the instruments and academic performance could be due, not only to the relative age effect, but also through its impact on health status. For instance, in Brazil Pinedo and Bermudez (2016) demonstrate an association between children born in the months of December and January and poor birth outcomes and argue such outcomes are related to climate conditions, such as high levels of temperature, humidity and rainfall, which favour the spread of viruses and diseases.

There is also a related literature that focuses on the potential linkage between birth events and socio-cultural aspects (Pinedo and Bermudez, 2016), which is particularly problematic for the purpose of our identification strategy, since birth seasonality could rather be reflecting family background. However, this has not been empirically observed. For instance, Lam and Miron (1987) find that the seasonal pattern of children’s births is unrelated to the wealth and marital status of their parents for several countries’ populations. In Brazil, Moreira (2013) does not find statistically significant differences of birth patterns among populations from different geographic regions, neither among socio-demographics characteristics of the mother, such as, age, marital status, education and occupation. According to this author, these evidences suggest that Brazilian conceptions are rather related to daily luminosity (photoperiod). As a result, the period of birth, in itself, should not be correlated with educational outcome, suggesting that this variable is plausibly exogenous for the purposes of this paper.

However, as already explained, the compulsory school attendance laws generate variation in the child’s age at school entry, which induce some children to enter at a relatively older (or younger) age. This, in turn, makes the date of birth within the year an important determinant of educational achievement and, at the same time, plausibly exogenous.

In Brazil, because of the Federal law of 2008, children born after March start school relatively older[[9]](#footnote-9). Provided that our sample is composed of children who entered school when the Federal law of 2008 was still present; we have found a significant correlation between period of birth and educational achievement. Specifically, students born in the second semester (relatively older) achieve systematically better in math and Portuguese language tests of *Prova Brasil*, as illustrated in Table 2. The same is observed for those born in the 3rd quarter and in the period of September to November.

|  |  |  |
| --- | --- | --- |
| Table 2  Correlations between period of birth and educational achievement | | |
|  | **Math** | **Portuguese Language** |
| *Model 1* |  |  |
| Born 1st semester *(dummy)* | 1.98  (0.23) | 1.64  (0.22) |
| Born 2nd semester *(dummy, December is reference)* | 3.95  (0.23) | 3.38  (0.23) |
| Additional controls\* | Yes | Yes |
| *R2* | 0.23 | 0.24 |
| Nº of observations | 599,103 | |
| *Model 2* |  |  |
| Born January to April *(dummy)* | 1.79  (0.23) | 1.52  (0.23) |
| Born May to August *(dummy)* | 3.24  (0.24) | 2.77  (0.23) |
| Born September to November *(dummy, December is reference)* | 3.74  (0.25) | 3.09  (0.24) |
| Additional controls | Yes | Yes |
| *R2* | 0.23 | 0.24 |
| Nº of observations | 599,103 | |
| *Model 3* |  |  |
| Born 1st quarter *(dummy)* | 1.57  (0.24) | 1.29  (0.23) |
| Born 2nd quarter *(dummy)* | 2.41  (0.24) | 2.01  (0.23) |
| Born 3rd quarter *(dummy)* | 4.49  (0.25) | 3.91  (0.24) |
| Born 4th quarter *(dummy, December is reference)* | 3.18  (0.26) | 2.63  (0.25) |
| Additional controls | Yes | Yes |
| *R2* | 0.23 | 0.24 |
| Nº of observations | 599,103 | |
| Source: Original compilation based on MEC/ Inep (2013). | | |
| \* Additional controls include proportions of 4th graders at school *j* born according to the period of the year considered in each model, student *i* (*Xi,j*) and school *j* (*Wj*) characteristics described in Table 1, as well as, State dummies. | | |

**5 Results**

Given the significant correlation between the period of birth and individual educational achievement, we now test if peers’ birth distribution can be used as an instrumental variable to detect the peers’ academic influence. Table 3 presents the results of IV and OLS estimations, for math and Portuguese language exams. As an initial exercise we investigate the correlation between individual performance and peers’ performance. The positive and significant coefficient shows that an individual’s academic performance and the academic performance of their peers are directly correlated, in both math and language evaluations (columns 3 and 6 of Table 3).

Columns (1), (2), (4) and (5) of Table 3 provide results of the GMM-IV estimations. The first comment to notice is the strong and significant correlation of the instruments with the potentially endogenous variable (peers’ achievement) provided by the first-stage regressions (columns 1 and 4). Schools with high proportions of peers born in the 2nd semester tend to perform better, in average, than those that concentrate children born in the 1st semester, even after the inclusion of state dummies, the student period of birth and a wide range of individual socioeconomic and school features. These findings capture the relative age effect on the quality of peers, induced here by the exogenous variation of the age at school entry defined by attendance laws.

The instrumented peers’ academic performance is then used in the second-stage regressions to capture educational peer effects on individual achievement. Columns (2) and (5) of Table 3 exhibit the results. For the math evaluation, the positive and significant coefficient *()* and its corresponding standardized coefficient *()[[10]](#footnote-10)* indicates that a one standard deviation increase in the peers’ grade, generates an improvement of 32% standard deviations in individual achievement. For the Portuguese language evaluation, this effect represents an increase of 30% SD of the student grade.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table 3  The effect of peers’ educational achievement on student’s performance at the 4th grade: IV and OLS regressions | | | | | | | | | |
| Independent variables | Dep. var: Peers math grade  (1st stage) | | Dep. var.: Student math grade | |  | Dep. var.: Peers Port. Lang. grade  (1st stage) | | Dep. var: Student Port. Lang. grade | | | | |
| IV  (2nd stage) | OLS | IV  (2nd stage) | OLS | | | |
| *Peers’ characteristics* | | | | | | | | | |
| Peers average math grade | | - | 0.60  (0.06) | 0.84  (0.003) |  | - | | - | - | |
| Peers average Port. Lang. grade | | - | - | - |  | - | | 0.61  (0.07) | 0.82  (0.003) | |
| Proportion born in the 1st semester | | 2.60  (0.67) | - | - |  | 3.96  (0.59) | | - | - | |
| Proportion born in the 2nd semester | | 14.20  (0.72) | - | - |  | 13.10  (0.63) | | - | - | |
| *Individual characteristics* | | | | | | | | | |
| Born 1st semester | | -0.17  (0.10) | 2.02  (0.21) | 2.07  (3.81) |  | -0.17  (0.09) | 1.72  (0.20) | | 1.76  (0.20) | | |
| Born 2nd semester | | 0.02  (0.10) | 3.88  (0.22) | 3.81  (0.22) |  | 0.002  (0.09) | 3.37  (0.21) | | 3.31  (0.21) | | |
|  | |  |  |  |  |  |  | |  | | |
| Additional controls\* | | Yes | Yes | Yes |  | Yes | Yes | | Yes | | |
|  | |  |  |  |  |  |  | |  | | |
| R2 | | 0.49 | 0.32 | 0.33 |  | 0.48 | 0.31 | | 0.32 | | |
|  | |  |  |  |  |  |  | |  | | |
| H0 = “Peers average math grade” exogenous | | - | 18.69  (p = 0.000) | - |  | - | - | | - | | |
| H0 = “Peers average Port. Lang. grade” exogenous | | - | - | - |  | - | 9.94  (p = 0.002) | | - | | |
| H0 = Instruments jointly valid (math) | | - | 3.63  (p = 0.06) | - |  | - | - | | - | | |
| H0 = Instruments jointly valid (Port. Lang.) | | - | - | - |  | - | 0.49  (p = 0.48) | | - | | |
| Nº of observations | | 599,103 | 599,103 | 599,103 |  | 599,103 | 599,103 | | 599,103 | | |
| Source: Original compilation based on MEC/ Inep (2013). | | | | | | | | | |
| \* Additional controls include student *i* (*Xi,j*) and school *j* (*Wj*) characteristics described in Table 1, as well as, state dummies.  Note: The instruments are the proportions of peers born in the first semester (January - June) and in the second semester (July – November), December being the reference. | | | | | | | | | |

*5.1 Exogeneity, overidentification and other robustness tests*

The Hausman tests presented in columns (2) and (5) of Table 3 reject the null hypothesis that peer’s average grade is exogenous. Indeed, for both types of exams, the OLS coefficients seem to overestimate the influence of peers on individual achievement, when comparing to IV (2nd stage) estimates. This is somehow expected once endogenous group selection is likely to lead to upward bias in the OLS coefficient, given that members of the same group tend to share similar unobserved attributes.

The overidentification tests are also implemented in order to check the validity of our instruments for peers’ academic achievement. As can be verified from columns (2) and (5) of Table 3, the null hypothesis of the validity of our instruments cannot be rejected at 1% level, for both evaluations: math (p-value = 0.06 > 0.01) and Portuguese language (p-value = 0.49 > 0.01).

The following Table 4 presents a robustness test for the independence assumption. It provides a balancing test on observables in order to show that there are no apparent discrepancies between schools with higher proportions of 4th graders born in the 1st (or 2nd) semester. We find very similar descriptive statistics for the students and school characteristics illustrated in Table 4. Differences appear, as expected, on the average proportions of 4th graders by semester, and also on average age of student body (students born in 2nd semester are relatively older), which is consistent with the cut-off date for age at school entry. It should also be noticed that there are more schools with higher concentration of 4th graders born in the 1st semester (n = 20,381) than in the 2nd semester (n = 15,326), this finding is consistent with the birth seasonality peaks discussed in Section 4. Although it is not a direct way to test for the independence assumption, this balancing exercise on observables, together with the randomness of birth events, offer a reliable way to defend the exogeneity of the instruments.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Table 4  Summary statistics of individual and school characteristics by schools with higher proportions of peers born by semester | | | | | |
|  | Higher proportion of peers born in the 1st semester | |  | Higher proportion of peers born in the 2nd semester\* | | |
| Individual and school characteristics | Mean | Std. Dev. |  | Mean | Std. Dev. | |
| Age | 3.69 | 1.05 |  | 4.07 | 1.07 | |
| Proportion of peers born in the 1st semester | 0.55 | 0.10 |  | 0.51 | 0.08 | |
| Proportion of peers born in the 2nd semester | 0.37 | 0.09 |  | 0.41 | 0.08 | |
| Total number of enrolled students | 677.41 | 412.05 |  | 670.37 | 412.44 | |
| Male | 0.52 | 0.50 |  | 0.53 | 0.50 | |
| White | 0.36 | 0.48 |  | 0.35 | 0.48 | |
| Mixed race | 0.48 | 0.50 |  | 0.49 | 0.50 | |
| Black | 0.10 | 0.30 |  | 0.11 | 0.31 | |
| Student lives with the mother | 0.91 | 0.28 |  | 0.91 | 0.28 | |
| Educational level (mother) | 3.94 | 1.48 |  | 3.91 | 1.48 | |
| Literacy (mother) | 0.96 | 0.21 |  | 0.95 | 0.21 | |
| Student lives with the father | 0.71 | 0.45 |  | 0.71 | 0.45 | |
| Educational level (father) | 3.87 | 1.54 |  | 3.83 | 1.54 | |
| Literacy (father) | 0.93 | 0.26 |  | 0.93 | 0.26 | |
| Pre school | 1.82 | 0.85 |  | 1.83 | 0.86 | |
| Grade repetition | 1.32 | 0.59 |  | 1.34 | 0.61 | |
| Frequency student has already abandoned school | 1.09 | 0.33 |  | 1.09 | 0.33 | |
| Day-shift classes | 0.57 | 0.49 |  | 0.57 | 0.49 | |
| Afternoon-shift classes | 0.43 | 0.49 |  | 0.43 | 0.49 | |
| Night-shift classes | 0.0002 | 0.01 |  | 0.001 | 0.01 | |
| Federal school | 0.0009 | 0.03 |  | 0.001 | 0.03 | |
| State school | 0.24 | 0.43 |  | 0.22 | 0.42 | |
| Municipal school | 0.76 | 0.43 |  | 0.77 | 0.42 | |
| Urban area | 0.92 | 0.28 |  | 0.91 | 0.29 | |
| Nº of observations | 20,381 | |  | 15,326 | | |
| Source: Original compilation based on MEC/ Inep (2013).  \*It is a dummy variable that takes the value 1 when the proportion of 4th graders born in the 2nd semester, for each school, is at least as high as the proportion of 4th graders born in the 1st semester; and the value 0 otherwise. | | | | | |

The monotonicity assumption also cannot be directly checked, because again it involves unobservable variables, only one of (or ) is observed. However, we propose a test that consists on restricting the estimated models over the subpopulation of compliers, in which we identify only students who enrolled in the 1st grade when they turned 6 years old by March, as well as those who had to wait one more year to start school if they turned 6 after this period. The subsample of compliers is restricted to 330,406 individuals, representing 55% of our sample. Table 5 presents the results and it shows the peer effects coefficients reduce in the restricted sample, for both types of evaluations; however they are not statistically different from those of the complete sample, as illustrated by the test F. This kind of exercise provides an indirect way of proving that the treatment intensity (peers’ average performance) responds robustly to the instruments and, as such, we assume there is no reason to expect schools to respond differently to the instrument status.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Table 5  IV regressions for the effect of peers’ educational achievement on student’s performance over the restricted (complier) and unrestricted sample | | | | | | |
| Independent variables | Dep. var.: Student math grade  (2nd stage) | | | Dep. var: Student Port. Lang. grade  (2nd stage) | | |
| Unrestricted | Restricted (compliers) | | Unrestricted | | Restricted (compliers) |
| *Peers’ characteristics* | | | | | | |
| Peers average math grade | 0.60  (0.06) | 0.51  (0.08) | - | | - | |
| Peers average Port. Lang. grade | - | - | 0.61  (0.07) | | 0.53  (0.10) | |
| *Individual characteristics* | | | | | | |
| Born 1st semester | 2.02  (0.21) | 0.79  (0.29) | 1.72  (0.20) | | 0.01  (0.30) | |
| Born 2nd semester | 3.88  (0.22) | 2.32  (0.36) | 3.37  (0.21) | | 1.49  (0.36) | |
|  |  |  |  | |  | |
| Additional controls\* | Yes | Yes | Yes | | Yes | |
|  |  |  |  | |  | |
| R2 | 0.32 | 0.29 | 0.31 | | 0.28 | |
|  |  |  |  | |  | |
| H0 = “Peers average math grade” exogenous | 18.69  (p = 0.000) | 15.43  (p=0.000) | - | | - | |
| H0 = “Peers average Port. Lang. grade” exogenous | - | - | 9.94  (p = 0.002) | | 9.36  (p=0.002) | |
| H0 = Instruments jointly valid (math) | 3.63  (p = 0.06) | 0.37  (p=0.54) | - | | - | |
| H0 = Instruments jointly valid (Port. Lang.) | - | - | 0.49  (p = 0.48) | | 0.36  (p=0.55) | |
| H0= “Equal coefficients” |  | |  | | | |
| Nº of observations | 599,103 | 330,406 | 599,103 | | 330,406 | |
| Source: Original compilation based on MEC/ Inep (2013). | | | | | | |
| \* Additional controls include same variables as the model of Table 3.  Note: The instruments are the proportions of peers born in the first semester (January - June) and in the second semester (July – November), December being the reference. | | | | | | |

**6 Final considerations**

The present paper contributes with new evidence for the role of peer effects in the Brazilian public school system. Using data from the *Prova Brasil* exams for the year of 2013, we investigate the dissemination of peer effects on academic achievement for the 4th grade students. Our identification strategy builds on the use of an IV approach, in which the instruments are the proportions of peers born in the first or second semester of the year. The idea behind the instruments is that educational achievement is related to age at school entry because of the age variation induced by compulsory school attendance laws. In Brazil, children born in the second semester start school at a relatively older age, because of the Federal laws (Brasil, 2008 and 2010).

The results demonstrate that schools with high proportions of peers born in the 2nd semester tend to perform better, in average, than those that concentrate children born in the 1st semester, even after the inclusion of a wide range of control variables. For the math evaluation, a one standard deviation increase in the peers’ grade generates an improvement of 32% standard deviations in individual achievement. For the Portuguese language evaluation, this effect represents an increase of 30% SD of the student grade. Exogeneity, overidentification and other robustness tests favored the strength of the instruments.

To better understand the role of peer effects in the school environment is a key issue to improve the development of educational policies. Further research is needed to help understanding the mechanisms through which children influence each other, in order to better prescribe classroom interventions which takes advantage of the peer effects dissemination.

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**Annex**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Table A1**  **Brazilian laws regarding minimum age for school entry in 2009** | | | |  |
| **State** | **First grade entry age** | **Birthday cutoff** | **Statute** | **Source** |
| Paraná | 6 | 31-December | LEI Nº 16.049 DE 19/02/2009 | Lei 16049 - 19 de Fevereiro de 2009. Publicado no Diário Oficial nº. 7915 de 19 de Fevereiro de 2009. Disponível em: <http://www.legislacao.pr.gov.br/legislacao/listarAtosAno.do?action=exibir&codAto=19943>. Acesso em: 20 jun. 2016. |
| Rio Grande do Sul | 6 | Beginning of school year | PARECER CNE/CEB Nº: 4/2008 – MEC | BRASIL. Ministério da Educação. Resolução CNE/CEB n. 4, de 20 fev. 2008.Publicado no *Diário Oficial da União,* Brasília, 10 Jun. 2008, Disponível em: <http://portal.mec.gov.br/cne/arquivos/pdf/2008/pceb004\_08.pdf>. Acesso em: 20 jun. 2016. |
| Santa Catarina | 6 | Beginning of school year | PARECER CNE/CEB Nº: 4/2008 - MEC |
| São Paulo | 6 | 31-December | DELIBERAÇÃO CEE N° 73/2008 - SÃO PAULO | DELIBERAÇÃO CEE N° 73/2008. Disponível em: <http://desumare.edunet.sp.gov.br/Supervisao/09/deliberacoes/deliberacao\_CEE\_7308.pdf>. Acesso em: 20 jun. 2016. |
| Rio de Janeiro | 6 | Beginning of school year | PARECER CNE/CEB Nº: 4/2008 - MEC | BRASIL. Ministério da Educação. Resolução CNE/CEB n. 4, de 20 fev. 2008.Publicado no *Diário Oficial da União,* Brasília, 10 Jun. 2008, Disponível em: <http://portal.mec.gov.br/cne/arquivos/pdf/2008/pceb004\_08.pdf>. Acesso em: 20 jun. 2016 |
| Minas Gerais | 6 | Beginning of school year | PARECER CNE/CEB Nº: 4/2008 - MEC |
| Espírito Santo | 6 | 1-March | RESOLUÇÃO CEE Nº 1790/2008 - CONSELHO DE EDUCAÇÃO DO ESPÍRITO SANTO | RESOLUÇÃO CEE Nº 1790/2008. Publicado no Diário Oficial em 14/11/2008. Disponível em: <http://www.cee.es.gov.br/download/res1790.pdf>. Acesso em: 20 jun. 2016. |
| Mato Grosso | 6 | Beginning of school year | PARECER CNE/CEB Nº: 4/2008 - MEC | BRASIL. Ministério da Educação. Resolução CNE/CEB n. 4, de 20 fev. 2008.Publicado no *Diário Oficial da União,* Brasília, 10 Jun. 2008, Disponível em: <http://portal.mec.gov.br/cne/arquivos/pdf/2008/pceb004\_08.pdf>. Acesso em: 20 jun. 2016. |
| Mato Grosso do Sul | 6 | Beginning of school year | PARECER CNE/CEB Nº: 4/2008 - MEC |
| Goiás | 6 | Beginning of school year | PARECER CNE/CEB Nº: 4/2008 - MEC |
| Distrito Federal | 6 | Beginning of school year | PARECER CNE/CEB Nº: 4/2008 - MEC |
| Amazonas | 6 | Beginning of school year | PARECER CNE/CEB Nº: 4/2008 - MEC |
| Acre | 6 | Beginning of school year | PARECER CNE/CEB Nº: 4/2008 - MEC |
| Amapá | 6 | Beginning of school year | PARECER CNE/CEB Nº: 4/2008 - MEC |
| Roraima | 6 | Beginning of school year | PARECER CNE/CEB Nº: 4/2008 - MEC |
| Rondônia | 6 | Beginning of school year | PARECER CNE/CEB Nº: 4/2008 - MEC |
| Tocantins | 6 | Beginning of school year | PARECER CNE/CEB Nº: 4/2008 - MEC |
| Pará | 6 | Beginning of school year | PARECER CNE/CEB Nº: 4/2008 - MEC |
| Bahia | 6 | Beginning of school year | PARECER CNE/CEB Nº: 4/2008 - MEC |
| Sergipe | 6 | 30-April | PORTARIA N° 5957/2008 - GOVERNO DE SERGIPE | PORTARIA N° 5957/2008. Disponível em: <http://seed.se.gov.br/arquivos/Portaria\_Diretrizes\_Escolas\_Publicas\_Estaduais\_2009.pdf>. Acesso em: 20 jun. 2016. |
| Alagoas | 6 | Beginning of school year | PARECER CNE/CEB Nº: 4/2008 - MEC | BRASIL. Ministério da Educação. Resolução CNE/CEB n. 4, de 20 fev. 2008.Publicado no *Diário Oficial da União,* Brasília, 10 Jun. 2008, Disponível em: <http://portal.mec.gov.br/cne/arquivos/pdf/2008/pceb004\_08.pdf>. Acesso em: 20 jun. 2016. |
| Pernambuco | 6 | Beginning of school year | PARECER CNE/CEB Nº: 4/2008 - MEC |
| Paraíba | 6 | Beginning of school year | PARECER CNE/CEB Nº: 4/2008 - MEC |
| Rio Grande do Norte | 6 | Beginning of school year | PARECER CNE/CEB Nº: 4/2008 - MEC |
| Ceará | 6 | 30-April | RESOLUÇÃO Nº 0410/2006 - CONSELHO DE EDUCAÇÃO DO CEARÁ | RESOLUÇÃO Nº 0410/2006 - CONSELHO DE EDUCAÇÃO DO CEARÁ. Disponível em: < http://portal.mec.gov.br/arquivos/pdf/acs\_resolucao410.2006.pdf>. Acesso em: 20 jun. 2016. |
| Piauí | 6 | 30-June | RESOLUÇÃO CEE/PI Nº 141/2007 | RESOLUÇÃO CEE/PI Nº 141/2007. Disponível em: <http://www.ceepi.pro.br/Normas%20CEE/2007%20Resolu%C3%A7%C3%A3o%20141-%20E%20Fundamental%20%209%20anos.doc>. Acesso em: 20 jun. 2016. |
| Maranhão | 6 | Beginning of school year | PARECER CNE/CEB Nº: 4/2008 - MEC | BRASIL. Ministério da Educação. Resolução CNE/CEB n. 4, de 20 fev. 2008.Publicado no *Diário Oficial da União,* Brasília, 10 Jun. 2008, Disponível em: <http://portal.mec.gov.br/cne/arquivos/pdf/2008/pceb004\_08.pdf>. Acesso em: 20 jun. 2016. |

1. The sense of the term p*eers* in this article refers to all members belonging to a reference group, such as: same grade, classroom, school, neighborhood, etc. [↑](#footnote-ref-1)
2. Usually the empirical identification strategies rely either on the use of (i) exogenous instruments for peer’s educational outcome (Case and Katz, 1991; Evans *et al.,* 1992; Hanushek *et al*., 2003; Vigdor and Nechyba, 2007; Ding and Lehrer, 2007 and Sund, 2009); (ii) experimental or quasi-experimental data (Eisenkopf *et al.*, 2011; Duflo *et al.,* 2008; Sacerdote, 2001; Zimmerman, 2003; and Oosterbeek and Van Ewijk, 2014) and (iii) mostly recently on the architecture of social networks (e.g. Patacchini and Venanzoni, 2014; Badev, 2014; Patacchini *et al.*, 2011; Mele, 2010; Calvó-Armengol *et al.,* 2009; Bramoullé *et al.,* 2009; and Ballester *et al.,* 2006). [↑](#footnote-ref-2)
3. Similar IV approach was firstly proposed by Angrist and Krueger (1991, 1992) and Angrist and Imbens (1995). Angrist and Krueger (1991, 1992) show that students’ quarter of birth interacts with compulsory attendance laws in the US and age at school entry to generate variation in years of schooling. They show that educational attainment is related to age at school entry because children who enter at an older age (born in early quarters) are permitted to drop out after having completing less schooling than children who enter at a younger age. Angrist and Imbens (1995) based on such evidence also use student’s quarter of birth as an instrument for schooling in a wage equation. [↑](#footnote-ref-3)
4. According to legal guidance and standards set by the Brazilian National Board of Education / Ministry of Education in Resolution CNE/CEB 4/2008, to enter the first year of elementary education, the child must be six (6) years old by the beginning of the school year. Some States had different resolutions defined by their local boards of Education (see Table A1 of the Annex).

   In the year of 2010, a new resolution explicitly defined the cut-off date on March, 31st at the Resolution CNE/CEB 6/2010, according to the following articles:

   Article III – To enter the first year of elementary education, the child must be six (6) years old by March 31st before they are enrolled.

   Article IV – Children that reach the age of six (6) years after the date set in Article III must be enrolled at pre-school. [↑](#footnote-ref-4)
5. As pointed out by Goux and Maurin (2007), there is a literature on the influence of date of birth within the year (called the relative age effect) going back a few decades (Barnsley et al., 1985; Allen and Barnsley, 1993). It is shown that relative age has an impact on achievement in competitive activities (Hockey, Soccer), on achievement at school, on emotional development and even on the probability of committing suicide. [↑](#footnote-ref-5)
6. Where *nj* is the total number of 4th graders students at school *j*. [↑](#footnote-ref-6)
7. Suppose a specific school has a high proportion of students born in the second semester, and denote its average performance as . The non-observed counterfactual for that same unit would provide its average performance had that school concentrated more students born in the first semester. However, only one of (or ) is observed. [↑](#footnote-ref-7)
8. Resultant from conceptions in the period of June-August (end of Fall and beginning of the Winter in Brazil). [↑](#footnote-ref-8)
9. For our sample study, the average age at school entry in the 1st semester is 6.3 years old, while in the 2nd semester, it is 6.8. This difference is statistically significant at less than 1% level. [↑](#footnote-ref-9)
10. The standardized coefficient is calculated as follows: [↑](#footnote-ref-10)